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What is the net effect of financial liberalization on bank productivity? A decomposition analysis of bank total factor productivity growth

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ABSTRACT

We employ a unique framework to quantify the net effect of financial liberalization on banks' total factor productivity (TFP) growth through a decomposition analysis of two effects: a positive direct effect of financial liberalization on bank TFP growth; and a negative indirect effect operating through a higher propensity to systemic banking crisis. The empirical decomposition is based on a sample of 1,530 banks operating in 88 countries over the period 1999-2011. We find that the net effect of financial liberalization on bank TFP growth is positive: the direct positive effect outweighs the negative one. An important policy implication flows from these findings.

JEL Classification: G01; G21; G28; G32; D24; E44

Keywords: Financial liberalization; Banking crisis; Systemic risk; Bank productivity; Total factor productivity.

1. Introduction

Over the past three decades, the world has seen sustained financial liberalization and increasing levels of global financial integration and bank competition. As a result of these forces, banking sectors worldwide have undergone substantial changes aimed at enhancing efficiency and productivity through, for example, implementing more effective organizational structures and 'best practice' approaches, developing IT infrastructures, introducing new financial products and services and, more generally, exploiting more efficient methods of capital allocation to reduce intermediation costs (Isik and Hassan, 2003a; Levine, 2001). Indeed, much research, albeit mostly based on single-country studies, has documented empirically the direct positive effect of financial deregulation on bank productivity growth (see, *inter alia*, Berg et al., 1992; Isik and Hassan, 2003a; Kumbhakar and Lozano-Vivas, 2005; Nakane and Weintraub, 2005; Tirtiroglu et al., 2005).[1]

Alongside the direct effect of financial liberalization on bank productivity, a separate strand of literature has highlighted how the trend of financial liberalization, accompanied by greater bank lending and risk taking under more deregulated and internationally diversified financial regimes (Demirgüç-Kunt and Detragiache, 1999 and 2002; Gulamhussen et al., 2014; Fielding and Rewilak, 2015; Caballero, 2016), has led to increased co-dependence in default risk of commercial banks around the world, making them more susceptible to common exposure to economic, liquidity and information shocks that increase the likelihood of a systemic banking crisis (Anginer and Demirgüç-Kunt, 2014). Indeed, as recently observed by Cubillas and González (2014) in their compelling analysis of the channels

[1] But, for mixed findings, see also the studies by Wheelock and Wilson (1999), Mukherjee et al. (2001), Alam (2001), Dogan and Fausten (2003), Isik and Hassan (2003b) and Sanyal and Shanker (2011). At cross-country level, there is a paucity of research that investigates the impact of financial liberalization (or more generally technological, regulatory or environmental changes) on bank TFP growth, mostly reporting positive effects (see Casu et al., 2004; Brissimis et al., 2008; Koutsomanoli-Filippaki et al., 2009; Delis et al., 2011).

through which financial liberalization increases risk taking by banks and affects banks' financial stability, a consensus seems to have emerged around the idea that financial liberalization – as a result of all of its multifaceted manifestations ranging from greater international diversification to increased co-dependence – is one of the main culprits of the higher frequency and intensity of banking crises since the mid-1980s (see also Kaminsky and Reinhart, 1999; Mehrez and Kaufmann, 2000; Aka, 2006; Gupta and Karapatakis, 2008; Kaminsky and Schmukler, 2008).[2]

Banking crises, in turn, by generating substantive output losses and a wide variety of sector-specific and economy-wide inefficiencies, have been found to impact firm productivity negatively, including labor productivity, both in the short- and long-term. For example, Oulton and Sebastiá-Barriel (2013) argue that since crises impede the reallocation of capital from less productive to more productive uses, they hinder the productivity growth of firms. Although it can be argued that by eliminating inefficient/unproductive banks crises should help raise the overall productivity of the industry, it can also be argued that with the same inputs, many banks loose substantial outputs (loan charge offs, depreciated portfolio of securities, etc.) during the crises, which may cause bank productivity to decline and, in some cases, banks may even fail.[3] With such failures, the level of outputs with respect to inputs gradually decline. Millard and Nicolae (2014) highlight, using an endogenous growth model, an alternative channel through which a financial shock, by reducing a firm's capacity to innovate via increased cost of borrowing, can permanently hinder its total factor productivity (TFP). Earlier, Isik and Hassan (2003b) demonstrated, using a non-parametric Malmquist

[2] But see also Angkinand et al. (2010), Noy (2004) and Menkhoff and Suwanaporn (2007), who find that the relationship between financial liberalization and banking crises is mitigated by the implementation of institutional reforms and prudential regulation. Majerbi and Rachdi (2014) also find that more stringent banking regulation and supervision, better law and order, government stability, and lack of corruption and bureaucratic efficiency, generally lower the probability of crises.

