Financial Liberalization and Capital Adequacy in Models of Financial Crises

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Abstract:

We characterize the effects of financial liberalization indices on OECD banking crises, controlling for the standard macro prudential variables that prevail in the current literature. We use the Fraser Institute's Economic Freedom of the World database. This yields a variable that captures credit market regulations which broadly measures the restrictions under which banks operate. We then test for the direct impacts of some of its components, interest rate and private sector credit constraints, on crisis probabilities and their indirect effects via capital adequacy. Over the period 1980 - 2012, we find that less regulated markets are associated with a lower crisis frequency, and it appears that the channel comes through interest rate liberalization strengthening the defense that capital provides. On the other hand, liberalization of private sector credit or private (versus government) ownership of banks has no significant impact on OECD crises incidence. Our results are robust when controlling for alternative sensitivity tests for robustness purposes.

JEL classification: C52; E58; G21; G28

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1. Introduction

If we are to learn enduring lessons from the sub-prime crisis we need to know whether it was in some way unique, or whether it shared features in common with earlier banking crises. Recent research in banking is increasingly focusing on macro determinants of crises providing evidence that a high proportion of OECD crises can be explained by capital adequacy, liquidity, house price and current account imbalances (Barrell et al. 2010; 2013a). However by definition, these impacts are conditional on the regulatory environment under which banks operate. On the other hand, over the last three decades the regulatory architecture has experienced major transformations, however there is little consensus as to how those changes have affected bank risk taking behavior and hence the probability of crises. Given the established links between financial liberalization, banking system development, crises and efficiency[1], the relevance of capital and liquidity may change once regulatory variables are included. To our knowledge previous crises prediction models have ignored variables that capture the regulatory environment although studies such as Chortareas et al. (2012; 2013) imply that they should be explicitly controlled for.

This paper constitutes the first attempt, to our knowledge, to explicitly characterize the effects of financial liberalization indexes on OECD banking crises between 1980 and 2012. Our approach combines both the macro and micro strands of the literature on banking stability. To capture these dynamics we utilize the economic freedom index drawn from the Fraser Institute database. We focus explicitly on credit market regulation which captures the independence of

[1] See Barth et al. (2006) and Chortareas et al. (2013).

financial and banking markets from government control. This variable can be decomposed into interest rate restrictions, government ownership and private sector credit constraints. We test for the direct impacts of these components on crisis probabilities and their indirect effects via capital adequacy.

Our results suggest that we cannot evaluate the impacts of financial liberalization in broad terms. It is important to distinguish between the types of liberalization and specifically, we find that interest rate liberalization has a crises reducing effect in the OECD. On the other hand, liberalization of private (versus government) ownership of banks or liberalization of private sector credit has no significant impact on OECD crises. Interestingly, the beneficial effects of interest rate deregulation, or the removal of financial repression (see Reinhart, 2012) seems to work by strengthening the effects of capital buffers. We also show that when we control for liberalization, capital adequacy and liquidity, the main driver of financial crises is property price growth. Other factors do not seem to be significant, and increased financial repression after the crisis may have marginally increased the probability of future crises.

The reminder of the paper is organized as follows: Section 2 reviews the relevant literature. Section 3 presents the empirical methodology and the data. Section 4 discusses the empirical results, and Section 5 concludes.

2. Banks and the factors driving bank crises

Banking crises emerge either because banks do not have enough on book liquidity to meet the needs of depositors, and cannot access the wholesale market, or because loan losses have built up to the point where capital is expected to be exhausted. Hence, a relatively simple banking crisis model must include the liquid assets ratio and capital ratios as explanatory

variables. In addition, we should control for factors that can affect the variability of loan losses and deposits. Before discussing the standard controls used in the literature, we note an important omission in these studies: none of the previous studies include liberalization variables as controls despite their intended impact on bank behavior and performance.

Figure 1-3 illustrates the changes in OECD regulation over the past three decades. A clear trend of liberalization is accompanied by an increase in crisis frequency. At the same time, capital buffers have improved while the liquidity position has on average worsened. The question is to what extent has liberalization increased or decreased the incidence, or probability of, crises, and whether liberalization interacts with regulatory capital buffers to affect crises probabilities. To answer this question we test an aggregate measure of liberalization and then we decompose this to check for differential impacts of specific types of liberalization. Our approach marries the macro- and micro- literature in terms of early warning studies and bank performance literature. We review relevant studies in each of these areas next.

<Insert Figures 1-3 about here>

Many studies have searched for factors that can be used to explain historic crises and forewarn future episodes. Studies such as Demirguc-Kunt and Detragiache (1998; 2005) rely on heterogeneous country sets with contemporaneous[2] variables to explain crises. Hence, these models cannot be classed as true early warning systems whilst the wide country coverage limits the explanatory data available for inclusion. Subsequently, Barrell et al. (2010) focus on the OECD with more homogenized banking systems. In this context they show that capital adequacy, liquidity, property prices and current account deficits supersede traditional macro

[2] Credit growth being the exception

variables as crisis determinants. The lag structure of these models ensures true early warning properties and explanatory power within and out-of-sample is high (see Barrell and Karim, 2013b). In this paper, we continue with the Barrell et al. (2010) model but recognise that it is contingent on the degree of liberalization in each banking sector. Before turning to the micro literature of liberalization, we briefly summarize the key explanatory variables in our base line model.

Crises are often the result of poor quality lending. It appears that a boom in real estate prices inflates the availability of collateral causing lending to be excessive and credit to be mispriced (the financial accelerator). When prices fall from unsustainable levels, this process goes into reverse, sharply tightening credit conditions and overextended borrowers have strong incentives to default. Reinhart and Rogoff (2008) suggest that property price developments can change crisis probabilities, and Barrell et al. (2010) show this to be the case.

Barrell et al. (2013a) suggest that widening current account imbalances have been common forerunners of banking crises in OECD. Current account deficits may be accompanied by monetary inflows that enable banks to expand credit excessively, generating and reflecting a high demand for credit, as well as boosting asset prices in an unsustainable manner.[3] These trends may be exacerbated by lower real interest rates than would otherwise be the case. The existence of a current account deficit also indicates a shortfall of national saving over investment and hence a need for the banking sector to access the potentially volatile international wholesale market.

Other factors that would indicate an increased risk of loan losses are discussed extensively in Barrell et al. (2010), Demirguc-Kunt and Detragiache (1998; 2005) and Beck et al.

[3] In addition foreigners may cease to be willing to finance deficits in domestic currencies if they consider their assets are vulnerable to monetization via inflation, and such a cessation can disrupt asset markets and banks' funding. See Haldane et al. (2007) for an assessment of the impact of such a hypothetical unwinding in the US

(2006). These variables include the growth of real GDP, M2 / Foreign exchange reserves, and the rate of inflation which capture macroeconomic developments that affect banks' asset quality. Rapid credit growth may also indicate lax lending standards as well as potentially triggering an asset boom, as was commonly suggested prior to the subprime crisis. Loose monetary policy, as indicated by the short term real interest rate may also induce lax lending and feed asset bubbles. Fiscal deficits often affect the risk of crises by overheating the economy. A large fiscal deficit also reduces the scope available to recapitalise banks when difficulties emerge, making a systemic crisis more likely. Fiscal difficulties were not present prior to the subprime crisis but emerged afterwards, as the economy slowed and authorities had to recapitalize banks.

Over the last decade several micro studies have focused on financial liberalization and various aspects of the economy but few test for the effects of liberalization, as defined in this paper. Some exceptions are found as in Chortareas et al. (2011; 2013). Instead these variables are typically used in a macro context to evaluate the effects of liberalization on the overall economy (e.g., La Porta et al., 1998; De Haan and Sturm, 2000; Gwartney, 2009; Giannone et al., 2011). Where micro studies focus on bank performance, the variables of interest usually capture regulatory structures as opposed to liberalization (e.g. Demirguc-Kunt et al., 2004; Barth et al., 2006; Chortareas et al., 2012). The increased research in this area is driven by recent regulatory changes which have made banks more concerned about controlling their costs while optimising revenues. A common thread that emerges from these studies is that a high degree of liberalization boosts bank efficiency, reduces corruption in lending, or lowers banking system fragility. Thus, in economies that promote liberalization we might expect improved profitability, lower prices, and improved service quality for consumers, as well as greater safety and soundness if their savings are directed towards improving capital buffers that absorb risk.

