How early of the early warning signal in banking crisis? The three booms, Credit, Housing and Capital, cases

Chung-Hua Shen
Department of Finance,
National Taiwan University,
Taipei, Taiwan

Hao Fang
Department of Assets and Property Management,
Hwa Hsia University of Technology,
Taipei, Taiwan

Yen-Hsien Lee*
Department of Finance,
Chung Yuan Christian University,
Taoyuan City, Taiwan
E-mail: yh@cycu.edu.tw

Abstract

Many studies or anecdotal episodes claim that fast growth of credit, housing or international capital flow may cause the banking crisis. This study examines this argument by pursuing two unresolved issues. First, their individual and joint effects provide an early warning signal (i.e., EWS) for the banking crises. Next, how early of these EWS sends the signal. Using 49 sample countries (33 from OECD and 16 from non-OECD countries), credit boom has more effective early warning for advanced countries than emerging countries. In contrast, housing boom has more effective prediction power in emerging countries than advanced countries. Capital boom has the same warning power in these two types of countries. We find that the power of the predictability increases as the number of booms adds simultaneously. Hence, the joint occurrence of the three booms has the most effective early warning in terms of leading time and power of predictability. We find interesting evidence that this phenomenon does not change in the different boom definitions, but it is more likely to occur in the emerging countries.

Keywords: Credit, Housing, Capital flow, boom, early warning signal, bank crisis.
JEL: E32, E37, E6, F31.

* Professor Lee is a corresponding author.

1. Introduction

Recent studies have found that fast growth of credit, housing and international capital flow markets (hereafter three markets) can be an effective early warning signal (EWS) for banking crisis. Anecdotal evidences such as Asian financial crisis and sub-prime financial crisis also often claim that fast growth of these three markets leads the crisis. For example, many studies find that fast credit explanation significantly affect the banking crisis.[1] In terms of capital inflow, the results of Reinhart and Reinhart (2009) and Caballero (2010) find that surges in capital inflow are associated with a higher likelihood of economic crises (including systemic banking crises). Reinhart and Rogoff (2013) use the 3-year moving average to empirically demonstrate that the periods of high international capital mobility have repeatedly produced international banking crises, not only famously as they did in the 1990s, but historically. Furceri, Guichard and Rusticelli (2012) suggest that a large capital inflow episode increases the probability of having a banking crisis in the two following years. Last, studying the single housing boom that affects banking crisis can be found in the following literature. Bordo and Jeanne (2002) find that a bank crisis is likely to exist either at the peak of housing boom or in the subsequent period of housing bust. The results of Reinhart and Rogoff (2008) show that the sustained growth in real housing prices are followed by a large decrease in the year of the crisis and subsequent years. Reinhart and Rogoff (2013) demonstrate that the downturn in housing prices persisted for four-six years before the occurrence of banking crises.

We examine whether the booms of the aforementioned three markets can serve as an effective EWS. Our study has the following three novel contributions. First,

[1] Honohan (1997) empirically finds that rapid growth in lending is likely to trigger the occurrence of financial crisis. The results of Borio and Lowe (2002) shows that sustained domestic credit growth increase the likelihood of financial instability. Kraft and Jankov (2005) indicate that the rapid loan growth would produce the current account and foreign debt problems.

some studies argue that the individual market alone may not be able to cause a big crisis. They focus on two of the above three markets jointly. Claessens and Kose (2013) and Brunnermeier and Oehmke (2012) suggest that fast increase in credit and housing price growths jointly affect financial stability. Borio and Lowe (2002) argued that sustained rapid credit growth combined with large increases in asset prices, such as housing prices, appeared to increase the probability of an episode of financial instability. Acharya and Richardson (2010) argued that the fundamental causes of the current crisis are the credit boom and the housing bubble. Honohan (1997) proposed that a credit-financed asset price boom characterized by unusual asset price movements and rapid growth in bank lending, may trigger the occurrence of financial crisis. Shen et al. (2014), Shen et al. (2015) examine the causality between credit and housing markets during the boom and non-boom periods.

Despite the existence of many studies on how one or two market affects financial stability, the discussion of the joint effect of three markets has not yet been available and in particular, they do not consider the boom periods. If the one or two booms have strong predictability of future banking crisis, the natural logical argument is that the occurrence of the three booms should have even stronger predictability. Hence, we first examine whether the single, twin and triple booms can successfully provide an EWS for the banking crisis and then hypothesize that the power of the predictability incases as the number of booms increases simultaneously.

Next, there are rarely studies regarding the leading period prior to the crisis. This is an important issue because a good EWS should provide signals at the optimal time prior to the crisis. Knowing the potential likelihood for future crisis, the authority can lean against the wind to reduce the loss. However, most studies focus on variables selection by using lag one or two periods without considering how early they send the signal. Kaminsky and Reinhert (1998) have suggested within 2 years prior to the

currency crisis to be a good leading indicator of crisis. Some studies deem that the effect of credit boom on banking crises is within the two following years (Bunda and Ca'Zorzi, 2010; Hamdi and Jlassi, 2014), but the results of other studies show that the influence of credit boom is above four years (Reinhart and Rogoff, 2008; 2009; Roy and Kemme, 2012). By taking the advanced economics for the sample, Reinhart and Rogoff (2008, 2009) empirically find that over four years prior to a crisis a credit boom is likely to increase the probability of bank crisis. Similar uncertainty for leading years that is ahead of crisis also exists for housing and capital booms. For example, although a few studies propose that the impact of housing boom on bank crisis is within the one year (Bordo and Jeanne, 2002; Bunda and Ca'Zorzi, 2010), many studies suggest that the effect of credit boom is over four years (Shiller, 2005; 2008; Reinhart and Rogoff, 2008; 2009; Reinhart and Rogoff, 2013). In terms of capital boom, the results of some studies show that the impact of capital boom on bank tensions is within a time span of two years (Furcer, et al., 2012; Caballero, 2010), but the relatively few studies (such as Reinhart and Rogoff, 2013) deem that the effect of capital boom is above two years. Hence, there is no consensus, how many years earlier that the credit booms provide the early warning system.

Because of leading time is uncertain, we consider one to six years ahead of crisis to examine how early the warning is provided. Our results show that the warning years change for the booms after controlling other macroeconomic and financial variables. The joint effect of three booms provides warning one year ahead of crisis.

Last, while past studies have considered the fast growth of credit, house and capital mobility may cause the crisis, only some of them incorporate the concept into the model. Borio and Lowe (2002), Acharya and Richardson (2010), Roy and Kemme (2012), Brunnermeier and Oehmke (2012) and Claessens and Kose (2013) use credit to GDP and housing price as the explanatory variables to predict the crisis, but they

do not consider that it may be their boom that affect the crisis. Recent studies, such as Barajas et al. (2007) and Mendoza and Terrones (2008) consider whether the credit booms can predict the crisis but they have not yet considered the housing and capital flow boom into the model. Except for these and related studies, most studies simply consider variable of credit, house and capital mobility to predict crisis. This study examines whether the boom of three markets can be EWS for the banking price.

When we focus on whether boom can be EWS, we are confronted with the definition of booms. In theory, a boom denotes periods where volumes or prices—either their growth rate or deviation from the trend—exceed certain critical values and become abnormally high. Using credit boom to illustrate the concept, Barajas et al. (2007) suggested two meanings of credit boom. One is that the deviation of credit-to-GDP ratio from the trend (hereafter, credit ratio gap) that is greater than 1.5 times its historical country-specific standard deviation and the normal growth rate of the credit ratio exceeds 10%. The other definition views credit boom as a situation, in which the annual growth rate of the credit ratio exceeds 20%. Also see Dell'Ariccia, Igan, Laeven, and Tong (2012) and Mendoza and Terrones (2008). Baker (2008) defines the housing boom as the growth rate of house prices nearly 30 percent after adjusting for inflation. See next section for detailed description.

Our results show that different boom's definitions commonly result in different dating of boom periods, which then affect the results. More importantly, it affects the number of times that three booms jointly occur, which affects our hypothesis that more booms and better prediction.

We separate our sample into advanced countries and emerging markets. We find advanced countries have higher banking crisis than emerging market. Also credit booms are more common in emerging markets than advanced countries but the other two booms are just opposite. Our study reaches the interesting results. We find that

there is a strong prediction power when the three jointly happened one year before the crisis.

There are six sections in our study. The remainder of this study proceeds as follows. Section 2 summarizes the related literature review. Section 3 reports the definition of three booms used in this study. Section 4 illustrates our econometric model. Section 5 shows the empirical results. Section 6 concludes our paper.

2. Literature review

Given that there are abundant studies about banking crisis, a complete survey is not easy and may distract readers the focus. Our review focuses on the use of different explanation variables to build up EWS with particular focus on the three booms. Also, since it is early warning, we examine the leading time that three booms occur ahead of crisis.

2.1 review of credit, housing and financial account mobility market in affecting banking crisis

Past studies commonly select the following three groups of variables in building up EWS. The first group is macroeconomic variables, consisting of the rate of gross domestic product growth, GDP per capita, rate of exchange rate, real interest rate and change in terms of trade.[2] The second group of explanatory variables are financial variables include the ratio of broad money to foreign exchange reserves and the credit to GDP.[3] Last, explanatory variables consider country governance included, such as Levine (1999), Levine, Loayza, and Beck (2000), Shen and Lee (2006) and Shen, Lee and Lee (2010) which are often based on the studies of La Porta et al.

[2] See Garcia Herrero and Del Rio (2003), Beck et al. (2006), Tanveer and De Haan (2008), Buyukkaraback and Valev (2010), Khan and Dewan (2011), Khan, Khan and Dewan (2013), Caggiano et al. (2014), Apanard and Willett (2011), Davis, Karim, and Liadze (2011), Buyukkarabacak and Valev (2012), Demirgüc-Kunt and Detragiache (2002), Komulainen and Lukkarila (2003), Demirgüc-Kunt and Detragiache (1997), Beck et al. (2006) and Demirgüc-Kunt and Detragiache (2002).

[3] See Demirgüc-Kunt and Detragiache (1997), Eichengreen and Arteta (2002), Komulainen and Lukkarila (2003) and Angkinand, Sawangngoenyuang and Wihlborg (2010).

(1998, hereafter LLSV), Kaufman (2004).

In addition to the above three groups of variables, a growing attention is paid to the credit, housing and capital mobility markets. For example, Honohan (1997) find that credit and house prices can cause banking crisis. See also Borio and Lowe (2002), Acharya and Richardson (2010), Roy and Kemme (2012), Brunnermeier and Oehmke (2012) and Claessens and Kose (2013) use the same two prices in studying factors affecting banking crisis. Capital flow is also found to affect banking crisis. Capital account variables which include a large capital inflow, tends to produce the subsequent sudden stops and financial crisis. Reinhart and Reinhart (2009) also showed that during the periods where capital mobility was interrupted, there was a remarkable decrease in banking crises. The three markets are also interacted. The surges in capital inflows are easily followed by asset-price boom since the funds of large capital inflows tend to fast inject into real estate market, which easily results in housing-price boom.

However, the existing studies on the EWS have not completely employed the concept of boom in predicting crisis. They use the growth rate of these three markets and find that they are significant in affecting crisis at the same or lagged one year.[4] However, except for Barajas et al. (2007), Mendoza and Terrones (2008), Reinhart and Rogoff (2008, 2009) and Bunda and Ca'Zorzi (2010), they rarely consider whether booms can predict the crisis. Also, past studies focus on either the advanced or emerging countries, whereas we consider both of them.