[3] For evidence showing that inefficient banks are more likely to fail, see, e.g., Wheelock and Wilson (1995, 2000).

TFP change index, how the Turkish 1994 banking crisis (after financial deregulation in the 1980s) seriously disrupted its banking sector productivity (and efficiency) through a general decline in economic activity which resulted from suppressing bank loans and services to households and firms.

Despite the widespread acknowledgement that financial liberalization has sometimes seemed to cause more problems than it has solved (as epitomized by the title of a well-known study by Diaz-Alejandro, 1985, "*Good bye financial repression, hello financial crash*"), with the notable exception of the study by Ranciere et al. (2006), to our knowledge, relevant literature has never attempted to integrate the two contrasting views on the impact of financial liberalization within a unifying empirical framework capable of gauging the net effect. Ranciere et al. (2006) develop an integrated framework to empirically quantify and contrast the economy-wide dual effects of financial liberalization on long-term average (output) growth on the one hand, and financial crises (defined by the concomitance of a banking crisis and a currency crisis) on the other. However, to date, no subsequent study has applied this unique methodological framework to investigate the sector-specific consequences of financial liberalization for banking business (or any other sector in fact), at either single- or cross-country level.

Drawing on the novel empirical strategy developed by Ranciere et al. (2006), the present study contributes to this literature by decomposing the dual effects of financial liberalization on the banking sector. Specifically, we decompose the impact of financial liberalization on bank productivity into two contrasting effects: (i) a positive direct effect on bank total factor productivity growth; and (ii) a negative indirect effect on bank total factor productivity via a higher propensity to a systemic banking crisis (due to greater risk taking,

bank risk and financial fragility).[4] Whilst these two individual effects (alongside the various underlying channels that lead to them) have been already amply investigated and are well documented in relevant literature, the attempt to ascertain empirically the net effect – which constitutes the central purpose of the present analysis - has not yet been reported in the literature. Our empirical decomposition of the effects of financial liberalization is based on an international sample of 1,530 banks operating in 88 countries over the period 1999-2011.

The critical innovation inherent in our application of Ranciere et al.'s analytical framework lies in our consideration of *bank total factor productivity* (TFP) growth rather than economy-wide output growth.[5] There is a purposeful rationale for the choice of this specific TFP measure given our interest in the effects of financial liberalization. As noted by Fiordelisi and Molyneux (2010), the changing structural landscape of banking systems resulting from financial liberalization can be expected to impact on the efficiency and productivity of the banking sector. As in the case of an economy-wide system, the capacity of the banking sector to supply services depends both on the quantities and qualities of the primary inputs into the production process – capital and labor – and on the efficiency with which they are combined.[6] This concept embeds the notion of TFP, which provides an ideal

[4] In broad terms, a systemic banking crisis is said to occur when much or all of the banking capital in the country is exhausted, a situation emerging when the total value of the banking system liabilities exceeds the value of its assets (see, e.g., Caprio and Klingebiel, 2003; and Honahan and Laeven, 2005). However, in our empirical analysis, we employ the measure developed by Laeven and Valencia (2008; 2012; 2013) according to which systemic banking crises are events in which there are both significant signs of financial distress and significant policy interventions in banking. Whilst recognizing that bank risk is exogenously determined while bank risk taking is endogenous (since it stems from bank behaviour), the latter can have amplified knock-on effects on the former thereby increasing the overall financial fragility of the banking system and expose it to a higher likelihood of crises.

[5] At an aggregate, economy-wide level, Kose et al. (2009) have also re-directed attention on the value of considering the effects of financial openness on TFP growth rather than output growth (see also Mishkin, 2006; Bonfiglioli, 2008; Bekaert et al., 2011). We extend this investigative route by considering the bank TFP growth indicator as the ideal bank productivity measure.