Because much of the data on regulation used in other studies is limited in its time domain we focus on the only set that gives indicators over our whole time period we wish to study. The use of quantitative indices of economic freedom and liberalization allows us to explicitly evaluate the potential effects (or lack of them) of economic institutions on banking crises. Economists and regulators who believe that liberalization has contributed to increased crisis incidence have argued that changes in bank regulation and supervision practices are needed. Our research suggests that this agenda should be pursued with care, as some forms of liberalization reversal may actually increase crisis incidence.

Even when liberalization is analyzed it is typically introduced as an aggregated variable (e.g., Claessens and Laeven, 2004; Goddard et al., 2011). Since specific bank regulation counterparts are not used, misspecification bias may arise (Heckelman and Stroup, 2000). To our knowledge, only one study exists that explicitly investigates various aspects of economic freedom/liberalization and governance effectiveness in banking performance (Chortareas et al., 2013). Evidence suggests that the higher the degree of an economy's financial freedom, the higher the benefits for banks in terms of cost advantages and overall efficiency. No systematic attempt exists to explicitly measure the impact of financial liberalization directly on crisis probabilities and indirectly via capital adequacy and this is the task that we pursue in the following sections.

3. Methodology and data

We utilize the logit model which has been the standard approach to predicting crises (Demirguc-Kunt and Detragiache, 2005; Davis and Karim, 2008). The logit estimates the

probability that a banking crisis will occur in a given country with a vector of explanatory variables X_{it}. The banking crisis variable Y_{it} is a zero-one dummy which is one at the onset of a banking crisis, and zero elsewhere. The logistic estimator is given by:

$$\mathrm{Prob}(Y_{it}=1)=F(\beta X_{it})=\frac{e^{\beta' X_{it}}}{1+e^{\beta' X_{it}}} \quad (1)$$

where, β is the vector of unknown coefficients and $F(\beta X_{it})$ is the cumulative logistic distribution. The log likelihood function is:

$$Log_e\ L=\sum_{i=1}^{n}\sum_{t=1}^{T}\left[(Y_{it}\log_e F(\beta' X_{it}))+(1-Y_{it})\log_e(1-F(\beta' X_{it}))\right] \quad (2)$$

Coefficients show the direction of the effect on crisis probability, although its magnitude is conditional on values of other explanatory variables at time t. ßi represents the effect of X_i when all other variables are held at their sample mean values. We include a constant to allow for the hypothesis that there is an exogenous probability of a crisis occurring.

Our dataset includes 23 systemic and non-systemic crises in OECD countries. The crises between 1980 and 2003 are from Barrell et al. (2010): Canada (1983), Denmark (1987), Finland (1991), France (1994), Italy (1990), Japan (1991), Norway (1990), Sweden (1991), the UK (1984, 1991, 1995) and the US (1988). In extending the estimation further to 2008 we rely on Laeven and Valencia (2010) who classify crises in the US, the UK, Belgium, France, Germany, Denmark, Spain, Sweden (marginally) and the Netherlands. We date crises in these countries in 2008 with the UK and US having distinct crises in both 2007 and 2008. We evaluate our model using forecasts tests for 2009 to 2012, with crises dated by Laeven and Valencia (2012) in Germany and Denmark in 2009 and Spain in 2011.

As discussed in Section 2, the variables included in our model are: real GDP growth, inflation, M2/ Foreign Exchange Reserves, real interest rates, fiscal surplus/GDP ratios, the current account as a ratio to GDP and real domestic credit growth.[4] We follow Barrell et al. (2010) and include unweighted bank capital adequacy and bank narrow liquidity as well as real house price growth.

The above macroeconomic and financial data are from the IMF's IFS database, with the following exceptions: house prices are from the BIS database, while banks' unweighted capital adequacy is obtained from the OECD Bank Income and Balance Sheet database, except for the UK, where data are obtained from the Bank of England. We use narrow liquidity[5] derived from IFS rather than the broad measure provided in the OECD Bank Income and Balance Sheet database.

Data on liberalization are collected from the Fraser Institute (2012)[6]. The Fraser Institute's Economic Freedom of the World index allows us to explicitly focus on regulation that is pertinent to the banking system. The Credit Market Regulation (CMR) variable is an overall indicator of private versus government ownership of banks; government borrowing compared to private borrowing; and interest rate controls.[7] Variables on financial liberalization range in value from 0 to 10, with greater values signifying better protection of financial liberalization. In order

[4] We do not include certain Demirguc-Kunt and Detragiache (1998; 2005) variables because they are irrelevant to OECD countries. For example, GDP per capita is broadly comparable across OECD countries, while virtually all OECD countries have some form of deposit insurance scheme. Variations in the level of credit/GDP (as opposed to credit growth) may reflect the differing nature of the financial system in OECD countries (i.e. bank versus market dominated) rather than the risk of crisis, and we exclude this variable as well.

[5] Narrow liquidity is defined as a sum of banks' claims on general government and the central bank, while total assets comprise foreign assets, claims on general government, central bank and private sector.

[6] There exist two major attempts to measure economic freedom, namely the Economic Freedom of the World Annual Reports produced by the Fraser Institute and the Index of Economic Freedom created by the Heritage Foundation and the Wall Street Journal. Because data provided by the Heritage foundation are limited in the time dimension, we are unable to test this in our model.

[7] See Appendix A for more details on the Fraser variables.

to specifically characterize the effects of financial liberalization on banking crises we control for the sub-components of CMR.

The variable on interest rate regulation (IRR) is constructed by using data on credit-market constraints and regulations. Countries with interest rates determined by the market, stable monetary policy, and positive real deposit and lending rates received higher ratings. Conversely, 0 ratings were assigned when governments fixed deposit and lending rates and real rates were persistently negative by double-digit amounts or hyperinflation had virtually eliminated the credit market. In our sample persistently negative short term real interest rates, as defined for this indicator, only existed for extended periods at the start of the 1980s and in the post sub-prime crisis period, and financial repression, as defined by Reinhart (2012) was largely absent.

The Private Sector Credit (PSC) sub-component measures the extent to which government borrowing crowds out private borrowing. Crowding out is measured by the government fiscal deficit as a share of gross saving[8] (where available) or the share of private credit to total banking credit. Finally, ownership of banks (OWN) variable equals the percentage of deposits held in privately owned banks. Greater values here imply more freedom in the domestic credit market[9].

4. Results

4.1. Estimation of a baseline model

[8] In this case, larger deficits receive a lower ranking of the index
[9] This variable remains insignificant in all our estimations hence we do not report results in our next section.

A priori we do not assume the dominance of any explanatory variables, since each contributes to a separate hypothesis on the causes of crises. We therefore rely on nested testing of a logit model of OECD banking crises over 1980-2008. We start our analysis with all variables included, and eliminate them one at a time, removing the least significant each time and repeating the reduced regression. This procedure terminates when only significant regressors are left in our set. Unlike Demirguc-Kunt and Detragiache (2005), all variables are lagged at least one period to provide a true early warning model.[10] We follow Barrell et al (2010) and lag house prices by 3 years while AIC tests suggest that for other variables the appropriate lag length should be set at one.[11]

<Insert Table 2 about here>

As can be seen in Table 2, all of the variables typically used in global samples are insignificant, including factors highlighted prior to the subprime crisis such as GDP growth, credit growth and real interest rates. However, the current account/GDP ratio, real house price growth, unweighted bank capital adequacy, and bank narrow liquidity/assets are significant in all specifications. The first variable to be eliminated is inflation, followed by the constant, which suggests that there is no strong evidence that crises are inevitable and unexplainable. The next variable to be deleted is the M2/ reserves, possibly because FX reserves take on a different function in sophisticated financial markets as compared to emerging ones. The same might be argued for the lack of significance of credit, as discussed in Barrell and Karim (2013b).[12] The

[10] As noted above, they only lag credit growth, with other variables being contemporaneous.
[11] In general current dated variables were better on the AIC, but they could not form part of an early warning system as they are not known in advance.
[12] Our result for insignificance of credit expansion is nevertheless consistent with Mendoza and Terrones (2008) who found that credit booms often link to banking crises in emerging market economies but less often in OECD countries.

next variables to disappear (in order) are the government budget balance, real GDP growth and the real interest rate. The credit market regulation variable disappears last. This suggests it cannot be completely disregarded since it has some explanatory power. Moreover, it has the same sign as capital adequacy suggesting that perhaps less regulated markets are less prone to crises.