2.2 Singling prior to banking crisis

To be a good EWS, it is crucial to know the number of years that booms

[4] Bordo and Jeanne (2002), Borio and Lowe (2002), Shiller (2005, 2008), Kindleberger and Aliber (2005), Terrones and Mendoza (2006), Caballero (2010), Acharya and Richardson (2010), Roy and Kemme (2011), Roy and Kemme (2012), Furceri et al. (2012), Brunnermeier and Oehmke (2012), Reinhart and Rogoff (2013), Claessens and Kose (2013) and Hamdi and Jlassi (2014).

sending a signal preceding the banking crises. In terms of credit boom, some studies deem that the effect of credit boom on banking crises is within the two following years (see Bunda and Ca'Zorzi, 2010; Hamdi and Jlassi, 2014),[5] but the results of other studies show that the influence of credit boom is above four years (see Reinhart and Rogoff, 2008; 2009; Roy and Kemme, 2012).[6]

Turning to the case of housing price, the findings of Reinhart and Rogoff (2008, 2009, 2013) all show that a boom in real housing prices is followed by a marked decrease over four years before the crisis, but Bunda and Ca'Zorzi (2010) demonstrate that growth in real house prices is likely to increase the probability of bank crisis within one year. Literature also suggests that prior-year housing bubbles are a very common feature of banking crises (see Shiller, 2005; 2008; Kindleberger and Aliber, 2005; Roy and Kemme, 2011). Bordo and Jeanne (2002) study the advanced economies and find that banking crises are prone to occur either at the peak of the boom in real housing prices or right after the bust.

Last, the results of Furceri et al. (2012) suggest that a large capital inflow episode increases the probability of a banking crisis in the two following years. Reinhart and Reinhart (2009) find that during the periods where capital mobility was interrupted, there was a remarkable decrease in banking crises. The results of Caballero (2010) show that previous-year bonanzas in net capital flows are associated with systemic banking crises, even in the absence of a lending boom. By using the 3-year moving average, Reinhart and Rogoff (2013) empirically find that the periods

[5] Bunda and Ca'Zorzi (2010) empirically find that a credit boom would significantly and positively result in financial tensions within a time span of two years. For a panel of 58 developing countries, the results of Hamdi and Jlassi (2014) show that the growth of bank credit to the private sector in a lag of one period has a significantly positive impact on the occurrence of bank crisis.

[6] By using the joint samples of advanced economies and emerging markets, By taking the advanced economics for our sample, Reinhart and Rogoff (2008, 2009) empirically find that over four years prior to a crisis a credit boom is likely to increase the probability of bank crisis. Roy and Kemme (2012) use a representative sample of advanced economies to demonstrate that the sustained credit growth significantly increase the majority of the banking crises.

of high capital mobility have repeatedly produced banking crises especially during the financial liberalization. In addition, Agosin and Huaita (2012) demonstrate that a capital boom would significantly increase the probability of suffering a sudden stop.

3 Definition of three booms

3.1 Credit boom

We classify the credit growth market into four development stages, namely, starting, rapid credit growth, credit boom, and declining growth (Shen et al., 2014; Shen et al., 2015). The International Monetary Fund (2004) defines the second stage of rapid credit growth as the period when the average real credit growth over three years exceeds the median rate of real credit growth. Using data from 28 emerging countries from 1970 to 2002, Terrones and Mendoza (2006) found that the episode of rapid credit growth reached around 17% of their sample.

A credit boom is an episode of excessive credit expansion that is unsustainable and eventually collapses on its own accord (IMF, 2004). Therefore, not all episodes, in which private credit grows more rapidly than nominal GDP, can qualify as a credit boom. Moreover, a credit boom may arise from a surge in capital inflows driven by external factors (e.g., low interest rates in advanced economies), or from periods of strong disinflation (Gourinchas, Valdés, and Landerretche, 2001) and rising housing prices. Housing price can boost favorable real lending conditions, higher asset prices, and more optimistic risk assessments. Mendoza and Terrones (2012) proposed a methodology to measure credit booms and describe their relation to macroeconomic variables. Credit growth and housing price are most likely linked during a twin boom period.

Credit boom has four slightly different operational definitions in the literature. The first definition is from Barajas et al. (2007), who suggested two meanings of credit boom. One is that the deviation of credit-to-GDP ratio from the trend (hereafter,

credit ratio gap) that is greater than 1.5 times its historical country-specific standard deviation and the normal growth rate of the credit ratio exceeds 10%. The other definition views credit boom as a situation, in which the annual growth rate of the credit ratio exceeds 20%. Hilbers et al. (2005) suggested a credit ratio gap greater than five percentage points as an indicator of excessive credit in the economy. The second definition considers a slightly different credit definition. Mendoza and Terrones (2012) used real credit growth, i.e., the average of two contiguous end-of-year observations of nominal credit per capita deflated by their corresponding end-of-year consumer price index. In an earlier study, Mendoza and Terrones (2004) adopted the real private credit gap when the gap is greater than 1.75 times the standard deviation. Third, Gourinchas et al. (2001) suggested that the relative gap exceeds 5 or the absolute gap exceeds 3. Finally, Ottens et al. (2005) considered a policymaker's loss function in deciding the boom. The policymaker will find that applying intervention when the credit ratio is more than 5% above its trend for two consecutive years is optimal if the cost of a banking crisis is equal to five times the cost of taking preventive actions.

As the above four approaches share similarities, we simply integrated the above definitions by defining two kinds of credit booms. Credit boom 1 (*CB*1) is the episode when the annual growth rate of the credit ratio exceeds 15%. Credit boom 2 (*CB*2) is the episode when the deviation of credit from the trend is greater than *k* times its standard deviation, and the normal growth rate of the credit ratio exceeds 10%, where *k* is temporarily set to be 1.5.We also consider different *k* values for robust checking.

$$CB1_{i,t} = \begin{cases} 1 \ \ if \ \ CreditGrow > 15\% \\ 0 \quad \text{otherwise} \end{cases} \tag{1}$$

$$CreditGrow_{i,t} = \alpha_0 + \alpha_1 trend_{i,t} + \alpha_2 trend_{i,t}^2 + \varepsilon_{i,t} \tag{2}$$

$$CB2_{i,t} = \begin{cases} 1 \ \ if\ \varepsilon_{i,t} > \mu_{i,t} + k \times \sigma_{\varepsilon} \ \text{ and } \ CreditGrow > 10\% \\ 0 \quad \text{otherwise} \end{cases} \tag{2b}$$

In the equation above, *CreditGrow* is the growth rate of *Credit* (i.e., credit-to-GDP ratio), and *CB*1 and *CB2* denote the two different definitions of credit boom used in this study. *CB*1 assumes that credit growth exceeds a certain threshold, which is 15% in this study. *CB*2 considers the large deviations from the trend regression, where *k* is assumed to be 1.65; μ and σ are the mean and standard deviation of credit growth rate, respectively.

We first use *CB*1 and then use *CB*2 as the robust testing.

3.2 **Definition of housing boom**

Early studies typically focused on how housing markets and the macroeconomy are interrelated at the country and international levels. These studies have demonstrated that housing prices are strongly influenced by the business cycle, and therefore, are driven by fundamentals, such as income growth, industrial production, and employment rate (see Hwang and Quigley, 2006; Ceron and Suarez, 2006). Other studies have found that financial variables, such as interest rate, money and credit supply, are related to developments in housing prices (see, e.g., Kennedy and Andersen, 1994; Englund and Ioannides, 1997; Kasparova and White, 2001). Gerdesmeier et al. (2009) focused on the reasons behind episodes of asset price bust by studying sample data of 17 OECD industrialized countries from the first quarter of 1969 to the third quarter of 2008. Estimates validated through pooled probit model showed that domestic credit aggregates, nominal long-term interest rates, and investments are the best indicators of forecast busts up to eight quarters in advance. However, only a few studies have empirically examined the role of fundamental factors in explaining significant housing price swings under the labels “booms” and

"busts" (see Leung, 2004; Gilchrist and Leahy, 2002).

Though housing prices are important, delineating booms and busts is a difficult task that involves different degrees of arbitrariness. Similar to defining credit booms, defining housing booms considers three propositions, and assumes that these episodes occur when current asset prices are considerably out of line and exhibit an estimated historical reference level. First, Bordo and Jeanne (2002) detected a boom or a bust in an asset price series when the three-year moving average of growth rate falls outside a confidence interval, which is defined by referring to the historical first and second moments of the series. Interestingly, they reported that a regular feature of boom-bust episodes is the link between the fall in asset prices on the one hand and economic slowdown and financial and banking problems on the other hand.

Second, Borio and Lowe (2002) defined asset price booms as periods when real asset prices deviate from their respective trends through a specific threshold amount. They found that sustained credit growth, combined with large increases in asset prices, increases the probability of episodes of financial instability [see also Kaminsky and Reinhart (1999) for a similar definition of crisis and booms]. Third, Detken and Smets (2004) defined asset price booms as a period when real asset prices are greater than 10% beyond the estimated trend, which is calculated recursively using a one-sided Hodrick-Prescott (HP) filter with a high smoothing parameter. They found that high-cost booms among the 18 OECD countries are those in which real estate prices seem to exhibit rapid growth in real money and real credit stocks immediately before a boom and at its early stages (see also Goodhart et al., 2008).

Considering that the three approaches are similar in nature, housing price boom is defined in the current study as a persistent deviation of real housing prices from a smooth trend, which considers normal and squared trends.[7] Parallel to the two

[7]Agnello and Schuknecht (2011) use HP with a smoothing parameter of 10,000. We did not use cubic trend and HP method because of the small sample size for the housing price of each country.

definitions of credit boom, the two housing booms are defined as follows. Similar as those used in calculating credit boom, housing boom 1 (*HB*1) is the growth rate of the housing price index exceeding 15%. Housing boom 2 (*HB*2) is the deviation of the housing price index, which exceeds a certain threshold, and is the normal growth rate of the housing price index that exceeds 10%.

3.4 Definition of capital boom

Our capital is the inflow and outflow of the financial account in the balance of payments. Following Agosin and Huaita (2012), the financial boom (*FB*) is actual financial account (FA) exceeding its mean with one standard deviation as well as its financial exceeding deviation eabove its mean and is at least 5% of the GDP.

$$FB_{i,t} = \begin{cases} 1 \ \ if \ \ FA_{i,t} > \overline{FA_i} + \sigma_{F_i} \text{ and } FA_{i,t} / GDP_{i,t} > 5\% \\ 0 \qquad\qquad\qquad\qquad \text{otherwise} \end{cases} \tag{3}$$

where $FA_{i,t}$ is the value of the financial account of country *i* in year *t*, $\overline{FA_i}$ is its mean for the entire period and σ_{F_i} is its standard deviation. The normalization by *GDP* is used in order to detect surges that represent a large deviation with respect to the country's economic size.

4. Econometric Model

Our model extends the above current EWS model for banking crisis. Given that there is no consensus about the leading periods, we consider three booms *CB*, *HB* and *FB*, lagging one to six periods so that we can consider their prediction ability before the event erupts. Hence, our model for individual boom effect is set up as follows.

$$Prob(BC_{i,t} = 1|Z) = \alpha_0 + \sum_{j=1}^{6} \alpha_j CB_{i,t-j} + \sum_{j=1}^{6} \beta_j HB_{i,t-j} + \sum_{j=1}^{6} \theta_j FB_{i,t-j} + \delta_k Z_{k,i,t-1} + \varepsilon_{i,t} \tag{4}$$

where the subscript *i* and *t* denotes the country *i* at the time *t*. *BC* is the banking crisis dummy variable, which takes a value of one in the banking crises and zero otherwise. *CB* is the credit boom, *HB* is the house boom and *FB* is the capital boom. Z

is control variables; include GDP growth (*GDPG*), change of terms-of-trade (ΔTT), exchange depreciation rate (*Depreciation*), GDP per capita (*GDPPC*), interest rates (*Rrate*) and M2/reserves (*M2/FR*) and $\varepsilon_{i,t}$ is the error term. See Table 1 for detailed definitions.