[6] It bears reminding that the original economy-wide measure of TFP growth is based on the Solow residual, referred to as that part of output growth that cannot be accounted for by the growth of the primary factors of production, i.e., capital and labor.

measure to capture the productivity and supply capacity of the banking sector, and how this is affected by financial liberalization. Other novel features that distinguish our contribution from that by Ranciere et al. (2006) include the adoption of a more comprehensive model that caters for both bank specific and country level influences in the estimation of crises and TFP growth in addition to using more up-to-date measures of *de jure* and *de facto* financial liberalization. Moreover, we explicitly control for endogeneity bias in our robustness checks.

To carry out our investigation we adopt a two-stage empirical approach which involves estimating bank TFP growth in the first stage and then assessing the dual effects of financial liberalization on bank TFP growth in the second stage. In estimating bank TFP growth, we follow most previous studies in the bank productivity literature by deriving Malmquist indices using Data Envelopment Analysis (DEA) techniques of all the banks included in our sample**.** Then, following the empirical strategy of Ranciere et al. (2006), we use a 'treatment effect' model to decompose the impact of financial liberalization on bank TFP growth into the two effects discussed above.

Our results indicate that financial liberalization has a positive direct impact on bank TFP growth. We also find that liberalization leads to a higher propensity to banking crises, themselves, in turn, having a negative impact on bank TFP growth. However, in net terms, the positive bank TFP growth effect more than outweighs the negative one.

The rest of the paper is organized as follows. In Section 2, we describe the methodology and data. Section 3 presents and discusses the results. Section 4 concludes.[7]

[7] We refrain from adding a literature review section because a synthesis of previous studies beyond those already elaborated upon in our introduction would add little, and merely obfuscate the significance of the novel analysis underlying the present contribution. This is particularly so when acknowledging that while many studies have already investigated the specific mechanisms underlying the individual positive or negative effects of financial liberalization on bank productivity, none of them has developed an integrated framework to quantify the net effect, which constitutes the original endeavour of our empirical investigation.

2. Empirical methodology

2.1. Measuring total factor productivity change

There are two alternative ways of measuring TFP change of a production unit (or decision making unit), the parametric approach (as documented in Kumbhakar and Lovell, 2003) and the nonparametric method (as in Coelli et al., 2005). While there is no consensus on the ideal method,[8] as both approaches have advantages and disadvantages, we opt for the nonparametric DEA-based Malmquist method, which is the one most commonly used to estimate the impact of deregulatory reforms in the banking sector. The popularity of the DEA-based Malmquist method stems from its computational ease, and the fact that it does not rely on assumptions of economic behaviour such as cost minimization or profit maximization or any particular functional form for estimation.[9] The limitation of this method is that – unlike the parametric approach – it cannot separate measurement errors and random noise from technical inefficiency but since in the present study we are not interested in testing specific hypotheses regarding the assembling components of bank TFP growth, the DEA-based Malmquist method is fit for purpose.

In order to derive bank TFP growth estimates, we follow Delis et al. (2011) who favour the *output-oriented* Malmquist method.[10] Defined by Caves et al. (1982) and

[8] Casu et al. (2004) compare the two methodologies and reveal broadly similar results in terms of identifying the components of productivity growth in European banking during the 1990s.

[9] Unlike the statistical regression method that tries to fit a regression plane through the data average, DEA uses linear programming techniques to float a piecewise linear surface to rest on top of the data. This means that while the regression method estimates the parameters in the assumed functional form by a single optimization over all the production units, DEA uses optimizations for different production units without *a priori* assumptions on the underlying functional forms.

[10] Coelli et al. (2005) suggest that the DEA linear programming technique does not suffer from statistical problems such as simultaneous equation bias, and so the choice of output or input orientation is not crucial. In many instances, such a choice has only a minor influence upon the scores obtained (Coelli and Perelman, 1999). Our results confirm this as the correlation obtained by comparing the TFP results using both output and input orientated approaches is close to 1.

estimated using DEA techniques by Fare et al. (1994), the Malmquist index expresses the change in TFP as:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{\mathrm{D}^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

where M_o refers to the productivity change from time *t* to *t+1*; and $D^t(x^t, y^t)$ denotes the output distance to the production frontier under the production combination (x^t, y^t) at time *t*. A value of M_o greater than one indicates positive TFP growth while a value less than one indicates a decrease of TFP.