We leave the evaluation of the performance of the model to a later section where we compare it to other possible approaches to explaining crises. The in sample performance of this model is good, with 17 of the 23 crises 'called' at the sample average cut-off of 0.0631 per cent, with only 28 per cent false calls. It performs particularly well in the sub-prime period on this basis, calling 8 out of 11 crises at the sample cut-off.

As we would expect, from a bank's balance sheet perspective, higher levels of capital and liquidity allow the banking system to absorb larger shocks. Increasing the ability to cope with deposit runs (a function of deposit variance) and bad loan sequences (a function of variance in non-performing loans) is clearly important. Crises often stem from the accumulation of foreign assets where risks are not fully appreciated, and it is possible that this accumulation shows up directly in the current account. House price booms are often generated by overoptimistic expectations and unwise lending, and they are often reversed. When this happens debts can turn bad, and losses may mount.[13]

Given the potential information content of credit market regulation, the next logical step is to decompose it to test whether specific types of liberalization matter.

4.2. Decomposing Financial Market liberalization

[13] However, not all asset price booms and current account deficits can be treated as harbingers of crises.

Our indicator of regulatory intensity is a composite of the intensity of interest rate regulation and financial repression, private sector credit constraints and a public ownership indicator. We first replace the composite indicator with the measure of financial repression and interest rate regulation, which increases over time mainly because of a reduction in regulations. After the financial crisis in 2007-8 the indicator fell again, but this is outside our estimation period, but within our forecast horizon.

<Insert Table 3 about here>

We repeat our elimination procedure, and credit growth, M2 /reserves, inflation, real interest rates, the budget balance and GDP growth all dropped out before the constant (Table 3). The last three variables to drop out are the constant, the capital adequacy ratio and the current account. Interest rate regulation 'knocks out' two of the explanatory variables from Table 1. Interestingly, the regulatory variable has a negative and significant sign suggesting that more interest rate liberalization reduces the risk of banking crises. We first note that the interest rate regulation variable 'knocks' out the core regulatory variable (capital) at a late stage and if it were the case that the two are proxies for each other, the policy implications would be significant. Hence, we expand the model by adding an extra variable where we multiplicatively 'cross' interest rate regulation with capital as they both entered with a negative sign. The results are presented in Table 4.

<Insert Table 4 about here>

Insignificant variables drop out in a similar way to the previous tests, with credit growth and M2 /reserves discarded first. Interestingly, when we include the interaction term the regulation variable is eliminated very early unlike the previous model. The last two insignificant variables are the unweighted capital adequacy ratio and the constant. The remaining variables are the current account, the lagged growth of real house prices and liquidity along with unweighted capital adequacy multiplied by the interest rate regulation variable.

As the interest rate regulation variable is 'stronger' than the overall composite indicator, it is worth looking at its other components to see if they in some ways offset the effects on interest rate liberalization. We look at both the private sector credit constraints indicator and the ownership indicator, and it is clear that in this sample at least, ownership which varies little over time, has little effect on the incidence of crises.[14]

Table 5 reports on the result of including the private sector credit constraints indicator rather than the overall composite indicator. In the process of sequential elimination the credit control variable survives until two steps before the end. It has a positive sign, suggesting that a reduction in private sector credit constraints increases the frequency of crises, although not statistically significantly. Due to its insignificance we do not cross the credit constraints indicator with capital or liquidity, but if we were to include it, we would introduce it as a ratio since the indicator has the opposite sign to the regulatory variables.

<Insert Table 5 about here>

As interest rate controls and private sector credit constraints have opposite signs in our experiments, it is clear why the interest rate control variable is stronger that the composite of

[14] The results with ownership are not reported in the tables but are available upon request from the authors.

these two opposites. As we can see from Table 1 the indicator of credit constraints rises through the sample period and there is some evidence this may have raised crisis incidence. However, the interest rate regulation indicator also rose over time, and it has an offsetting effect on the crisis probability. Overall, it looks as if liberalization reduced the probability of a crisis occurring, but this was more because liability side restraints were reduced rather than coming from a change in assets side restrictions.

4.3. Model selection and the use of ROC Curves

We have three potential models and we need to choose between them. Receiver Operating Characteristic (ROC) curves test the "skill" of binary classifiers and hence can be used to discriminate between competing models. In the context of logit estimators, probabilistic forecasts can be classified for accuracy against a continuum of thresholds. This generates a true positive rate and true negative rate for each threshold and correspondingly a false positive and false negative rate. In the terminology of ROC analysis the two variables of interest are the true positive rate (sensitivity of the discriminator) and the false positive rate (1-specificity). The true positive rate is plotted on the y axis and the false positive rate on the x axis. At a probability threshold of 0.0001 almost all crises would be correctly called. However, almost all other periods would have a false positive call, corresponding to the top right hand corner of figure 4. As the cutoff threshold for calls rises true positives will fall, but in a good model it falls much less rapidly than the false positives. For a recent example of ROC curve usage in the context of crises, see Barrell et al. (2013b) and Schularick and Taylor (2012).

We can compare ROC curves by looking at the Area Under the Curve or AUC (the equivalent of a Gini Coefficient). If the true positive rate declines more slowly than the false positive rate when the threshold is raised then the AUC is above a half. The larger the difference between these two rates of decline the higher the AUC. This avoids evaluating or the ranking of models at particular thresholds. An AUC of 0.5 is equivalent to a "naïve" estimator that replicates a random coin toss (corresponding to the 45^0 line) so an AUC above 0.5 implies the model adds value in terms of the ability to call crises correctly with low false negative rates. Hosmer and Lemeshow (2000) indicate that an AUC ≥ 0.9 is highly improbable for logit models since this level of discrimination would require complete separation of the crisis and non-crisis event and the logit coefficients could not be estimated. Hence for our approach we would accept models with AUCs ≥ 0.7.

<Insert Table 6 about here>

The AUCs for our competing models are given in Table 6 whilst the corresponding ROC curves are given in figure 4. All the fitted models have AUCs well above 0.70, and the baseline model outperforms that with interest rate regulation alone. However, the model where capital and interest rate regulation are interacted outperforms the baseline model, suggesting that this cross increases the generalized information content of our analysis. The model with the cross between interest rate regulation and unweighted capital adequacy contains the most generalized information, and we would say that it is our preferred model. We plot the ROC curves for our baseline model and our preferred specification, and it is clear that the interest rate regulation and its cross with capital both have marginally better discrimination at low thresholds, and given the

AUC the model including capital crossed with interest rate regulation might be strongly preferred by a policy maker who was looking to operate at these low levels of probability of a crisis, which one might want to do if crises are expensive events.

<Insert Figure 4 about here>

4.4. In sample and forecast performance

It is common to evaluate models by their specific call rates (did they have an above sample mean predicted probability when there was a crisis) both within sample and out of sample, and it is also common to look at out of sample ROCs. We can use these to evaluate the forecast performance of our chosen model, a cross of capital with interest rate de-regulation, and we can also look at a comparison to our baseline model. We first discuss in sample call rates, especially in relation to the sub-prime crisis, and then we look at out of sample performance.

Over the period 1980 to 2008 the frequency of banking crises was 0.0631 in 406 country-years, and we can denote a predicted probability in excess of this as a 'correct call' if it took place either in the year a crisis happened or the year before the crisis occurred. On this basis the model with the interest rate liberalization cross with capital called 11 out of 12 crises in the sub-prime period, with only one missed crisis in Germany. The German crisis did not follow on from domestic problems, but rather from excessive exposure to US sourced MBSs. On the same basis there were only two false calls, and both occurred in Canada, where the combination of an oligopolistic banking system, a well-organized central bank and close knowledge of US mortgage markets meant that fewer risk were taken than elsewhere, given other factors.

<Insert Table 7 about here>

Out of sample performance is perhaps more revealing at this threshold, and we plot calls and crises in Table 8. Laeven and Valencia (2012) suggest that there were three systemic crises after 2008, in Germany and Denmark in 2009 and in Spain in 2011. At the in sample threshold we once again fail to call Germany, but using a current or immediately prior call measure of accuracy we are able to give an early warning of the other two crises. There were 22 false crisis calls, with the largest number being in Canada (4) and in 2009 (8 out of 14). The true crisis call rate is 2/3rds whilst the false crisis call rate is just under 40 per cent. Both of which are good by the standards of the literature.