In addition to the three individual booms on the right of the regression, we also consider the "twin boom effect", which takes the interaction of any two booms into account. Namely, the individual boom *CB*, *HB* and *FB* in Equation (4) are replaced by $CB \times HB$, $HB \times FB$ and $CB \times FB$. Similarly, we examine the "triple boom effect", which take the interaction of three booms into account at the same time and use the term $CB \times HB \times FB$ to replace the individual boom.

The lag length of one to six is based on the suggestion of our Table 2 (see Section 2), where we find that the booms occur more frequently before the 1998 and 2008 crisis one to six years early.

Our control variables are based on the studies of Demirguc-Kunt and Detragiache (2005), Davis and Karim (2008), Barrll, Davis and Liadze (2010) and more. For the simplicity, the selected control variables in this study are lagged for one period. Among them, a few studies (such as Buyukkaraback and Valev, 2010; Khan and Dewan, 2011; Khan, Khan and Dewan, 2013) have demonstrated that lower GDP growth and lower GDP per capita is separately associated with a higher probability of banking crisis. Demirgüc-Kunt and Detragiache (2002) and Tanveer and De Haan (2008) have found that a depreciation of the domestic currency and the increase in real interest rate would trigger banking crises, respectively. The results of some papers (such as Demirgüc-Kunt and Detragiache, 1997; Khan, Khan and Dewan, 2013) have shown that change in terms of trade would decrease the occurrence of a bank crisis. Several studies (such as Eichengreen and Arteta, 2002; Komulainen and Lukkarila, 2003; Angkinand, Sawangngoenyuang and Wihlborg, 2010) have suggested that

*M*2/*FR* is exposed to raise the probability of a banking crisis

5 Basic statists and empirical results

5.1 Data source and basic statistics.

Our sample consists of 49 countries[8] spanning the period of 1979–2013. Annual data are used. *Credit* (i.e., credit-to-GDP ratio) is collected from the International Monetary Fund and World Bank databases. *House* (i.e., housing price indices) is collected from three sources, which are the Bank of International Settlement, and OECD and the international House Price database of the Federal Reserve Bank of Dallas. Financial account (i.e., net sum of direct investment, portfolio investment and other investment) is collected from International Financial Statistics. All control variables are also collected from IFS. Because housing price starts from different sample period, our sample becomes unbalanced. Banking crisis is collected from Laeven and Valencia's (2013) systematic banking crisis definition by considering the first year that two conditions are met to be the year when the crisis became systemic.

Table 2 represents the number of booms and banking crises over year in our sample. Our results show that highest number of banking crises in 2008 when the sub-prime crisis outburst, followed by 1998 when the Asian financial crisis occurs. Around one to six years prior to these two years (i.e., 1998 and 2008), the number of credit boom identified is considerably higher than other periods, for example, the number of credit boom is 7, 3, 3, 4, 5 and 8 before 1998 and is 1, 4, 5, 9, 8 and 7 before 2008. The high number of credit booms in this case suggests a higher likelihood that credit boom predicts the crisis. Similarly, the number of housing boom continuously rises one to six years before the occurrence of these two years' banking crises. It is interesting to note that the number of capital boom reach the peak one to

[8] The 49 countries are 33 developed countries (Australia, Austria, Belgium, Canada, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Philippines, Portugal, Singapore, Slovak, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Kingdom and United States) and 16 non-developed countries (Brazil, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Poland, Romania, Russian, South Africa, Thailand and Turkey).

three years prior to the two banking crises. The years of each boom ahead of other years' banking crisis are also around one to six years. Hence, our lag length in the econometric model is selected to be from one to six.

We also examine the twin and triple booms cases. The number of them occurring jointly is considerably less than those of the individual booms. While it is uneasy to evaluate whether the twin and triple booms can provide early warning signal her, the twin boom of housing and capital booms occurs around one to two years before the crisis. The twin boom of credit boom and housing boom is around five years before the crisis. Furthermore, the triple booms occur one year ahead of 2008's sub-prime crisis.

Table 3 present the number of banking crises and three booms for each country Panels A and B present the results in advanced and emerging markets, respectively. The number of crises and credit booms in the emerging market is higher than that in the advanced market, whereas the number of housing and capital booms are higher in advanced than in emerging markets. For example, in emerging markets, Peru (8) and Turkey (9) have the highest number of credit boom of all countries, where the figures in the parenthesis are the number of credit boom. By contrast, the advanced countries of Australia (16), Denmark (16), Ireland (16), Spain (18) and UK (16) have the highest number of housing boom. Also, the advanced countries of Portugal (6), Singapore (6) and United States (6) have the highest number of capital boom. Hence, emerging market tend to encourage banks to make loans, whereas advanced countries tend to attract more foreign capital and boost their housing market.

In terms of Twin booms, credit and capital booms occur jointly in the emerging market more often than in the advanced market. By contrast, housing and capital booms as well as credit and housing booms occur less frequently in emerging market. The triple booms occur only in emerging market and not in the advanced market. et.

Table 4 presents the basic statistics of banking crisis, three booms and other explanatory variables. *House* has the highest growth (24.8%) and *Credit* has the

lowest growth (7.3%). Also, *House* and *Credit* exhibits the highest and loweset volatility (43.2% and 26.0%), respectively. Among other explanatory variables, the rule of law exhibits the highest volatility (23.331) and real interest rate has the lowest volatility (0.0715).

5.2 Estimated regression results: whole sample

Table 5 presents the estimation results using individual boom as the core explanatory variable. The panel logistic regression is used with the consideration of fixed effect. We choose the lag length from one to six based on our basic statistical results that reported in Table 2 (mainly based on the 1998 and 2008 crises). Our results show that significantly positive coefficients are found for *CB* at only lag period five (column 1), for *HB* at lag periods five and six (column 2) and for *FB* at lag periods two, four and five (column 3).

The intuition suggests that five year after larger credit growth is associated with a higher probability of a banking crisis. This is consistent with Reinhart and Rogoff's (2008, 2009) argument that over four years prior to a crisis a credit boom is likely to increase the probability of bank crisis. Also, five and six lag periods after housing boom tend to have a crisis. Banking crisis is likely to occur in the countries with higher growth in housing prices after five and six years. The result is in line with previous studies (see Reinhart and Rogoff, 2008; 2009; Shiller, 2005; 2008; Kindleberger and Aliber, 2005; Roy and Kemme, 2011) that presents a positive effect of housing boom before over four years on the likelihood of a bank crisis. Also, capital boom is often ahead of banking crisis from pre-crisis second year to fifth years. The results mean that a large capital inflow is positively and persistently associated with banking crises from pre-crisis second year to fifth years. The sustained prediction of capital boom on bank crisis may come from the continue impact of a

large capital inflow. The finding is new probably because the past studies have not used capital boom to investigate the crisis prediction. Also, it is possible that advanced and emerging markets on banking crises are mixed in total sample. We later compare the possible differences in advanced and emerging countries.

The coefficients of the control variables show the expected signs. Our result shows that the coefficient of GDP growth is significantly negative, which means that banking crisis is triggered when economic growth of a country is low. Meanwhile, the coefficient of GDP per capita is almost significantly negative, suggesting that banking crisis is likely to occur when real GDP per capita of a country is low. We also find that the coefficient of change in the nominal exchange rate is significantly positive, which denotes that a depreciation of the domestic currency would stimulate the occurrence of a bank crisis. Coefficients of *Rrate*, *M2/FR* and ΔTT show the expected signs but are statistically insignificance. Last, the coefficient of *Effective* among country governance variables is significantly negative, denoting that good government effectiveness will mitigate the probability of banking crises.

Table 6 presents the results of estimating "twin boom effect". The coefficients of the twin booms are significant for CB ×HB at lag 5; HB×FB at lags 1~5 and for CB×FB at lags 1, 2 and 5. Hence, housing and capital booms are more likely to lead banking crisis one to five year before the crisis. The sustained predictability of this twin booms can mainly result from the continue influence in a large capital inflow. However, credit boom together with other booms also lead bank crisis but the likelihood is smaller. Hence, to our surprise, credit boom may not immediately lead to banking crisis even though it happens with other boom. The first four years credit growth may cause economic growth rather than the crisis. Moreover, we can see from the coefficients that the power of predictability of twin booms is better than that of single boom.

The results of control variables in Table 7 remain the similar as those in Tables 5 and 6. Hence, we skip the report of them. Table 7 presents the results of triple booms. To our surprise, the coefficient is significantly positive at lag 1. Hence, banking crisis is likely to occur when three booms jointly take place one year earlier. We further find that the simultaneous occurrence of the three booms more largely and fast leads to the coming of banking crises than the occurrence of the single boom or twin booms.

5.3 EWS for OECD and non-OECD samples

We repeat our exercise for 33 OECD and 16 non-OECD samples. Using OECD countries as the sample, in Table 8, we find that credit boom becomes more effective in predicting banking crisis given that more lags are significant (2, 4, 5 and 6). Housing boom becomes ineffective in all lags and capital boom remain the same. Hence, the banking crisis is more likely to occur after credit boom but not housing boom in OECD countries. Capital boom has the equal leading effect in both types of countries.

Table 9 presents the twin booms in OECD countries. The interaction of CB with HB or FB with lags 3 or 2 tends to have strong prediction power. HB becomes effective when there is FB. FB is still effective in year lag 2. Because there is almost no simultaneous evidence in the three booms in the advanced countries by observing figure 2, we do not estimate the result of the triple booms in these countries.

Booms in non-OECD market are less effective given that most of the coefficients are insignificant. In Table 10, only lag 5 of CB and HB are significant and only lags 2 and 4 of FB are significant. Hence, single booms do not lead the crisis as those in non-OECD countries. In Table 11, when twin booms occur jointly, the EWS becomes more powerful for HB x FB and CB x FB. Lags 1, 2 and 4 are significant for HB x FB and lags 1, 3, 4, 5, 6 of CB x FB are significant. In Table 12, when triple booms occur,

lag 1 remains significant as results using the whole sample.

In sum, CB is the better EWS for banking crisis in OECD than non-OECD countries. By contrast, housing boom is a better EWS in emerging countries and capital boom is the same for two types of countries. Also, twin booms have roughly equal prediction power in both types of countries. Triple booms in the pre-crisis one year occurring only in the emerging countries largely and fast lead banking crisis.

5.4 Robust Testing CB2 and HB2.

We employ the definitions of CB2 and HB2 to examine the robustness test of our results. In Table 13, we find that CB2 becomes effective in predicting banking crisis given that significant lags are **more and quick (1 to 3)**. However, HB2 becomes ineffective in all lags. Hence, the warning signal of HB2 is weaker than that of HB1, but there is the contrary situation as comparing the warning signal of CB2 with that of CB1. Table 14 reports the twin booms of interacting with CB2 or HB2. The warning signal of CB2 x HB2 becomes quick with the significant lag 3. However, the prediction of HB2 x FB turns into non-persistent and slowly. Next, the EWS of CB2 x FB is the similar with that of CB1 x FB. Thus, the interaction of CB2 with HB2 tends to have strong predictability, while the interaction of HB2 with FB tends to have weak prediction power. In Table 15, when triple booms occur, we again demonstrate the EWS of the three booms on banking crises in the pre-crisis one year. Also, we consistently confirm that the simultaneous occurrence of the three booms will largely and fast lead to banking distress.