As anticipated above, a virtue of the Malmquist index approach to productivity measurement is that it provides a computationally simple decomposition of TFP change (TFPCH) into *technological change* (TECH), which is associated with a shift in the best practice frontier, and *technical efficiency change* (TEFCH), which reflects the proximity of the sample banks to the frontier on average (the 'catch-up' effect). This decomposition is useful in identifying the sources of changes in productivity (growth or disruptions) that may be linked to episodes of credit booms or crises during the period of investigation. As Isik and Hassan (2003a) show, the technical change component of TFPCH reflects *technical progress* if the production frontier shifts upward or *technical regress* if the frontier shifts downward. While the former may result from financial innovation or heightened competition, the latter may stem from a financial shock or crisis.

2.2. The treatment effect model

In order to examine the decomposed effect of financial liberalization (FL) on bank productivity growth, the Malmquist TFP growth scores serve as the dependent variable in the

estimation of a productivity growth model which includes a financial liberalization measure and a banking crisis dummy. Furthermore, we treat the banking crisis dummy as an endogenous variable that depends on other variables including a financial liberalization indicator. Thus we use an integrated model to assess the dual effects of financial liberalization, comprising a *productivity growth equation* as well as a *crisis equation*.

The *productivity growth equation* has the following specification:

$$y_{i,j,t} = \alpha X_{i,j,t} + \beta FL_{j,t} + \gamma I_{j,t}^{crisis} + \delta M_{j,t} + \theta_t + \lambda_j + \varepsilon_{i,j,t} \qquad (1)$$

where $y_{i,j,t}$ is TFP growth of bank *i* that operates in country *j* at time *t*; $FL_{j,t}$ is a country level financial liberalization indicator; $I_{j,t}^{crisis}$ is a dummy variable taking value one if country *j* experienced a banking crisis in period *t* and zero otherwise. Additionally, we account for bank level control variables $X_{i,t}$, country level control variables $M_{j,t}$, and year and country fixed effects θ_t and λ_j, respectively. $\varepsilon_{i,j,t}$ is the random error term.

The *crisis equation* includes the banking crisis dummy $I_{j,t}^{crisis}$ as an endogenous variable. $I_{j,t}^{crisis}$ depends on the realization of an unobserved latent variable W_{jt}^{*} under the following conditions:

$$I_{j,t}^{crisis} = \begin{cases} 1 \text{ if } W_{j,t}^{*} > 0 \\ 0 \text{ otherwise} \end{cases} \qquad (2)$$

$$W_{j,t}^{*} = aZ_{j,t} + \mathrm{b}FL_{j,t} + \varphi_{j,t}$$

The above equations (1) and (2) make up the integrated model that allows us to examine the decomposed effects of financial liberalization on bank productivity growth through a direct TFP growth channel, and an indirect banking crisis channel which captures the associated costs of banking crises in terms of lower productivity growth. Like Ranciere et al. (2006) we assume that W_{jt}^{*} is a linear function of a set of control variables (covariates)

$Z_{j,t}$, of the financial liberalization indicator $FL_{j,t}$, and of a random term $\varphi_{j,t}$. Under 'white noise' assumption, i.e., $\varphi_{j,t} \sim N(0,1)$, the *crisis equation* can be re–expressed as:

$$I_{j,t}^{crisis} = \begin{cases} 1 \text{ with probability} : \Pr\left(W_{j,t}^{*} > 0\right) = \Phi\left(aZ_{j,t} + bFL_{j,t}\right) \\ 0 \text{ with probability} : \Pr\left(W_{j,t}^{*} \le 0\right) = 1 - \Phi\left(aZ_{j,t} + bFL_{j,t}\right) \end{cases}$$

where Φ denotes the cumulative distribution function of the standard normal distribution. This transformation ensures that the fitted probabilities will lie between 0 and 1, making estimation of the parameters suitable through a probit model.

It is useful to point out that the mixed model made up by (1) and (2) above is analogous to a *treatment effect model* for which standard estimation techniques apply (see Heckman, 1978; and Maddala, 1983). The banking crisis dummy represents the 'treatment', the productivity growth regression (1) corresponds to the 'outcome equation', and regression (2) is the 'treatment equation' reflecting the probability of the effect of the treatment on the outcome.