<Insert Table 8>

It is best to compare the two models using ROC curves and AUC indicators. As we can see from Figure 5 the model with capital crossed with the interest rate liberalization indicator performs noticeably better at low thresholds with fewer false crisis calls, but as the threshold rises the two ROCs cross, and the forecast AUC for the crossed model of 0.741 is marginally worse that the baseline model with no regulatory indicator which has a forecast AUC of 0.743. It is hard to distinguish between these models, but if policy makers are particularly worried about low probability events they might well be better using the crossed model.

<Insert Figure 5 about here>

4.5. The factors contributing to crisis incidence

It is useful to summarize the factors that have affected the incidence of crises in our sample period. This involves calculating the marginal effects $(MARG)$ of each variable across time period and country, as they will differ, and using these to assess the changes in probabilities indicated by the model. For each variable (i) in each country (j) and each time period (t) we may calculate the contribution of the factor $X_{i,j,t}$ to the change in predicted probability by calculating

$$Contrib_{i,j,t} = MARG_{i,j,t} \times (X_{i,j,t} - X_{i,j,t-1}) \quad (3)$$

This can then be rescaled to show its proportionate contribution to the explanation of the change in predicted probability we observe at time t in country j. In table 9 we take these proportionate contributions and report their averages across decades and countries, allowing us to give a summary of the relative importance of the factors we observe. These averages will of course hide large movements within time periods, and large difference between countries, but they are informative.

<Insert Table 9 about here>

Our preferred model, which includes capital, liquidity, house price growth and the interest rate controls and repression indicator, gives a significant overall weight to house prices.

In the 1980s, changes in capital marginally increased crisis probabilities, whilst changes in liquidity and in regulation reduced them. On average in this period most of the explanation of increased crisis incidence is driven by changes in house price growth, which contributes almost 90 per cent of the explanation. In the 1990s the decline in capital ratios, as evidenced in Table 1 above, was the major factor driving changes in crisis incidence, and regulation had no overall effects. In the 2000s the decline in liquidity we see in Table 1 contributes about 40 per cent of the explanation of the change in the probability of crises between years, whilst changes in house price growth contributes most of the rest. The reversal of liberalization around the financial crisis in some countries in our sample means that this variable had a minor impact on the probability of crises, raising it slightly.

4.6. Sensitivity analysis

In this section, we present a variety of additional estimates to examine the robustness of our results. These tests deals with the sensitivity of our results when (i) dropping the systemic crises countries individually, (ii) relaxing the assumption that crises last for one year, and (iii) estimating the results up to the 2006 sub-prime.

In particular, we re-estimate the logit equation in model 10 from Tables 3 and 4 using a number of alternative procedures. Following Barrell et al. (2010), we re-estimate our models to examine the possibility that variable behaviour in systemic crises economies drive our main results. This results in the deletion of UK, US, Japan, US and Japan together, Norway, Finland and Sweden. The estimations in Table 10 show that our results remain virtually the same as those discussed in Section 4.2. Secondly, in an attempt to examine whether the measures of banking crises that we use in this paper are sufficient in capturing the crisis year by altering the 1-year lag

period (or longer) and taking the second lag prior to the crises. As shown in Table 11 this amendment does not change the results to any great extent. Finally, we continue to find the same results even when changing the estimation period by dropping the post-crisis observations, as Table 12 shows.

5. Conclusion

It is often thought liberalization is associated with an increased incidence of financial crises. We show that the bank regulatory variables, capital and liquidity, along with asset prices and the current account balance impacted on the probability of banking crises in OECD countries over 1980-2012, as did indicators of financial market liberalization. Using a composite indicator of financial liberalization, we find that less regulated markets are associated with a lower crisis frequency and it appears that the channel comes through strengthening the defense that capital provides.

When we decompose our aggregate liberalization measure, we find that the reduction in crisis incidence is driven by a variable that captures both interest rate liberalization and financial repression. Alleviating restrictions in these areas appears to strengthen the defense that bank capital provides, enhancing financial system stability. On the other hand, private sector credit liberalization may have an opposing effect although a lack of significance means this effect is not as strong. The proportion of private versus public ownership of banks does not appear to affect OECD crisis probabilities in our sample. Once we control for interest rate liberalization, capital adequacy and liquidity, we find that in the OECD for our sample period, the main driver

of crises has been property price growth. The above results appear robust to a variety of alternative estimation checks.

From a policy perspective, regulators should monitor future house price dynamics and they may wish to mitigate large appreciations in house prices. In addition, the promotion of financial liberalization may yield benefits in terms of financial stability. As it stands, the increase in financial repression, following the subprime crisis, may have increased the probability of future crises.

REFERENCES

Barrell, R., Davis, E. P., Karim, D., Liadze, I., 2010. Bank regulation, property prices and early warning systems for banking crises in OECD countries. Journal of Banking and Finance 34, 2455-64.

Barrell, R., Davis, E. P., Karim, D., Liadze, I., 2013a. Off balance sheet exposures and banking crises in OECD countries. Journal of Financial Stability (in press).

Barrell, R., Karim, D., 2013b. The role of capital, liquidity and credit growth in financial crises in Latin America and East Asia. LSE financial markets group special papers 217.

Barth, J.R., Caprio, G., Levine, R., 2006. Rethinking Bank Regulation: Till Angels Govern. Cambridge University Press, New York.

Beck, T., Demirgüc-Kunt, A., Levine, R., 2006. Bank concentration, competition and crises, first results. Journal of Banking and Finance 30, 1581-1603.

Chortareas, G., Girardone, C., Ventouri, A., 2011. Financial frictions, bank efficiency and risk: Evidence from the Eurozone. Journal of Business, Finance and Accounting 38, 259-287.

Chortareas, G., Girardone, C., Ventouri, A., 2012. Bank supervision, regulation, and efficiency: Evidence from the European Union. Journal of Financial Stability 8, 292-302.

Chortareas, G., Girardone, C., Ventouri, A., 2013. Financial freedom and bank efficiency: Evidence from the European Union. Journal of Banking and Finance 37(4), 1223-1231.

Claessens, S., Laeven, L., 2004. What drives bank competition? Some international evidence. Journal of Money, Credit and Banking 36, 563-584.

Davis, E.P., Karim, D., 2008. Comparing early warning systems for banking crises. Journal of Financial Stability 4, 89-120.

De Haan, J., Sturm, J.E., 2000. On the relationship between economic freedom and economic growth. European Journal of Political Economy 16, 215-241.

Demirguc-Kunt, A., Detragiache, E., 1998. The determinants of banking crises in developed and developing countries. IMF Staff Paper 45(1).

Demirguc-Kunt, A., Laeven, L., Levine, R., 2004. Regulations, market structure, institutions and the cost of financial intermediation. Journal of Money, Credit and Banking 36, 593-622.

Demirgüç-Kunt, A., Detragiache, E., 2005. Cross-country empirical studies of systemic bank distress: A survey. IMF Working Papers 05/96, International Monetary Fund.

FDIC, 1997. History of the Eighties: Lessons for the Future, Federal Deposit Insurance Corporation.

Fraser Institute, 2012. Economic Freedom Dataset. Economic Freedom of the World. Annual Report.

Giannone D., Lenza, M., Reichlin, L., 2011. Market freedom and the global recession. IMF Economic Review 59(1), 111-135.

Goddard, J.A., Liu, H., Molyneux, P., Wilson, J.O.S., 2011. The persistence of bank profit. Journal of Banking and Finance 35, 2881-2890.

Gwartney, D.J., 2009. Institutions, economic freedom, and cross-country differences in performance. Southern Economic Journal 75(4), 937-956.

Haldane, A., Hall, S., Pezzini, S., 2007. A new approach for assessing risks to financial stability. Bank of England Financial Stability Paper 2.

Heckelman, J.C., Stroup, M.D., 2000. Which economic freedom contributes to growth?. Kyklos 53, 527-544.

Hosmer, D.W. and Lemeshow, S. 2000. Applied Logistic Regression. 2nd ed. John Wiley & Sons.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R.W., 1998. Law and finance. Journal of Political Economy 106, 1113-1155.

Laeven, L., and Valencia, F., 2010. Resolution of banking crises: The good, the bad, and the ugly. IMF working paper 10/146.

Laeven, L., and Valencia, F., 2012. Resolution of banking crises. IMF Working Paper WP/12/146.

Mendoza, E. G., Terrones, M. E., 2008. An anatomy of credit booms: evidence from macro aggregates and micro data. NBER Working Paper 14049.