6. Conclusion

Our results show that credit boom, housing boom and capital boom exhibit varying degree of early warning signal on banking crisis one to six year by using 49

countries (33 OECD countries and 16 non-OECD countries). However, these results are not very satisfactory. Using the whole sample, contrary to most people thought that credit boom leads banking crisis in a short period, it is five years after the credit boom that banking crisis erupted. Although we do not have an exact definition about the optimal leading years as an effective EWS, the warning of five year ago may be an ineffective signal since few governments will actively take action in preparing it in such an early time. Furthermore, in modern democratic society, the presidential election takes place every four to six years. Even though there may be a crisis five years later, and the ruling party probably will not mitigate credit boom by adopting the tighten policy. Instead, the ruling party often adopts the easy policy to win the election. We echo Kaminsky and Reinhard's (1998) argument that EWS should be less than two years. Hence, in terms of leading time, whether credit boom per se is a good EWS deserves future study. Housing boom has the same long year ago prediction problem. Capital inflow provides the signal at lag years two, four and five persistently before five years are the better EWS in terms of leading time.

Our study also considers twin and triple booms cases which are rarely discussed in the literature. In terms of twin booms, the simultaneous occurrence of credit and housing booms can predict the banking crises again in pre-crisis fifth year. However, the leading periods are much shortened when capital boom takes place simultaneously. The joint occurrence of capital booms with other two booms signals banking crises persistently from pre-crisis one to fifth years. Surprisingly, banking crisis occurs fast one year after the triple boom. Hence, three booms occur jointly have the most effective early warning in terms of leading time and power of predictability. This phenomenon does not change in the different definitions of CB and HB. The past studies do not pay too much attention to how early of the warning periods.

We also find that the warning signal of different booms is not the same in

relative rich and poor countries. Credit boom is more effective in sending early warning for OECD than non-OECD countries. Especially, credit boom plays no role in non-OECD countries. By contrast, housing boom is more effective in non-OECD than OECD countries and capital boom has the same warning power in these two types of countries. Triple booms in the non-OECD countries largely and fast result in banking crisis. Hence, EWS of booms may have strong country effect and future studies can purse this issue.

Reference

1. Acharya, V. V., and M. Richardson, (2010) "Restoring Financial Stability: How to Repair a Failed System," *John Wiley & Sons, New York NY, 2010.*
2. Arteta, C., and B. Eichengreen, (2002) "Banking Crises in Emerging Markets: Presumptions and Evidence," *Blejer, M., Skreb, M. (Eds.), Financial Policies in Emerging Markets. MIT Press, Cambridge, MA.*
3. Agnello, L., and L. Schuknecht, (2011) "Booms and Busts in Housing Markets: Determinants and implications," *Journal of Housing Economics,* 20, pp. 171-190.
4. Agosin, M. R., and F. Huaita, (2012) "Overreaction in Capital Flows to Emerging Markets: Booms and Sudden Stops," *Journal of International Money and Finance,* 31, pp. 1140-1155.
5. Barajas, A., Dell'Ariccia, G., and A. Levchenko, (2007) "Credit Booms: The Good, The Bad and The Ugly," *IMF Working paper*.
6. Baker, D., (2008) "The Housing Bubble and The Financial Crisis," *Real-world economics review,* 46, pp. 73-81.
7. Barrel, R., Davis, E. P., Karim D., and I. Liadze, (2010) "Bank Regulation, Property Prices and Early Warning Systems," *Journal of Banking and Finance* 34, pp. 2255–2264.
8. Bordo, M. D. and O. Jeanne, (2002) "Boom-busts in Asset Prices, Economic Instability and Monetary Policy," *International Monetary Fund (IMF) and CEPR Discussion Paper No. 3398.*
9. Borio, C. and P. Lowe, (2002) "Asset Prices, Financial and Monetary Stability: Exploring The Nexus," *BIS Working paper.*
10. Brunnermeier, M. K. and M., Oehmke (2012) "Bubbles, Financial Crisis, and Systemic Risk," NBER Working Paper, 18398.

11. Bunda, I., and M. Ca'Zorzi, (2010), "Signals from Housing and Lending Booms," *Emerging Markets Review*, 11, pp.1-20
12. Büyükkarabacak, B. and N. T. Valev, (2010) "The Role of Household and Business Credit in Banking Crises," *Journal of Banking & Finance*, 34, pp. 1247-1256.
13. Caballero, J., (2010) "Do Surges in International Capital Flows Influence the Likelihood of Banking Crises?," *University of California.*
14. Ceron, J. A., and J. Suarez, (2006) "Hot and Cold Housing Markets: International Evidence," *CEPR Discussion Papers* No. 5411.
15. Claessens, S., and M. A. Kose, (2013) Financial Crises: Explanations, Types, and
    Implications, IMF Working Paper.
16. Dell'Ariccia, G., Igan, D., Laeven, L., Tong, H., Bakker, B. and J. Vandenbussche, (2012) "Policies for Macrofinancial Stability: How to Deal with Credit Booms," *Staff Discussion Notes No. 12/6.*
17. Demirgu¨c.-Kunt, A., and E. Detragiache, (1997) "The Determinants of Banking Crises: Evidence from Developing and Developed Countries," IMF Working Paper.
18. Detken, C. and F. Smets, (2004) "Asset Price Booms and Monetary Policy," *ECB Working Paper Series*, No. 364 (Frankfurt: European Central Bank).
19. Englund, P., and Y. M. Ioannides, (1997) "House Price Dynamics: an International Empirical Perspective," *Journal of Housing Economics* 6, pp. 119–136.
20. Furceri, D., Guichard, S., and E. Rusticelli, (2012) "Episodes of Large Capital Inflows, Banking and Currency Crises, and Sudden Stops," *International Finance,* 15(1), pp.1-35.
21. Gerdesmeier, D., Reimers, H. E., and B. Roffia, (2009) "Asset Price Misalignments and the Role of Money and Credit," *ECB Working Paper.*
22. Gilchrist, S., and J. V. Leahy, (2002) "Monetary policy and asset prices," *Journal of Monetary Economics*, 49 (1), 75–97.
23. Goodhart, C., and B. Hofmann, (2008) "House Prices, Money, Credit and the Macroeconomy," *ECB Working Paper Series*, No 888.
24. Gourinchas, P. O., Landerretche, O., and R. Valdés, (2001) "Lending Booms: Latin America and the World," *Economia* 1 (2), pp. 47–99.
25. Hamdi, H., and N. B. Jlassi, (2014) "Financial Liberalization, Disaggregated Capital Flows and Banking Crisis: Evidence from Developing Countries," *Economic Modelling*, 41, pp. 124-132
26. Hilbers, P., Otker-Robe, I., Pazarbasioglu, C., and G. Johnsen, (2005) "Assessing

and Managing Rapid Credit Growth and the Role of Supervisory and Prudential Policies," *IMF Working Paper.*

27. Honohan, P., (1997) "Banking system failures in developing and transition countries: diagnosis and prediction," *BIS Working Papers.*
28. Hwang, M., and J. Quigley, (2006) "Economic Fundamentals in Local Housing Markets: Evidence from US Metropolitan Regions," *Journal of Regional Science* 46 (3), pp. 425–453.
29. Kaminsky, G., and C. Reinhart, (1999) "The Twin Crises: The Causes and Banking and Balance-of-Payments Problems," *American Economic Review*, 89, pp. 473–500.
30. Kasparova, D., and M. White, (2001) "The Responsiveness of House Prices to Macroeconomic Forces: a Cross-country Comparison," *European Journal of Housing Policy*, 1 (3), pp. 385–416.
31. Kennedy, N., and P. Andersen, (1994) "Housing Saving and The Real House Prices: an International Prospective," *BIS Working Paper.*
32. Kindleberger, C. P. and R. Z. Aliber, (2005) "Manias, Panics and Crashes: A History of Financial Crises (5th ed.)," *Hoboken, NJ: John Wiley & Sons.*
33. Levine, R., Loayza N., and T. Beck, (2000) "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics*, 46, pp. 31–77.
34. Leung, C., (2004) "Macroeconomics and Housing: A Review of The Literature," *Journal of Housing Economics*, 13, pp. 249–267.
35. Mendoza, Enrique, and Marco Terrones, (2012) "An Anatomy of Credit Booms and Their Demise," *Journal Econom á Chilena* (The Chilean Economy), Central Bank of Chile, 15(2), 4-32.
36. Ottens, D., Lambregts, E. and S. Poelhekke, (2005) "Credit Booms in Emerging Market Economies: A Recipe for Banking Crises?," *DNB Working Papers.*
37. Reinhart, C. M., and V. R. Reinhart (2009), "Capital Flow Bonanzas: An Encompassing View of the Past and Present," *NBER Macroeconomics Annual, University of Chicago Press.*
38. Reinhart, C. M., and K. S. Rogoff, (2008) "Is The 2007 US Sub-prime Crisis so Different? An International Historical Comparison," *American Economic Review Papers and Proceedings*, 98(2), pp. 339–344.
39. Reinhart, C. M., and K. S. Rogoff, (2009) "This Time is Different: Eight Centuries of Financial Folly. Princeton," *NJ: Princeton University Press.*
40. Roy, S., and D. M. Kemme, (2011) "What is Really Common in The Run-up to Banking Crises?," *Economics Letters*, 113, pp.211–214.

41. Reinhart, C. M., and K. S. Rogoff, (2008) "Banking Crises: An Equal Opportunity Menace," *NBER Working Paper.*

42. Reinhart, C. M., and K. S. Rogoff, (2013) "Banking Crises: An Equal Opportunity Menace," *Journal of Banking & Finance* 37, pp. 4557-4573.

43. Roy, S., and D.M. Kemme, (2012) "Causes of Banking Crises: Deregulation, Credit Booms and Asset Bubbles, Then and Now," *International Review of Economics and Finance*, 24, pp. 270-294.

44. Shen et al., 2015, Does housing boom lead to credit boom or is it the other way around?

45. Shen and Lee, (2006), "Same Financial Development Yet Different Economic Growth — Why?," *Journal of Money, Credit, and Banking*, 38(7)

46. Shen, C. H., Lee C. C., and C. C. Lee, (2010) "What Makes International Capital Flows Promote Economic Growth? An International Cross-country Analysis," *Scottish Journal of Political Economy*, 57(5).