Consistent estimation of the treatment effect model requires that the error terms $\varepsilon_{i,t}$ and $\varphi_{i,t}$ are bivariate normal, with a zero mean and a covariate term Ψ of the resulting covariance matrix $\begin{pmatrix} \sigma & \Psi \\ \Psi & 1 \end{pmatrix}$ equal to zero, implying independence of equations (1) and (2) (see, for example, Wooldridge, 2002). However, the highly restrictive assumption that the covariance term Ψ will be zero may not be plausible and, if different from zero, estimation by OLS will tend to overestimate the treatment (Greene, 2000). One way to address this problem is to employ the traditional two-step procedure suggested by Maddala (1983). This entails, in the first step, obtaining probit estimates of the probability of banking crises:

$$\Pr\left(I_{j,t}^{crisis} = 1\right) = \Pr(W_{jt}^{*} > 0) = \phi\left(aZ_{j,t} + bFL_{j,t}\right)$$

Using the probit estimates $(\hat{a}, \hat{b})$, a hazard $h_{j,t}$ is then obtained for each *j,t* observation. In the second step, the productivity growth regression (1), i.e., the 'outcome equation', is estimated with the hazard added as an additional covariate so as to obtain consistent estimates for the parameters ($\alpha, \beta, \gamma, \delta$).

The total effect of financial liberalization on TFP growth is the sum of a direct effect and an indirect effect due to a change in the probability of a banking crisis:

$$\text{Total effect} = \underbrace{\hat{\beta}}_{\text{direct effect}} + \underbrace{\hat{\gamma}.E\left\{\Phi\left(\hat{a}Z_{j,t} + \hat{b}\right) - \Phi(\hat{a}Z_{j,t})\right\}}_{\text{indirect effect}} \qquad (3)$$

where $E\{.\}$ represents the (average) partial effect of financial liberalization on crisis probability.

In this application, therefore, the protocol developed by Ranciere et al. (2006) allows us to estimate jointly the linear productivity growth regression model and the probit model of a banking crisis. Given the findings from the literature cited in our introduction, our *a priory* expectations are that the direct bank TFP growth effect is positive and the indirect effect – via a higher probability of a banking crisis – is negative. As for the net effect, this remains the crucial empirical question the present study aims to shed light on.

2.3. Variables and data

The above model is estimated using data from a sample of 1,530 commercial banks from 88 countries covering the period 1999-2011. The chosen period is dictated by data availability and, given the similarity of production technology assumption implicit in our analysis, the sample is restricted to commercial banks only so as to ensure fair comparison of TFP estimates at cross-country level. During the sample period, a major systemic banking crisis occurred in 2007-08 although there were other episodes of such crises, both in earlier and later years, which affected a handful of countries, such as Turkey (2000), Argentina (2001), Dominican Republic (2003) and Nigeria (2009). According to the data from Laeven

and Valencia (2013), a total of 22 countries (out of 88 in our sample) were characterised as having reached systemic crisis proportions in 2011. A typical feature of these crises is that they are preceded, in most cases, by credit booms normally associated with greater financial integration.

Appendix A provides the list of countries in our sample, showing the number of banks as well as bank-year observations for each country, making up a total of 9,838 bank-year observations. Since there was significant growth in the number of banks over the sample period as well as numerous bank failures and mergers and acquisitions (M&As), we take account of these features in our empirical investigation by constructing an unbalanced panel to avoid selectivity bias.[11] In Appendix A, we also indicate the start year for the countries which suffered a systemic banking crisis during the period.

Descriptions of the sources of the variables employed in the empirical analysis are presented in Appendix B and the associated summary statistics are given in Table 1. All bank-level data were obtained from the balance sheets and income statements of commercial banks in the Bankscope database, and data for each individual bank were expressed in US million dollars for a given year, converted to 1995 prices (using country-specific GDP deflators). To ensure that our results are not driven by outliers, all the bank level data were "winsorized" at the 5% and 95% levels and, for a high degree of consistency, the data were also screened for reporting errors, inconsistencies and missing values.