Reinhart, C., 2012. The return of financial repression in public debt, monetary policy and financial stability. Banque de France, Financial Stability Review 16.

Reinhart, C., Rogoff, S.K., 2008. Is the 2007 US sub-prime financial crisis so different? An international historical comparison. American Economic Review 98(2), 339-44.

Schularick, M., Taylor, A., 2012. Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. American Economic Review 102(2), 1029-61.

Table 1.

Decade Averages of Regulatory Variables in OECD (1980-2010)			
Decade	1980-89	1990-99	2000-10
Crises	**4**	**8**	**11**
Credit Market Regulation	8.3	8.7	9.4
Interest Rate Regulation	8.9	9.9	9.9
Private Sector Credit Regulation	7.7	7.8	9.2
Capital (% of total bank assets)	4.7	5.5	5.9
Liquidity (% of total bank assets)	16.4	15.1	11.3

Source: Crises: Barrell et al (2010) and Leaven and Valencia (2012); Regulation Variables: Fraser Institute (2012) - Higher values indicate more liberalization; Capital and Liquidity: OECD, Bank of England and IFS.

Table 2.

The effects of credit market regulation on crises probabilities

Dependent Variable: Crisis Onset	Regression Stage								
	1	2	3	4	5	6	7	8	9
Capital Adequacy Ratio (-1)	-0.132 (0.41)	-0.131 (0.407)	-0.134 (0.388)	-0.137 (0.376)	-0.129 (0.395)	-0.15 (0.306)	-0.144 (0.323)	-0.158 (0.274)	-0.288 (0)
Liquidity Ratio (-1)	-0.126 (0.012)	-0.127 (0.012)	-0.129 (0.002)	-0.131 (0.002)	-0.131 (0.002)	-0.12 (0.001)	-0.117 (0.001)	-0.113 (0.002)	-0.131 (0)
Δ Real House Price (-3)	0.109 (0.003)	0.109 (0.003)	0.11 (0.002)	0.109 (0.002)	0.109 (0.002)	0.101 (0.002)	0.1 (0.003)	0.102 (0.002)	0.096 (0.004)
Current Account Balance (% of GDP) (-1)	-0.098 (0.25)	-0.097 (0.244)	-0.098 (0.227)	-0.103 (0.198)	-0.104 (0.195)	-0.12 (0.1)	-0.118 (0.105)	-0.132 (0.055)	-0.156 (0.018)
Credit Market Regulation (-1)	-0.132 (0.737)	-0.129 (0.739)	-0.169 (0.176)	-0.159 (0.178)	-0.165 (0.157)	-0.149 (0.187)	-0.132 (0.225)	-0.105 (0.289)	
Real Interest Rate (-1)	0.045 (0.631)	0.041 (0.537)	0.038 (0.528)	0.036 (0.544)	0.037 (0.531)	0.037 (0.527)	0.033 (0.571)		
ΔGDP (-1)	0.092 (0.493)	0.093 (0.481)	0.092 (0.487)	0.092 (0.485)	0.089 (0.495)	0.068 (0.583)			
Budget Balance (% of GDP) (-1)	-0.039 (0.64)	-0.04 (0.624)	-0.039 (0.629)	-0.043 (0.592)	-0.043 (0.593)				
Δ Domestic Credit (-1)	0.000 (0.833)	0.000 (0.838)	0.000 (0.784)	0.000 (0.806)					
M2 Money/ Forex Reserves (-1)	0.000 (0.861)	0.000 (0.859)	0.000 (0.861)						
Constant	-0.4 (0.923)	-0.443 (0.912)							
Inflation (-1)	-0.008 (0.958)								

Note: Coefficient (probability). Estimation Period: 1980 - 2010

Table 3.
The effects of interest rate regulation on crises probabilities

Dependent Variable: Crisis Onset	Regression Stage									
	1	2	3	4	5	6	7	8	9	10
Interest Rate Regulation (-1)	-0.287 (0.196)	-0.287 (0.194)	-0.283 (0.199)	-0.245 (0.223)	-0.268 (0.148)	-0.267 (0.149)	-0.266 (0.15)	-0.148 (0.13)	-0.212 (0)	-0.226 (0)
Liquidity Ratio (-1)	-0.112 (0.011)	-0.112 (0.011)	-0.114 (0.009)	-0.118 (0.005)	-0.117 (0.005)	-0.107 (0.005)	-0.106 (0.005)	-0.099 (0.007)	-0.096 (0.007)	-0.093 (0.008)
Δ Real House Price (-3)	0.117 (0.002)	0.117 (0.002)	0.117 (0.002)	0.115 (0.002)	0.116 (0.001)	0.109 (0.001)	0.107 (0.002)	0.105 (0.002)	0.103 (0.002)	0.116 (0)
Current Account Balance (% of GDP) (-1)	-0.104 (0.219)	-0.104 (0.218)	-0.108 (0.195)	-0.101 (0.213)	-0.108 (0.157)	-0.126 (0.063)	-0.124 (0.067)	-0.121 (0.074)	-0.103 (0.087)	
Capital Adequacy Ratio (-1)	-0.102 (0.525)	-0.103 (0.503)	-0.106 (0.49)	-0.1 (0.508)	-0.107 (0.473)	-0.129 (0.366)	-0.123 (0.389)	-0.106 (0.45)		
Constant	1.006 (0.683)	1.008 (0.682)	1.077 (0.657)	0.647 (0.771)	1.016 (0.573)	1.194 (0.502)	1.302 (0.461)			
ΔGDP (-1)	0.077 (0.573)	0.077 (0.573)	0.078 (0.571)	0.089 (0.513)	0.083 (0.54)	0.06 (0.638)				
Budget Balance (% of GDP) (-1)	-0.034 (0.692)	-0.034 (0.692)	-0.038 (0.652)	-0.045 (0.574)	-0.045 (0.578)					
Real Interest Rate (-1)	0.049 (0.596)	0.049 (0.596)	0.046 (0.614)	0.019 (0.777)						
Inflation (-1)	-0.072 (0.671)	-0.072 (0.669)	-0.072 (0.668)							
M2 Money/ Forex Reserves (-1)	0 .000 (0.847)	0.000 (0.846)								
Δ Domestic Credit (-1)	0.000 (0.991)									
Note: Coefficient (probability). Estimation Period: 1980 - 2010										

Table 4.
Interaction between interest rate regulation and capital adequacy

Dependent Variable: Crisis Onset	Regression Stage									
	1	2	3	4	5	6	7	8	9	10
Interest Rate Regulation*Capital Adequacy Ratio (-1)	-0.125 (0.418)	-0.123 (0.418)	-0.124 (0.415)	-0.074 (0.13)	-0.067 (0.143)	-0.071 (0.092)	-0.069 (0.097)	-0.069 (0.097)	-0.021 (0.12)	-0.031 (0)
Liquidity Ratio (-1)	-0.113 (0.011)	-0.113 (0.011)	-0.115 (0.009)	-0.113 (0.009)	-0.117 (0.005)	-0.116 (0.006)	-0.106 (0.006)	-0.104 (0.006)	-0.108 (0.007)	-0.13 (0)
Δ Real House Price (-3)	0.121 (0.001)	0.121 (0.001)	0.12 (0.001)	0.12 (0.001)	0.118 (0.001)	0.12 (0.001)	0.111 (0.001)	0.11 (0.001)	0.104 (0.002)	0.101 (0.003)
Current Account Balance (% of GDP) (-1)	-0.112 (0.197)	-0.111 (0.198)	-0.115 (0.178)	-0.113 (0.182)	-0.105 (0.199)	-0.111 (0.15)	-0.132 (0.052)	-0.129 (0.056)	-0.14 (0.043)	-0.158 (0.018)
Constant	-4.037 (0.551)	-4.002 (0.552)	-3.953 (0.556)	-1.642 (0.165)	-1.705 (0.146)	-1.58 (0.13)	-1.361 (0.167)	-1.248 (0.191)	-0.771 (0.384)	
Capital Adequacy Ratio (-1)	1.091 (0.46)	1.083 (0.461)	1.089 (0.458)	0.604 (0.234)	0.541 (0.261)	0.575 (0.211)	0.53 (0.237)	0.537 (0.23)		
ΔGDP (-1)	0.081 (0.559)	0.081 (0.559)	0.081 (0.556)	0.078 (0.571)	0.088 (0.518)	0.083 (0.538)	0.058 (0.649)			
Budget Balance (% of GDP) (-1)	-0.043 (0.617)	-0.043 (0.614)	-0.047 (0.579)	-0.042 (0.613)	-0.049 (0.54)	-0.05 (0.54)				
Real Interest Rate (-1)	0.044 (0.637)	0.044 (0.638)	0.041 (0.657)	0.042 (0.645)	0.015 (0.818)					
Inflation (-1)	-0.062 (0.722)	-0.06 (0.725)	-0.062 (0.719)	-0.07 (0.677)						
Interest Rate Regulation (-1)	0.241 (0.732)	0.235 (0.735)	0.243 (0.727)							
M2 Money/ Forex Reserves (-1)	0.000 (0.81)	0.000 (0.813)								
Δ Domestic Credit (-1)	0.000 (0.948)									
Note: Coefficient (probability). Estimation Period: 1980 - 2010										