47. Shiller, R. J., (2005) "Irrational Exuberance (2nd ed.)," *Princeton, NJ: Princeton University Press (Preface & Chapter 2).*

48. Shiller, R. J., (2008), "The Subprime Solution: How Today's Global Financial Crisis Happened and What to do about it?" *Princeton, NJ: Princeton University Press (Chapters2–3).*

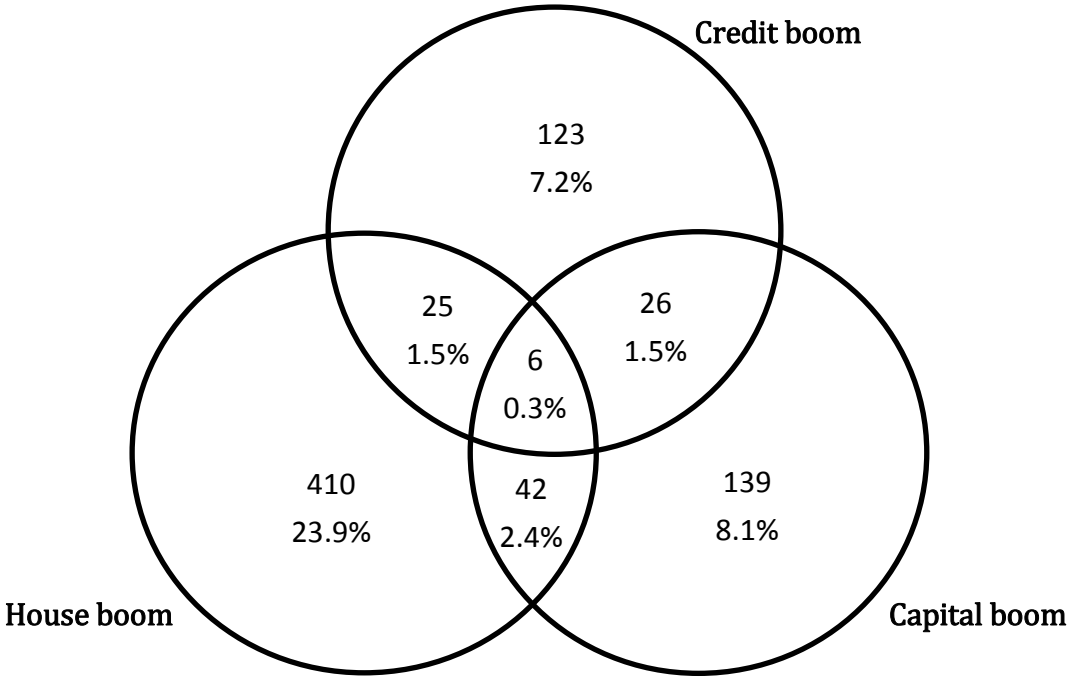


Figure 1. Total sample
(Figure indicates the frequency of (simultaneous) credit, house, and capital booms, including the total number and fraction (in percentage) of such booms)

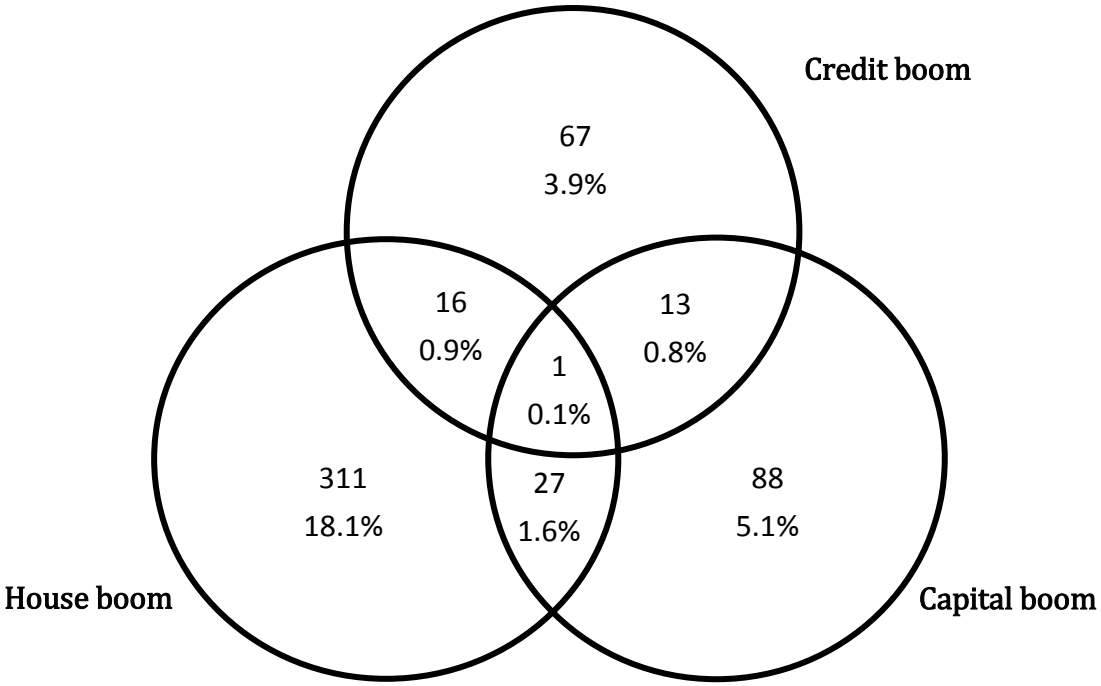


Figure 2. OECD countries sample
(Figure indicates the frequency of (simultaneous) credit, house, and capital booms, including the total OECD countries number and fraction (in percentage) of such booms)

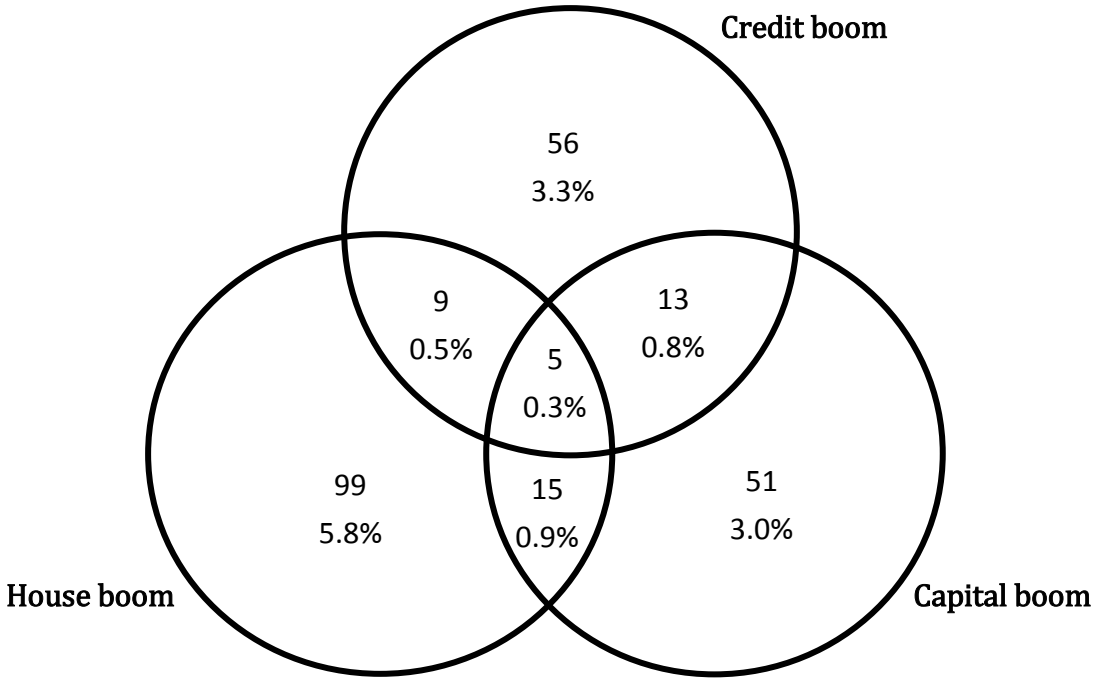


Figure 3. Emerging countries sample
(Figure indicates the frequency of (simultaneous) credit, house, and capital booms, including the total emerging countries number and fraction (in percentage) of such booms)

Table 1. Variable definitions

Variable	Definition	Formula	Source
BC	Bank Crisis	The onset of banking crisis dummy, which is equal to 1 in a first year of each banking crisis episode and 0 otherwise.	Laeven and Valencia (2013)
FA	Financial account	Net sum of direct investment, portfolio investment and other investment.	IFS
FB	Capital boom	Financial boom is based on the financial account in balance of payment. $FB_{i,t} = \begin{cases} 1 \text{ if } FA_{i,t} > \overline{FA_i} + \sigma_{F_i} \text{ and } FA_{i,t} / GDP_{i,t} > 5\% \\ 0 \quad \text{otherwise} \end{cases}$ where $FA_{i,t}$ is the value of the financial account of country *i* in year *t*. $\overline{FA_i}$ is its mean for the entire period and σ_{F_i} is its standard deviation.	Agosin and Huaita (2012) Calvo et al. (2004)
CB	Credit boom	Definition 1: $CB = 1$ if *Credit growth rate* >15%,0 otherwise Definition 2: $CB = 1$ if $\varepsilon > \mu + 1.65 \times \sigma$, 0 otherwise $\textit{Credit growth rate} = \frac{\textit{Credit}_t - \textit{Credit}_{t-1}}{\textit{Credit}_{t-1}} \times 100\%$	IMF
HB	Housing boom	Definition 1: $HB = 1$ if *House growth rate* >15%,0 otherwise Definition 2: $HB = 1$ if $\varepsilon > \mu + 1.65 \times \sigma$, 0 otherwise $\textit{House growth rate} = \frac{\textit{House}_t - \textit{House}_{t-1}}{\textit{House}_{t-1}} \times 100\%$	CEIC, BIS, OECD
Twin boom	Twin booms	$= FB \times CB$ ($CB \times HB$ or $FB \times HB$)	CEIC, BIS, OECD
Triple-booms	Three booms	$= FB \times CB \times HB$	CEIC, BIS, OECD
Control variables			
GDPG	GDP growth	Annual percentage change of real GDP	IFS
Depreciation	Depreciation	Rate of change of the nominal exchange rate vs. the US dollar. An increase indicates a depreciation of the domestic currency	IFS
ΔTT	Terms of trade	Rate of change in the terms of trade of goods and services	IFS
M2/FR	M2/Foreign Reserves	Ratio of M2 to foreign exchange reserves of the Central Bank	IFS
Rrate	Real interest rate	Lending interest rate adjusted for inflation as measured by the GDP deflator	IFS
GDPPC	GDP/ population	Ratio of GDP (in US Dollar) to total population	IFS
Effective	Government effectiveness	Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	WGI
RuleLaw	Regulatory quality	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	WGI
Corrupt	Control of corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	WGI

Note: BIS: Bank of International Settlement, IMF: International Monetary Fund, CEIC: China Entrepreneur Investment Club, OECD: Organization for Economic Co-operation and Development and WGI: Worldwide Governance Indicators.

Table 2 Number of crises and booms over years

Year	*BC*	*CB*	*HB*	*FB*	*CB*×*FB*	*HB*×*FB*	*CB*×*HB*	*CB*×*HB*×*FB*
1979	1	0	0	0	0	0	0	0
1980	1	2	2	3	1	0	0	0
1981	3	4	9	4	1	0	1	0
1982	4	4	10	2	0	0	0	0
1983	6	1	17	1	0	0	0	0
1984	4	1	12	0	0	0	0	0
1985	3	3	14	0	0	0	2	0
1986	1	4	9	2	0	0	3	0
1987	0	0	13	5	0	1	0	0
1988	0	4	4	1	0	1	0	0
1989	0	6	7	1	0	0	1	0
1990	2	2	9	4	0	0	0	0
1991	6	1	9	2	0	0	0	0
1992	9	7	16	2	1	1	0	0
1993	8	3	11	4	0	0	0	0
1994	7	3	15	1	1	0	0	0
1995	5	4	7	6	1	0	0	0
1996	3	5	17	6	1	3	0	0
1997	9	8	11	5	2	1	0	0
1998	13	3	14	1	0	0	0	0
1999	8	4	9	1	0	1	3	0
2000	8	4	6	2	0	1	0	0
2001	6	7	11	0	0	0	3	0
2002	1	1	14	4	0	1	0	0
2003	0	4	13	1	0	0	2	0
2004	0	5	11	4	0	0	1	0
2005	0	9	16	10	4	1	2	0
2006	0	8	13	12	4	1	1	0
2007	2	7	16	18	6	7	3	3
2008	18	3	11	15	2	5	2	2
2009	0	3	28	9	0	8	1	0
2010	0	3	11	7	1	3	1	0
2011	0	0	14	4	0	1	0	0
2012	0	0	29	5	0	5	0	0
2013	0	2	18	2	1	2	1	1

Note:

1. *BC* is the bank crisis, *CB* is the Credit boom based on first definition of credit boom, *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom.
2. Twin boom is *CB*×*HB* , *CB*×*FB* or *HB*×*FB* . They are also dummy variables.
3. Triple boom is *CB*×*HB*×*FB* is the dummy variable when credit, housing and capital booms occur jointly and is zero otherwise.

Table 3. Number of booms by 49 countries

Country	*BC*	*CB*	*HB*	*FB*	*CB×FB*	*HB×FB*	*CB×HB*	*CB×HB×FB*
Panel A OECD Markets								
Australia	0	2	16	5	0	1	2	0
Austria	1	0	3	3	0	0	0	0
Belgium	1	2	9	0	0	0	0	0
Canada	0	2	15	1	1	0	1	0
Czech	5	1	0	2	0	0	0	0
Denmark	1	2	16	3	0	1	1	0
Estonia	3	5	1	3	1	1	0	0
Finland	5	0	15	3	0	2	0	0
France	1	0	12	0	0	0	0	0
Germany	1	0	15	0	0	0	0	0
Greece	1	3	8	4	0	1	3	0
Hong Kong	0	1	12	1	0	1	0	0
Iceland	1	8	8	2	1	0	2	0
Ireland	1	4	16	3	0	2	3	0
Israel	1	0	10	5	0	3	0	0
Italy	1	1	14	2	0	1	1	0
Japan	5	0	15	0	0	0	0	0
Luxembourg	1	2	3	0	0	0	0	0
Netherlands	1	1	15	0	0	0	0	0
New Zealand	0	1	15	5	0	1	0	0
Norway	3	2	15	3	0	1	2	0
Portugal	1	2	12	6	0	3	0	0
Singapore	0	2	3	6	0	0	0	0
Slovak	5	4	3	4	1	1	0	0
Slovenia	2	5	1	3	1	0	0	0
Spain	4	1	18	5	1	3	0	0
Sweden	6	2	13	4	0	1	0	0
Switzerland	1	1	14	2	0	2	0	0
United Kingdom	1	2	16	1	0	0	2	0
United States	2	0	10	6	0	1	0	0
Summary	55	56	323	82	6	26	17	0
Panel B Emerging Markets								
Brazil	9	4	6	1	1	1	1	1
Chile	5	2	4	4	1	1	0	0
China	1	1	5	0	0	0	1	0
Colombia	4	1	13	2	0	2	0	0
Hungary	6	2	2	5	0	0	0	0
India	1	0	3	1	0	0	0	0
Indonesia	5	5	3	2	0	0	0	0
Korea	2	1	11	1	0	1	1	0
Malaysia	3	6	3	4	1	0	0	0
Mexico	8	6	4	2	0	0	0	0
Peru	1	9	8	6	3	3	2	2
Philippines	9	5	2	4	3	0	0	0
Poland	3	3	4	5	2	2	1	1
Romania	3	7	2	5	3	0	0	0
Russian	2	6	8	1	1	1	3	1
South Africa	0	0	13	5	0	3	0	0
Taiwan	1	0	3	2	0	0	0	0
Thailand	5	3	7	5	1	1	0	0
Turkey	5	8	2	7	4	2	1	1
Summary	73	69	103	62	20	17	10	6

Note:

1. *BC* is the bank crisis, *CB* is the Credit boom based on first definition of credit boom, *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom. Twin booms are *CB×HB*, C*B×FB* or *HB×FB* and are the dummy variable when any two booms occur jointly and is zero otherwise. Triple boom is *CB×HB×FB* when credit, housing and capital booms occur jointly.

Table 4 Basic statistics of banking crisis, three booms and explanatory variables

Series	Mean	Std Error	Minimum	Maximum
BC	0.075	0.263	0.000	1.000
CB	0.073	0.260	0.000	1.000
HB	0.248	0.432	0.000	1.000
FB	0.084	0.277	0.000	1.000
GDPG	11.115	13.103	-7.964	120.090
Depreciation	3.816	14.393	-30.464	91.629
Rrate	0.116	0.0715	0.005	0.420
GDPPC	27.851	3.161	9.210	36.648
M2/FR	0.793	0.752	0.000	6.690
ΔTT	0.213	15.795	-139.820	324.600
Effective	78.460	18.698	21.951	100.000
RuleLaw	74.697	23.331	13.397	100.000
Corrupt	75.206	22.640	8.293	100.000

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.

2. N=49 and T= 35 (1979–2013).

Table 5. EWS of booms on banking crisis: individual boom using whole sample

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1}$	0.109	(0.20)					0.204	(0.35)
$CB_{i,t-2}$	0.402	(0.82)					0.288	(0.55)
$CB_{i,t-3}$	0.639	(1.40)					0.404	(0.83)
$CB_{i,t-4}$	0.341	(0.74)					-0.0250	(-0.05)
$CB_{i,t-5}$	1.418***	(3.47)					1.049**	(2.33)
$CB_{i,t-6}$	0.499	(1.12)					-0.111	(-0.23)
$HB_{i,t-1}$			-0.367	(-1.00)			-0.579	(-1.43)
$HB_{i,t-2}$			-0.493	(-1.28)			-0.711*	(-1.71)
$HB_{i,t-3}$			-0.320	(-0.85)			-0.390	(-0.96)
$HB_{i,t-4}$			-0.0288	(-0.08)			0.0581	(0.14)
$HB_{i,t-5}$			0.745**	(2.01)			0.703*	(1.75)
$HB_{i,t-6}$			0.824**	(2.24)			0.724*	(1.82)
$FB_{i,t-1}$					0.881**	(2.12)	0.683	(1.50)
$FB_{i,t-2}$					1.035**	(2.54)	1.037**	(2.38)
$FB_{i,t-3}$					0.617	(1.44)	0.418	(0.90)
$FB_{i,t-4}$					1.059**	(2.52)	1.030**	(2.38)
$FB_{i,t-5}$					0.994**	(2.13)	0.963**	(1.97)
$FB_{i,t-6}$					0.102	(0.20)	0.420	(0.81)
GDPG	-0.0229***	(-2.71)	-0.0225***	(-2.60)	-0.0164*	(-1.89)	-0.0171*	(-1.87)
Depreciation	0.0183**	(2.28)	0.0180**	(2.22)	0.0127	(1.52)	0.0126	(1.46)
Rrate	0.232	(0.84)	0.179	(0.64)	0.163	(0.59)	0.215	(0.75)
GDPPC	-0.101	(-0.68)	-0.230	(-1.58)	-0.358**	(-2.34)	-0.290*	(-1.74)
M2/FR	0.890	(1.29)	1.036	(1.44)	0.809	(1.11)	0.690	(0.92)
ΔTT	0.00138	(0.23)	0.000917	(0.13)	0.000549	(0.11)	0.000312	(0.05)
Effective	-0.132***	(-3.02)	-0.130***	(-2.97)	-0.0972**	(-2.18)	-0.107**	(-2.32)
RuleLaw	-0.0677	(-1.51)	-0.0572	(-1.31)	-0.0673	(-1.43)	-0.0748	(-1.54)
Corrupt	0.0248	(0.63)	0.0245	(0.66)	0.0403	(0.98)	0.0259	(0.60)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. t values in parentheses.

Table 6. EWS of booms on banking crisis: twin boom using whole sample

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1}$	0.784	(0.60)					0.392	(0.27)
$CB_{i,t-2} \times HB_{i,t-2}$	0.693	(0.51)					0.259	(0.17)
$CB_{i,t-3} \times HB_{i,t-3}$	.391	(1.12)					1.402	(1.00)
$CB_{i,t-4} \times HB_{i,t-4}$	-13.50	(-0.02)					-14.94	(-0.02)
$CB_{i,t-5} \times HB_{i,t-5}$	2.688***	(2.95)					1.812*	(1.80)
$CB_{i,t-6} \times HB_{i,t-6}$	1.488	(1.43)					0.660	(0.58)
$HB_{i,t-1} \times FB_{i,t-1}$			2.095***	(3.24)			1.981***	(2.75)
$HB_{i,t-2} \times FB_{i,t-2}$			1.275*	(1.70)			1.067	(1.27)
$HB_{i,t-3} \times FB_{i,t-3}$			1.494*	(1.93)			0.933	(1.08)
$HB_{i,t-4} \times FB_{i,t-4}$			1.619**	(2.02)			1.509*	(1.79)
$HB_{i,t-5} \times FB_{i,t-5}$			2.074**	(2.53)			1.605*	(1.80)
$HB_{i,t-6} \times FB_{i,t-6}$			0.373	(0.33)			0.366	(0.32)
$CB_{i,t-1} \times FB_{i,t-1}$					1.935**	(2.30)	1.729**	(1.98)
$CB_{i,t-2} \times FB_{i,t-2}$					1.900**	(2.13)	1.804**	(2.05)
$CB_{i,t-3} \times FB_{i,t-3}$					1.427	(1.50)	1.005	(1.01)
$CB_{i,t-4} \times FB_{i,t-4}$					1.301	(1.26)	0.942	(0.90)
$CB_{i,t-5} \times FB_{i,t-5}$					2.495***	(2.82)	1.799**	(1.98)
$CB_{i,t-6} \times FB_{i,t-6}$					1.401	(1.41)	1.227	(1.23)
GDPG	-0.0241***	(-2.83)	-0.0210**	(-2.51)	-0.0197**	(-2.29)	-0.0217**	(-2.43)
Depreciation	0.0201**	(2.47)	0.0165**	(2.10)	0.0161**	(1.99)	0.0177**	(2.12)
Rrate	0.123	(0.44)	0.427	(1.50)	0.154	(0.56)	0.369	(1.27)
GDPPC	-0.249*	(-1.75)	-0.292**	(-2.01)	-0.255*	(-1.75)	-0.354**	(-2.29)
M2/FR	1.098	(1.55)	1.120	(1.52)	0.764	(1.05)	0.700	(0.91)
ΔTT	0.00216	(0.36)	0.00387	(0.68)	0.00144	(0.24)	0.00338	(0.56)
Effective	-0.156***	(-3.47)	-0.121***	(-2.80)	-0.140***	(-3.12)	-0.166***	(-3.31)
RuleLaw	-0.0627	(-1.41)	-0.0837*	(-1.87)	-0.0504	(-1.08)	-0.0853*	(-1.69)
Corrupt	0.0361	(0.96)	0.0401	(1.06)	0.00860	(0.21)	0.0236	(0.54)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. t values in parentheses.