Table 5.
The effects of private sector credit regulation on crises probabilities

Dependent Variable: Crisis Onset	Regression Stage								
	1	2	3	4	5	6	7	8	9
Capital Adequacy Ratio (-1)	-0.133 (0.406)	-0.132 (0.401)	-0.122 (0.418)	-0.124 (0.412)	-0.143 (0.333)	-0.175 (0.217)	-0.168 (0.235)	-0.17 (0.229)	-0.288 (0)
Liquidity Ratio (-1)	-0.099 (0.045)	-0.1 (0.041)	-0.1 (0.039)	-0.102 (0.033)	-0.1 (0.037)	-0.091 (0.051)	-0.091 (0.052)	-0.107 (0.008)	-0.131 (0)
Δ Real House Price (-3)	0.11 (0.002)	0.11 (0.002)	0.11 (0.002)	0.109 (0.002)	0.112 (0.002)	0.101 (0.003)	0.099 (0.003)	0.1 (0.003)	0.096 (0.004)
Current Account Balance (% of GDP) (-1)	-0.092 (0.273)	-0.091 (0.268)	-0.091 (0.271)	-0.094 (0.251)	-0.113 (0.142)	-0.137 (0.045)	-0.134 (0.049)	-0.133 (0.052)	-0.156 (0.018)
Constant	-3.738 (0.181)	-3.746 (0.179)	-3.743 (0.18)	-3.638 (0.18)	-3.293 (0.214)	-2.512 (0.292)	-2.273 (0.333)	-0.947 (0.323)	
Private Sector Credit Controls (-1)	0.201 (0.406)	0.201 (0.406)	0.193 (0.421)	0.193 (0.416)	0.197 (0.398)	0.146 (0.504)	0.134 (0.536)		
ΔGDP (-1)	0.114 (0.404)	0.115 (0.395)	0.113 (0.399)	0.114 (0.394)	0.103 (0.444)	0.066 (0.597)			
Budget Balance (% of GDP) (-1)	-0.061 (0.495)	-0.061 (0.484)	-0.061 (0.484)	-0.065 (0.452)	-0.066 (0.451)				
Real Interest Rate (-1)	0.047 (0.616)	0.044 (0.493)	0.046 (0.469)	0.042 (0.493)					
M2 Money/ Forex Reserves (-1)	0.000 (0.799)	0.000 (0.797)	0.000 (0.811)						
Δ Domestic Credit (-1)	0.000 (0.821)	0.000 (0.823)							
Inflation (-1)	-0.006 (0.971)								

Note: Coefficient (probability). Estimation Period: 1980 - 2010

Table 6.
Estimated AUCs for model selection

MODEL	Baseline	Interest rate regulation	Capital and Interest rate regulation crossed
AUC	0.785	0.774	0.792

Table 7.
In-sample prediction

	Belgium	Canada	Denmark	Finland	France	Germanay	Italy
2007	√	√	√	×	√	×	√
2008	√	√	√	×	√	×	×
	Japan	Neths	Norway	Sweden	Spain	UK	US
2007	×	√	×	√	√	√	√
2008	×	√	√	×	√	√	√
	Notes: The red circle highlights the Systemic Banking Crises in Laeven and Valencia						

Table 8.
Out of sample predictions

	Years			
Countries	2009	2010	2011	2012
Belgium	√	√	×	×
Canada	√	√	√	√
Denmark	√	√	×	×
Finland	√	√	×	×
France	√	√	×	×
Germany	×	×	×	×
Italy	×	×	×	×
Japan	×	×	×	×
Neths	√	√	×	×
Norway	×	×	×	×
Sweden	√	×	×	×
Spain	√	√	×	×
UK	√	√	×	×
US	×	×	×	×

Note: The red circle highlights the Systemic Banking Crises in Laeven and Valencia, with a tick denoting a call

Table 9.
Relative contributions of variables to crisis probabilities

	Regulation	Capital	Liquidity	Real house prices
1980s	-0.01	0.1	-0.05	0.89
1990s	0	1.18	0.02	-0.27
2000s	0.04	-0.03	0.38	0.55
Source: Authors' calculations				

Table 10.
Results for country elimination tests

Final panel (a)	UK	US	Japan	US and Japan	Norway	Finland	Sweden
Interest Rate Regulation	not included	not included	not included	not included	not included	not included	not included
-0.226	-0.196	-0.167	-0.250	-0.189	-0.315	-0.363	-0.225
(0)	(0.002)	(0.19)	(0.014)	(0.003)	(0.002)	(0)	(0.006)
-0.093	-0.084	-0.088	-0.094	-0.090	-0.098	-0.110	-0.092
(0.008)	(0.024)	(0.013)	(0.007)	(0.011)	(0.005)	(0.002)	(0.009)
0.116	0.114	0.121	0.116	0.121	0.119	0.129	0.116
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Final panel (b) Interaction Interest Rate Regulation and Capital Adequacy	UK not included	US not included	Japan not included	US and Japan not included	Norway not included	Finland not included	Sweden not included
-0.031	-0.028	-0.024	-0.028	-0.026	-0.026	-0.033	-0.024
(0)	(0.002)	(0.005)	(0.021)	(0.003)	(0.023)	(0.001)	(0.015)
-0.130	-0.116	-0.102	-0.125	-0.115	-0.120	-0.140	-0.111
(0)	(0.006)	(0.005)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
0.101	0.101	0.117	0.102	0.111	0.100	0.101	0.104
(0.003)	(0.003)	(0.001)	(0.003)	(0.002)	(0.003)	(0.004)	(0.002)
-0.158	-0.147	-0.123	-0.157	-0.146	-0.155	-0.165	-0.154
(0.018)	(0.037)	(0.078)	(0.019)	(0.033)	(0.017)	(0.017)	(0.020)

Note: t-statistics in brackets.

Table 11.
Results for the second lag

	Final panel (a) Interest Rate Regulation	Final panel (b) Interaction Interest Rate Regulation and Capital Adequacy
Interest Rate Regulation (-2)	-0.228	-
	(0)	-
Liquidity Ratio (-2)	-0.088	-0.126
	(0.008)	(0)
D Real House (-3)	0.117	0.102
	(0)	(0.002)
Interest Rate Regulation*Capital Adequacy Ratio (-2)	-	-0.031
	-	(0)
Current Account Balance (% of GDP) (-2)	-	-0.185
	-	(0.012)

Note: t-statistics in brackets

Table 12.
Results for the impact of sub-prime crisis

	Final panel (a) Interest Rate Regulation	Final panel (b) Interaction Interest Rate Regulation and Capital Adequacy
Interest Rate Regulation (-1)	-0.330	-
	(0)	-
Liquidity Ratio (-1)	-0.053	-0.084
	(0.1464)	(0.018)
D Real House (-3)	0.110	0.097
	(0.003)	(0.019)
Interest Rate Regulation*Capital Adequacy Ratio (-1)	-	-0.055
	-	(0)
Current Account Balance (% of GDP) (-1)	-	-0.350
	-	(0.010)

Note: t-statistics in brackets

Figure 1.
Decade averages of regulatory variables in OECD (1980-89)