Table 7. EWS of booms on banking crisis: triple boom using whole sample

	$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1} \times FB_{i,t-1}$	3.789**	(2.31)	3.583**	(2.07)
$CB_{i,t-2} \times HB_{i,t-2} \times FB_{i,t-2}$			-11.97	(-0.00)
$CB_{i,t-3} \times HB_{i,t-3} \times FB_{i,t-3}$			-11.77	(-0.01)
$CB_{i,t-4} \times HB_{i,t-4} \times FB_{i,t-4}$			-12.01	(-0.00)
$CB_{i,t-5} \times HB_{i,t-5} \times FB_{i,t-5}$			-12.16	(-0.01)
$CB_{i,t-6} \times HB_{i,t-6} \times FB_{i,t-6}$			-11.97	(-0.01)
GDPG	-0.0235***	(-2.97)	-0.0235***	(-2.78)
Depreciation	0.0192**	(2.54)	0.0194**	(2.40)
Rrate	0.262	(0.95)	0.132	(0.48)
GDPPC	-0.232**	(-1.98)	-0.218	(-1.56)
M2/FR	0.916	(1.46)	1.180*	(1.68)
ΔTT	0.00221	(0.36)	0.00175	(0.29)
Effective	-0.120***	(-2.86)	-0.132***	(-3.09)
RuleLaw	-0.0552	(-1.28)	-0.0449	(-1.01)
Corrupt	0.0302	(0.83)	0.0286	(0.77)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 8. EWS of booms on banking crisis: individual boom using 33 OECD countries

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1}$	-0.478	(-0.50)					-0.371	(-0.37)
$CB_{i,t-2}$	1.653**	(2.12)					1.388*	(1.66)
$CB_{i,t-3}$	0.974	(1.28)					1.126	(1.32)
$CB_{i,t-4}$	1.291*	(1.66)					0.772	(0.85)
$CB_{i,t-5}$	1.625**	(2.09)					1.707**	(2.05)
$CB_{i,t-6}$	1.577*	(1.89)					0.832	(0.88)
$HB_{i,t-1}$			-0.270	(-0.60)			-0.611	(-1.15)
$HB_{i,t-2}$			-0.615	(-1.28)			-0.985*	(-1.73)
$HB_{i,t-3}$			-0.506	(-1.07)			-0.653	(-1.20)
$HB_{i,t-4}$			-0.455	(-0.95)			-0.486	(-0.85)
$HB_{i,t-5}$			0.505	(1.13)			0.466	(0.86)
$HB_{i,t-6}$			0.677	(1.57)			0.512	(1.00)
$FB_{i,t-1}$					1.108**	(2.02)	0.606	(0.95)
$FB_{i,t-2}$					1.210**	(2.24)	0.857	(1.30)
$FB_{i,t-3}$					0.694	(1.26)	0.0139	(0.02)
$FB_{i,t-4}$					1.005*	(1.80)	1.034	(1.59)
$FB_{i,t-5}$					1.383**	(2.25)	1.452**	(2.09)
$FB_{i,t-6}$					0.0693	(0.10)	0.665	(0.87)
GDPG	-0.0252	(-1.60)	-0.0339**	(-2.21)	-0.0259	(-1.63)	-0.0239	(-1.33)
Depreciation	0.0184	(1.17)	0.0273*	(1.78)	0.0200	(1.27)	0.0162	(0.90)
Rrate	0.0501	(0.10)	-0.0224	(-0.05)	-0.0993	(-0.20)	-0.116	(-0.18)
GDPPC	0.245	(0.68)	0.152	(0.47)	-0.195	(-0.51)	0.0487	(0.10)
M2/FR	1.259	(1.34)	1.790*	(1.80)	1.737	(1.63)	1.665	(1.42)
ΔTT	-0.00228	(-0.30)	-0.00302	(-0.39)	-0.00270	(-0.45)	-0.00407	(-0.56)
Effective	-0.360***	(-3.91)	-0.287***	(-3.54)	-0.325***	(-3.55)	-0.446***	(-3.92)
RuleLaw	-0.0164	(-0.18)	-0.0241	(-0.31)	0.0155	(0.17)	0.0261	(0.25)
Corrupt	0.0836	(0.89)	0.0576	(0.91)	0.0202	(0.26)	0.0830	(0.79)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=33 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 9. EWS of booms on banking crisis: twin boom using 33 OECD countries

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1}$	-14.26	(-0.01)					-13.00	(-0.00)
$CB_{i,t-2} \times HB_{i,t-2}$	-14.61	(-0.01)					-14.72	(-0.01)
$CB_{i,t-3} \times HB_{i,t-3}$	3.495**	(2.36)					3.797**	(1.96)
$CB_{i,t-4} \times HB_{i,t-4}$	-15.49	(-0.01)					-16.17	(-0.01)
$CB_{i,t-5} \times HB_{i,t-5}$	2.776	(1.62)					3.107	(1.36)
$CB_{i,t-6} \times HB_{i,t-6}$	2.898**	(2.19)					3.282*	(1.95)
$HB_{i,t-1} \times FB_{i,t-1}$			1.303*	(1.70)			1.537*	(1.88)
$HB_{i,t-2} \times FB_{i,t-2}$			0.431	(0.47)			0.0455	(0.04)
$HB_{i,t-3} \times FB_{i,t-3}$			0.881	(0.97)			-0.0453	(-0.04)
$HB_{i,t-4} \times FB_{i,t-4}$			1.094	(1.19)			0.675	(0.65)
$HB_{i,t-5} \times FB_{i,t-5}$			2.339**	(2.43)			2.856***	(2.66)
$HB_{i,t-6} \times FB_{i,t-6}$			-0.0294	(-0.02)			-0.0761	(-0.06)
$CB_{i,t-1} \times FB_{i,t-1}$					1.441	(1.16)	1.941	(1.45)
$CB_{i,t-2} \times FB_{i,t-2}$					3.565***	(2.73)	2.956**	(2.32)
$CB_{i,t-3} \times FB_{i,t-3}$					0.660	(0.42)	0.705	(0.45)
$CB_{i,t-4} \times FB_{i,t-4}$					1.183	(0.89)	1.583	(1.00)
$CB_{i,t-5} \times FB_{i,t-5}$					1.888	(0.97)	2.106	(0.66)
$CB_{i,t-6} \times FB_{i,t-6}$					-0.305	(-0.14)	-0.380	(-0.11)
GDPG	-0.0404***	(-2.70)	-0.0318**	(-2.12)	-0.0324**	(-2.19)	-0.0416**	(-2.53)
Depreciation	0.0324**	(2.21)	0.0261*	(1.76)	0.0264*	(1.80)	0.0359**	(2.22)
Rrate	-0.000619	(-0.00)	0.120	(0.24)	-0.0560	(-0.12)	-0.0899	(-0.17)
GDPPC	0.210	(0.57)	0.0149	(0.05)	-0.0475	(-0.14)	-0.224	(-0.53)
M2/FR	1.974*	(1.93)	1.847*	(1.92)	1.399	(1.37)	1.548	(1.43)
ΔTT	-0.00202	(-0.29)	-0.000143	(-0.02)	-0.00335	(-0.44)	-0.00153	(-0.19)
Effective	-0.326***	(-3.74)	-0.261***	(-3.29)	-0.345***	(-3.74)	-0.429***	(-3.85)
RuleLaw	-0.0361	(-0.44)	-0.0196	(-0.24)	0.00825	(0.09)	0.0143	(0.14)
Corrupt	0.0672	(0.98)	0.0518	(0.80)	0.00558	(0.07)	-0.0107	(-0.12)

Note:
1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. Twin boom are *CB*×*HB*, *CB*×*FB* or *HB*×*FB* and are the dummy variable when any two booms occur jointly and is zero otherwise.
3. This is a balanced panel data model with N=33 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
4. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. t values in parentheses.

Table 10. EWS of booms on banking crisis: individual boom using 16 emerging countries

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1}$	0.361	(0.47)					1.202	(1.39)
$CB_{i,t-2}$	-0.658	(-0.79)					-0.490	(-0.54)
$CB_{i,t-3}$	0.229	(0.34)					-0.102	(-0.13)
$CB_{i,t-4}$	-0.641	(-0.86)					-1.513	(-1.56)
$CB_{i,t-5}$	1.272**	(2.20)					0.581	(0.76)
$CB_{i,t-6}$	0.145	(0.23)					-0.721	(-0.90)
$HB_{i,t-1}$			-1.089	(-1.44)			-1.847*	(-1.86)
$HB_{i,t-2}$			-0.699	(-0.86)			-0.874	(-0.97)
$HB_{i,t-3}$			-0.290	(-0.40)			-0.361	(-0.44)
$HB_{i,t-4}$			0.721	(0.97)			1.039	(1.26)
$HB_{i,t-5}$			1.637**	(2.13)			1.721*	(1.89)
$HB_{i,t-6}$			1.318	(1.64)			1.469	(1.49)
$FB_{i,t-1}$					1.008	(1.37)	1.074	(1.24)
$FB_{i,t-2}$					1.280*	(1.74)	1.398	(1.61)
$FB_{i,t-3}$					0.685	(0.86)	1.315	(1.38)
$FB_{i,t-4}$					1.258*	(1.70)	1.071	(1.28)
$FB_{i,t-5}$					0.510	(0.63)	0.596	(0.68)
$FB_{i,t-6}$					0.346	(0.43)	0.577	(0.68)
GDPG	-0.0552**	(-2.04)	-0.0525*	(-1.92)	-0.0488	(-1.64)	-0.0335	(-1.02)
Depreciation	0.0236**	(2.02)	0.0194*	(1.68)	0.0185	(1.41)	0.0118	(0.80)
Rrate	1.282**	(1.98)	1.240*	(1.91)	1.148*	(1.67)	0.872	(1.19)
GDPPC	-0.316*	(-1.68)	-0.440**	(-2.31)	-0.455**	(-2.26)	-0.577**	(-2.30)
M2/FR	1.526	(0.92)	0.593	(0.35)	0.314	(0.17)	-0.251	(-0.12)
ΔTT	0.0227	(1.06)	0.0285	(1.27)	0.0173	(0.78)	0.0223	(0.83)
Effective	-0.0441	(-0.75)	-0.0482	(-0.82)	0.0396	(0.63)	0.0558	(0.79)
RuleLaw	-0.0871	(-1.55)	-0.106*	(-1.77)	-0.121**	(-2.03)	-0.159**	(-2.29)
Corrupt	0.0170	(0.34)	0.0122	(0.23)	0.0575	(1.06)	0.0510	(0.82)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=16 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 11. EWS of booms on banking crisis: twin boom using 16 emerging countries

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1}$	1.831	(0.83)					-12.70	(-0.00)
$CB_{i,t-2} \times HB_{i,t-2}$	1.919	(0.84)					-12.54	(-0.00)
$CB_{i,t-3} \times HB_{i,t-3}$	-12.37	(-0.00)					-14.64	(-0.00)
$CB_{i,t-4} \times HB_{i,t-4}$	-14.96	(-0.01)					-67.69	(-0.00)
$CB_{i,t-5} \times HB_{i,t-5}$	3.528	(1.51)					56.76	(0.01)
$CB_{i,t-6} \times HB_{i,t-6}$	-14.14	(-0.00)					-32.36	(-0.00)
$HB_{i,t-1} \times FB_{i,t-1}$			4.324***	(3.78)			3.544	(1.59)
$HB_{i,t-2} \times FB_{i,t-2}$			3.096**	(2.04)			3.061	(1.19)
$HB_{i,t-3} \times FB_{i,t-3}$			3.273	(1.64)			-27.01	(-0.00)
$HB_{i,t-4} \times FB_{i,t-4}$			3.908**	(2.37)			-9.621	(-0.00)
$HB_{i,t-5} \times FB_{i,t-5}$			-10.88	(-0.01)			-115.8	(-0.01)
$HB_{i,t-6} \times FB_{i,t-6}$			-10.81	(-0.01)			-13.23	(-0.00)
$CB_{i,t-1} \times FB_{i,t-1}$					3.201**	(2.37)	-13.18	(-0.00)
$CB_{i,t-2} \times FB_{i,t-2}$					-11.38	(-0.01)	-13.60	(-0.00)
$CB_{i,t-3} \times FB_{i,t-3}$					3.391**	(2.39)	2.080	(0.98)
$CB_{i,t-4} \times FB_{i,t-4}$					2.862*	(1.95)	1.846	(0.77)
$CB_{i,t-5} \times FB_{i,t-5}$					4.592***	(3.47)	46.27	(0.01)
$CB_{i,t-6} \times FB_{i,t-6}$					3.772***	(2.92)	28.76	(0.01)
GDPG	-0.0569**	(-2.12)	-0.0534*	(-1.89)	-0.0581*	(-1.91)	-0.0439	(-1.48)
Depreciation	0.0227**	(1.99)	0.0209*	(1.74)	0.0207*	(1.66)	0.0167	(1.32)
Rrate	1.366**	(2.11)	1.298*	(1.96)	1.372*	(1.92)	1.075	(1.53)
GDPPC	-0.412**	(-2.25)	-0.481**	(-2.52)	-0.411**	(-2.21)	-0.401**	(-2.11)
M2/FR	1.053	(0.63)	0.408	(0.22)	0.649	(0.32)	1.471	(0.59)
ΔTT	0.0392	(1.64)	0.0271	(1.22)	0.0307	(1.45)	0.0267	(0.98)
Effective	-0.0901	(-1.44)	-0.0373	(-0.65)	-0.0251	(-0.42)	-0.0451	(-0.63)
RuleLaw	-0.0865	(-1.49)	-0.165**	(-2.43)	-0.135**	(-2.11)	-0.129*	(-1.68)
Corrupt	0.0394	(0.76)	0.0351	(0.64)	0.0198	(0.36)	0.0118	(0.19)

Note:
1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. Twin boom are *CB*×*HB*, *CB*×*FB* or *HB*×*FB* and are the dummy variable when any two booms occur jointly and is zero otherwise.
3. This is a balanced panel data model with *N*=16 and *T* =35 (1979-2013). This is estimated based on Panel fixed logit method.
4. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 12. EWS of booms on banking crisis: triple boom using 16 emerging countries

	$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1} \times FB_{i,t-1}$	4.563***	(2.81)	4.091**	(2.51)
$CB_{i,t-2} \times HB_{i,t-2} \times FB_{i,t-2}$			-13.72	(-0.00)
$CB_{i,t-3} \times HB_{i,t-3} \times FB_{i,t-3}$			-12.34	(-0.00)
$CB_{i,t-4} \times HB_{i,t-4} \times FB_{i,t-4}$			-13.95	(-0.00)
$CB_{i,t-5} \times HB_{i,t-5} \times FB_{i,t-5}$			-13.67	(-0.00)
$CB_{i,t-6} \times HB_{i,t-6} \times FB_{i,t-6}$			-13.10	(-0.00)
GDPG	-0.0587**	(-2.33)	-0.0606**	(-2.23)
Depreciation	0.0221**	(2.00)	0.0239**	(2.07)
Rrate	1.455**	(2.40)	1.391**	(2.12)
GDPPC	-0.382**	(-2.35)	-0.378**	(-2.13)
M2/FR	-0.539	(-0.41)	1.021	(0.62)
ΔTT	0.0427*	(1.69)	0.0304	(1.29)
Effective	-0.0440	(-0.78)	-0.0496	(-0.88)
RuleLaw	-0.0886	(-1.57)	-0.0726	(-1.28)
Corrupt	0.0192	(0.38)	0.0224	(0.45)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on first definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. Triple boom is $CB \times HB \times FB$ is the dummy variable when credit, housing and capital booms occur jointly and is zero otherwise.
3. This is a balanced panel data model with N=16 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
4. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 13. EWS of booms on banking crisis: individual boom using whole sample- *CB*2 and *HB*2

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1}$	1.531***	(3.79)					1.374***	(3.10)
$CB_{i,t-2}$	0.870**	(1.98)					0.781*	(1.66)
$CB_{i,t-3}$	0.920**	(2.05)					0.933*	(1.88)
$CB_{i,t-4}$	0.303	(0.62)					0.350	(0.66)
$CB_{i,t-5}$	-0.474	(-0.84)					-0.549	(-0.92)
$CB_{i,t-6}$	0.408	(0.75)					0.516	(0.90)
$HB_{i,t-1}$			-0.427	(-1.13)			-0.472	(-1.05)
$HB_{i,t-2}$			-0.179	(-0.45)			-0.420	(-0.85)
$HB_{i,t-3}$			0.142	(0.36)			0.161	(0.34)
$HB_{i,t-4}$			0.0984	(0.25)			0.117	(0.25)
$HB_{i,t-5}$			0.106	(0.25)			-0.297	(-0.57)
$HB_{i,t-6}$			-0.157	(-0.39)			-0.584	(-1.15)
$FB_{i,t-1}$					0.881**	(2.12)	0.667	(1.37)
$FB_{i,t-2}$					1.035**	(2.54)	0.473	(1.00)
$FB_{i,t-3}$					0.617	(1.44)	-0.0375	(-0.07)
$FB_{i,t-4}$					1.059**	(2.52)	0.738	(1.49)
$FB_{i,t-5}$					0.994**	(2.13)	0.726	(1.39)
$FB_{i,t-6}$					0.102	(0.20)	-0.268	(-0.48)
GDPG	-0.00602	(-0.63)	-0.0231***	(-2.70)	-0.0164*	(-1.89)	-0.00860	(-0.86)
Depreciation	0.00252	(0.27)	0.0185**	(2.30)	0.0127	(1.52)	0.00475	(0.50)
Rrate	0.321	(1.11)	0.176	(0.62)	0.163	(0.59)	0.385	(1.23)
GDPPC	-0.151	(-1.04)	-0.190	(-1.31)	-0.358**	(-2.34)	-0.153	(-0.96)
M2/FR	0.106	(0.16)	1.282*	(1.78)	0.809	(1.11)	0.439	(0.60)
ΔTT	-0.00389	(-0.50)	0.00157	(0.25)	0.000549	(0.11)	-0.00452	(-0.70)
Effective	-0.176***	(-3.41)	-0.137***	(-3.13)	-0.0972**	(-2.18)	-0.169***	(-3.00)
RuleLaw	-0.0191	(-0.37)	-0.0474	(-1.10)	-0.0673	(-1.43)	-0.0195	(-0.36)
Corrupt	-0.000835	(-0.02)	0.0305	(0.82)	0.0403	(0.98)	0.00591	(0.12)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on second definition of credit boom; *HB* is the housing boom based on first definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion) ; *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
3. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.

Table 14. EWS of booms on banking crisis: twin boom using whole sample-*CB*2 and *HB*2

	$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1}$	0.674	(1.28)					0.326	(0.49)
$CB_{i,t-2} \times HB_{i,t-2}$	0.886	(1.63)					0.744	(1.03)
$CB_{i,t-3} \times HB_{i,t-3}$	0.972*	(1.74)					1.513*	(1.92)
$CB_{i,t-4} \times HB_{i,t-4}$	0.333	(0.52)					-0.357	(-0.43)
$CB_{i,t-5} \times HB_{i,t-5}$	0.0285	(0.04)					-0.766	(-0.73)
$CB_{i,t-6} \times HB_{i,t-6}$	-0.409	(-0.48)					-0.641	(-0.57)
$HB_{i,t-1} \times FB_{i,t-1}$			1.061	(1.58)			-0.0134	(-0.01)
$HB_{i,t-2} \times FB_{i,t-2}$			0.591	(0.82)			-2.134	(-1.57)
$HB_{i,t-3} \times FB_{i,t-3}$			0.339	(0.40)			-3.224*	(-1.90)
$HB_{i,t-4} \times FB_{i,t-4}$			1.305*	(1.67)			0.234	(0.20)
$HB_{i,t-5} \times FB_{i,t-5}$			1.132	(1.41)			-0.411	(-0.36)
$HB_{i,t-6} \times FB_{i,t-6}$			0.988	(1.23)			-0.510	(-0.46)
$CB_{i,t-1} \times FB_{i,t-1}$					1.350**	(2.48)	1.216*	(1.78)
$CB_{i,t-2} \times FB_{i,t-2}$					1.593***	(2.74)	1.996***	(2.65)
$CB_{i,t-3} \times FB_{i,t-3}$					1.428**	(2.46)	1.916**	(2.42)
$CB_{i,t-4} \times FB_{i,t-4}$					1.311**	(2.09)	1.558**	(2.16)
$CB_{i,t-5} \times FB_{i,t-5}$					1.393**	(1.99)	1.826**	(2.29)
$CB_{i,t-6} \times FB_{i,t-6}$					-0.0289	(-0.03)	-0.186	(-0.21)
GDPG	-0.0211**	(-2.45)	-0.0217**	(-2.56)	-0.0139	(-1.61)	-0.0127	(-1.37)
Depreciation	0.0171**	(2.13)	0.0179**	(2.21)	0.00995	(1.19)	0.0102	(1.17)
Rrate	0.180	(0.65)	0.128	(0.46)	0.186	(0.68)	0.186	(0.65)
GDPPC	-0.203	(-1.43)	-0.253*	(-1.73)	-0.299**	(-1.98)	-0.288*	(-1.92)
M2/FR	0.496	(0.70)	1.094	(1.54)	0.840	(1.14)	0.409	(0.54)
ΔTT	0.000308	(0.04)	0.00377	(0.63)	-0.00356	(-0.67)	-0.00544	(-0.95)
Effective	-0.123***	(-2.82)	-0.111**	(-2.56)	-0.107**	(-2.36)	-0.109**	(-2.28)
RuleLaw	-0.0521	(-1.16)	-0.0583	(-1.34)	-0.0467	(-0.96)	-0.0423	(-0.82)
Corrupt	0.0299	(0.77)	0.0366	(0.98)	0.0161	(0.39)	0.0135	(0.30)

Note:
1. *BC* is the bank crisis; *CB* is the credit boom based on second definition of credit boom; *HB* is the housing boom based on second definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. Twin boom are *CB*×*HB*, *CB*×*FB* or *HB*×*FB* and are the dummy variable when any two booms occur jointly and is zero otherwise.
3. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
4. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. t values in parentheses.

Table 15. EWS of booms on banking crisis: triple boom using whole sample CB2 and *HB*2

	$BC_{i,t}$		$BC_{i,t}$	
$CB_{i,t-1} \times HB_{i,t-1} \times FB_{i,t-1}$	1.380*	(1.79)	1.393*	(1.73)
$CB_{i,t-2} \times HB_{i,t-2} \times FB_{i,t-2}$			0.269	(0.29)
$CB_{i,t-3} \times HB_{i,t-3} \times FB_{i,t-3}$			1.232	(1.26)
$CB_{i,t-4} \times HB_{i,t-4} \times FB_{i,t-4}$			0.323	(0.27)
$CB_{i,t-5} \times HB_{i,t-5} \times FB_{i,t-5}$			0.681	(0.57)
$CB_{i,t-6} \times HB_{i,t-6} \times FB_{i,t-6}$			0.385	(0.31)
GDPG	-0.0292***	(-3.65)	-0.0284***	(-3.39)
Depreciation	0.0271***	(3.53)	0.0265***	(3.29)
Rrate	-0.0116	(-0.13)	-0.0161	(-0.16)
GDPPC	0.0239	(0.32)	0.0393	(0.51)
M2/FR	-0.0372	(-0.10)	0.00222	(0.01)
ΔTT	0.00234	(0.37)	0.00220	(0.36)
Effective	-0.0354	(-1.38)	-0.0349	(-1.30)
RuleLaw	-0.00747	(-0.33)	-0.00535	(-0.23)
Corrupt	0.0173	(0.69)	0.0161	(0.63)

Note:

1. *BC* is the bank crisis; *CB* is the credit boom based on second definition of credit boom; *HB* is the housing boom based on second definition of housing boom; *FB* is the capital boom; *GDPG* is the GDP growth; *Depreciation* is the deprecation rate of the exchange rate; *Rrate* is the real interest rate; *GDPPC* is GDP per capita; *M2/FR* is the M2/foreign reserves; ΔTT is the rate of change in the terms of trade of goods and services (units of 1 billion); *Effective* is government effectiveness; *RuleLaw* is rule of law; *Corrupt* is control of corruption.
2. Triple boom is $CB \times HB \times FB$ is the dummy variable when credit, housing and capital booms occur jointly and is zero otherwise.
3. This is a balanced panel data model with N=49 and T =35 (1979-2013). This is estimated based on Panel fixed logit method.
4. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively. *t* values in parentheses.