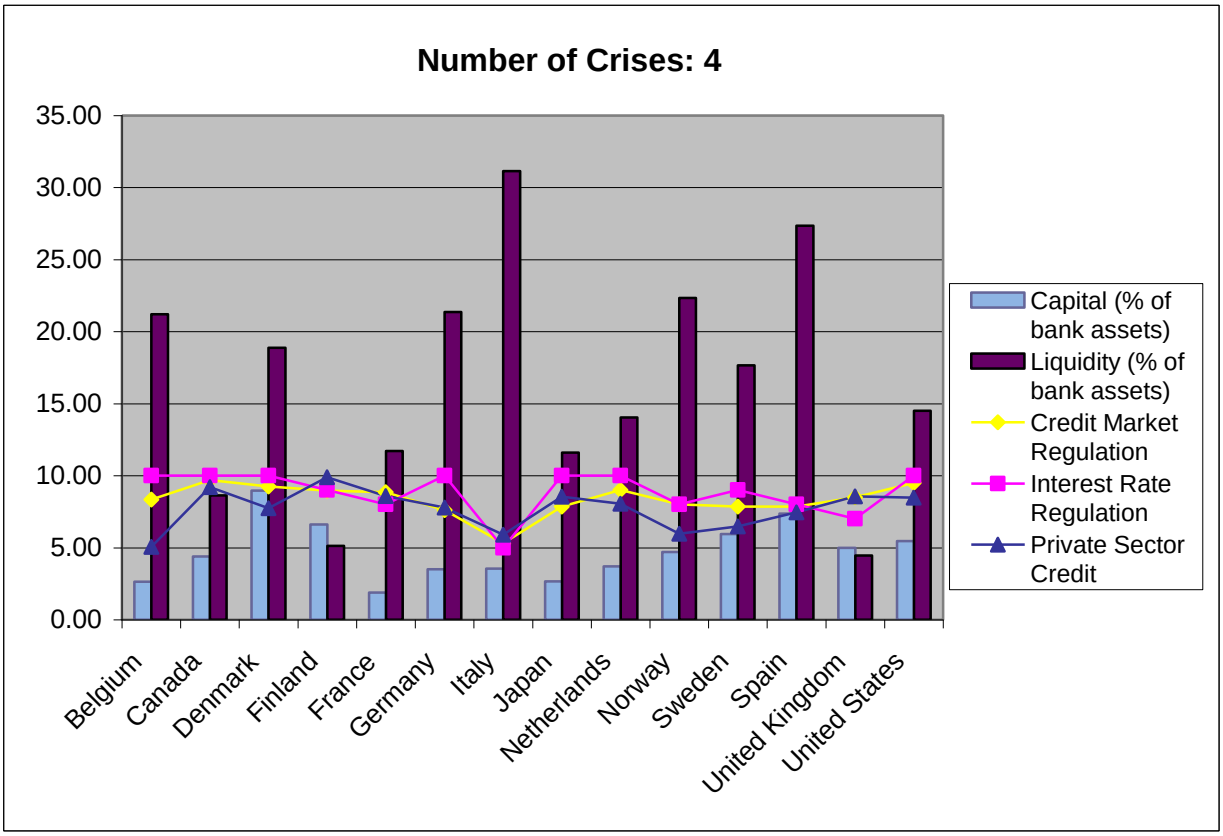


Figure 2.
Decade averages of regulatory variables in OECD (1990-99)

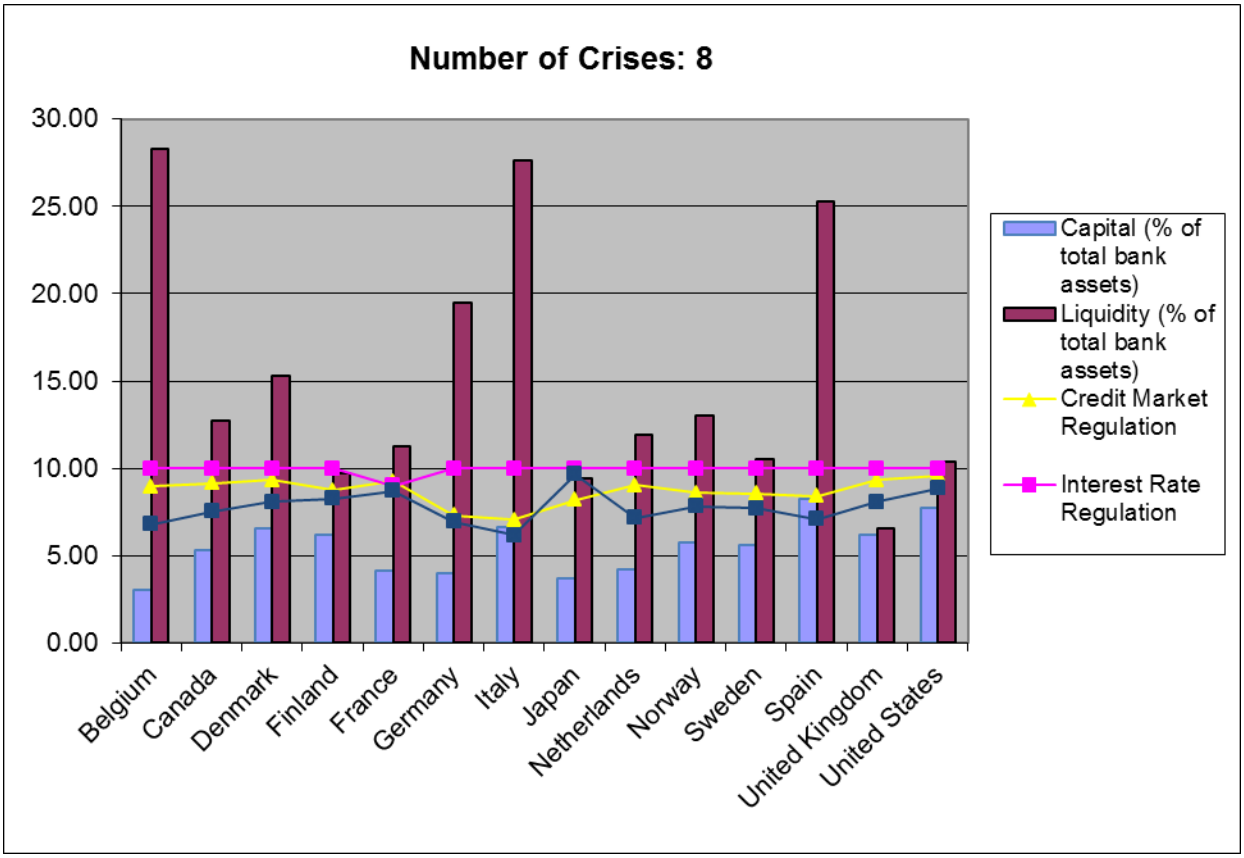


Figure 3.
Decade averages of regulatory variables in OECD (2000-10)

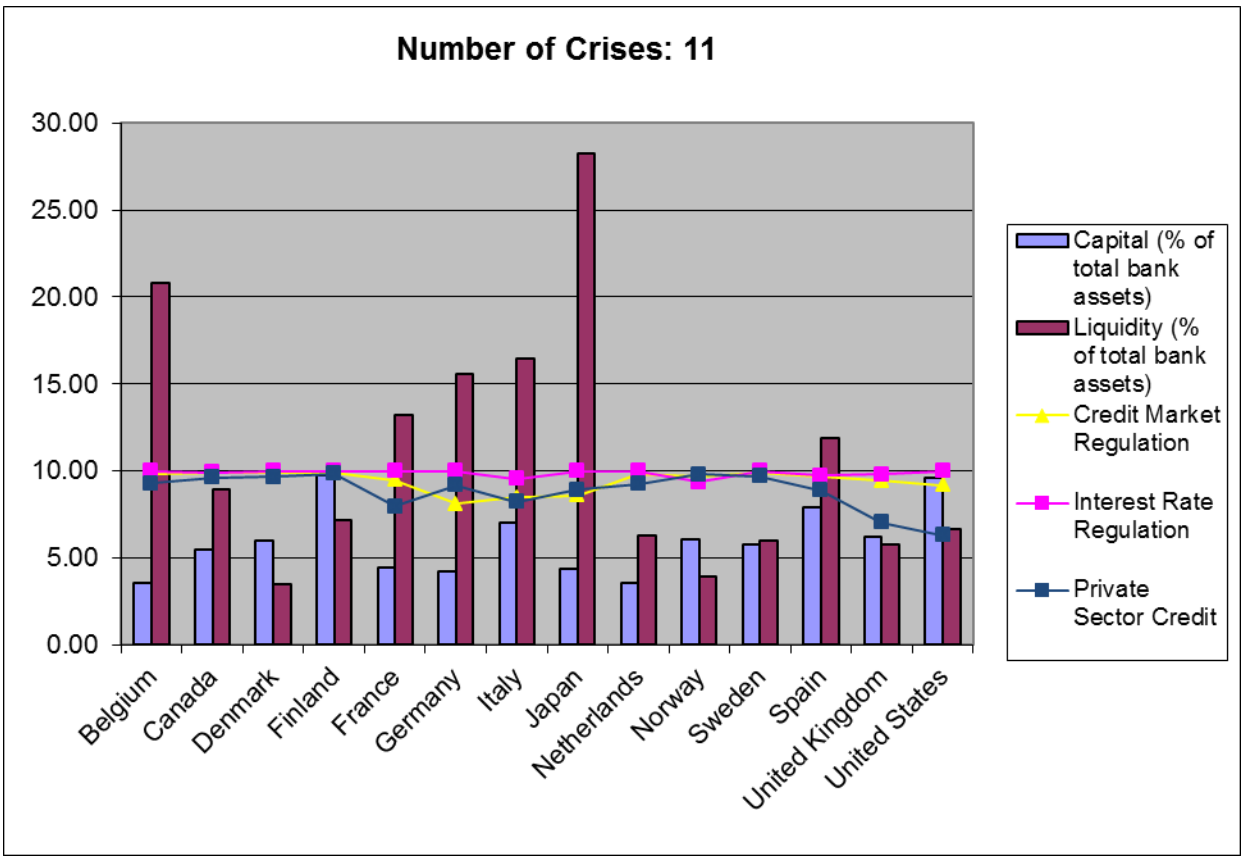


Figure 4.
ROCs for Fitted Models

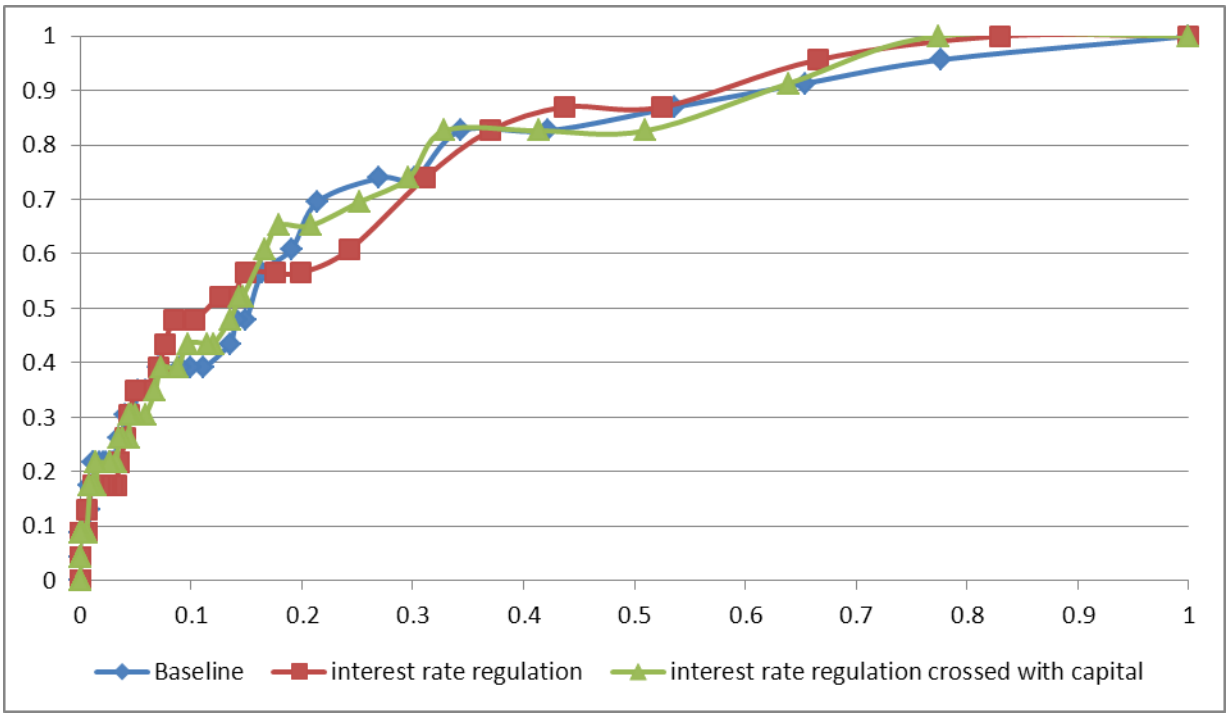
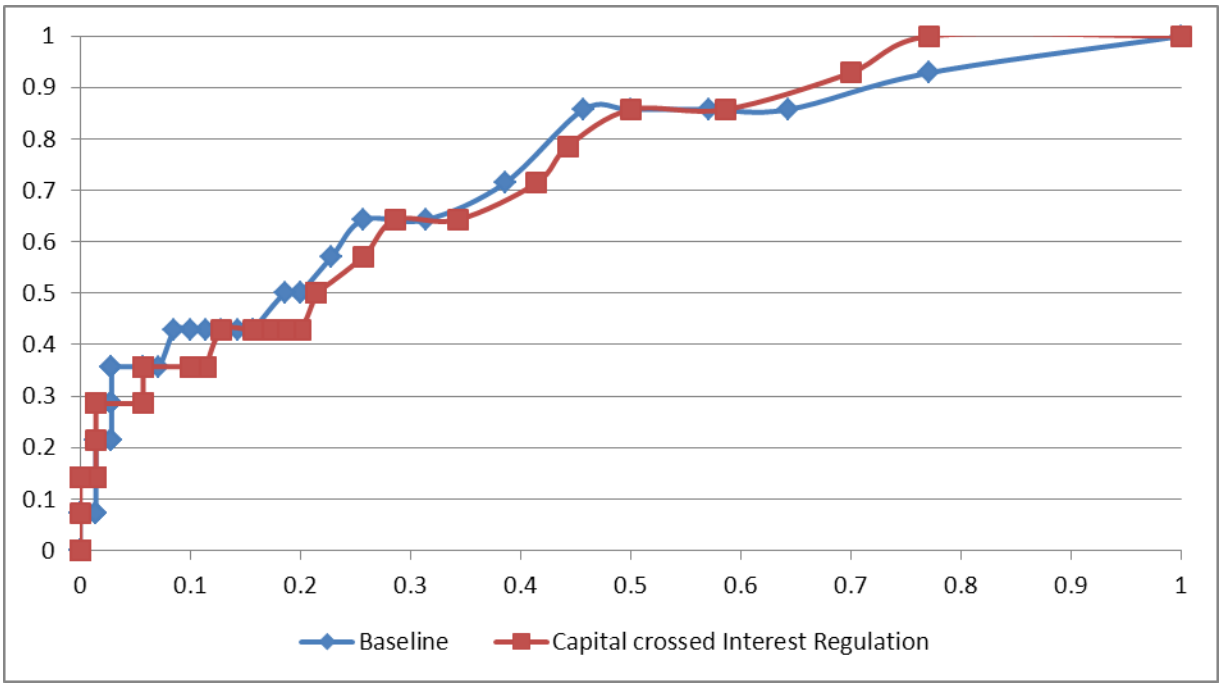


Figure 5.
Forecast ROC Curves for the baseline and crossed models



Appendix A:

Category	Description
Economic Freedom variables – Fraser Institute	
Credit Market Regulations	The indicators included in the index for credit market freedom are: (1) ownership of banks; (2) private sector credit; and (3) interest rate controls/negative real interest rates.
Ownership of Banks	An indicator of the percentage (%) of bank deposits held in privately owned banks. Countries with higher shares of privately held deposits received higher ratings. A zero rating is assigned when private deposits are 10% or less of the total.
Private Sector Credit	This variable measures the extent to which government borrowing crowds out private borrowing. It is calculated as the government fiscal deficit as a share of gross saving. Higher values are associated in higher economic freedom.
Interest rate controls/negative real interest rates	This variable is constructed using data on credit-market controls and regulations. Greater values are allocated to countries where interest rates determined by the market, monetary policy is stable, and there are positive real deposit and lending rates. A zero rating is assigned when the deposit and lending rates are fixed by the government and real rates are persistently negative by double-digit amounts or hyperinflation had virtually eliminated the credit market.

Sources: 2012 Economic Freedom Dataset, published in Economic Freedom of the World: 2012 Annual Report
Publisher: Fraser Institute