[Insert Table 1 here]

In calculating the Malmquist TFP index, we employ the widely accepted intermediation approach (Sealey and Lindley, 1977) to select inputs and outputs, which

[11] A balanced panel would impose the onerous requirement that banks exist throughout the 12 year period of our study, a hard challenge in turbulent markets. To avoid the possibility of selection bias towards the "champions", who are most likely to have survived during crises periods, we choose an unbalanced panel, which also accommodates for new entries, M&As and banks failures.

assumes that banks collect funds, using labor and physical capital, to transform them into various financial services and products. Accordingly, following Delis et al. (2011) and others, we use three outputs: loans (LOAN), other earning assets (OEA), and non-interest income (NII). The three inputs to produce these outputs are: fixed assets to also account for property and equipment (FA), deposits and short-term funding (DSTF), and personnel expenses (PE). Lack of available data on stock values for labor, capital and off-balance sheet items implies that, as done in other cross-country studies (see, among others, Brissimis et al., 2008; Delis et al., 2011; and Chortareas et al., 2013), we resort to using flow variables to represent these quantities.

In estimating the dichotomous effect of financial liberalization (FL) using the treatment effect model, we account for two alternative, yet complementary, measures: a *de jure* indicator, as constructed by Chinn and Ito (2008), and a *de facto* indicator, as developed by Kose et al. (2009).[12] The *de jure* indicator is constructed on the basis of the information published in the IMF Annual Report on the *Exchange Arrangements and Exchange Restrictions* (AREAER) to measure the intensity of capital market liberalization. The *de facto* indicator is computed from the ratio of sum of the gross stocks of foreign assets and liabilities to GDP and based on the work of Lane and Milesi–Ferretti (2007).[13] Figure 1 depicts the

[12] Well aware of the risks involved in opening the Pandora's box of the whole set of measures covered by the use of the term 'financial liberalization', which are still the subject of debate, our use of both *de jure* and *de facto* measures of financial liberalization can nevertheless be said to capture the most salient features of the construct, namely, the freedom of finance to move into and out of an economy (proxied by capital account liberalization) and, as a result of deregulation of financial markets, the freedom of banks to pursue profits unhindered by government directives, including the removal of restrictions on the ownership of banks, leading to de-nationalisation and freedom for foreign ownership (proxied by the ratio of sum of the gross stocks of foreign assets and liabilities to GDP).

[13] Like Kose et al. (2009), Gehringer (2013) too argues that a *de facto* measure of liberalization is a more reliable indicator. Accordingly, following the approach of recent studies (e.g., Luo et al., 2016), we employ both measures for comprehensiveness and comparative purposes. Alternative (composite) measures of liberalization, based on Abiad et al. (2008), which have been used in several studies (e.g., Angkinand et al., 2010; Majerbi and Rachdi, 2014) are not available over a recent time period.

evolution of these variables (averaged across all countries in the sample), revealing a general increase in the pace of FL prior to the recent wave of the banking crisis in 2007-08, with a concomitant decline experienced in both *de jure* and *de facto* measures of FL after 2009.

[Insert Figure 1 here]

The data on banking crises is constructed by Laeven and Valencia (2008) but we use the updated dataset of Laeven and Valencia (2013), which includes information up to 2011 (see also Laeven and Valencia, 2012). Chaudron and de Haan (2014) recently analyzed the robustness of three databases of banking crises in terms of their consistency in the identification and timing of crises and found that whilst there were large and statistically significant discrepancies between the three datasets, the database compiled by Laeven and Valencia, which is the one we use, proved to be the most accurate. This database identifies 'systemic banking crises' defined as events in which there are both: (i) significant signs of financial distress (bank runs, bank losses, bank liquidation); and (ii) significant policy interventions in banking (liquidity support, bank restructuring, nationalizations, guarantees, asset purchases, deposit freeze, bank holiday). To capture the effect of systemic crises, we follow the practice adopted in previous studies (see, e.g., Kroszner et al., 2007; Dell'Ariccia et al., 2008; Cubillas et al., 2012; Fernández et al., 2013) by using a dummy variable which takes value 1 for three years, covering the year of inception of a crisis as reported by Laeven and Valencia (2013) and the two following years, and value 0 otherwise. As Isik and Hassan (2003b, p. 306) state, "Crisis is a fundamental event, whose sources might have formed in a long time period and whose impacts could persist many years after its occurrence".[14]

[14] In this framework, the likelihood of a crisis is therefore approximated by the latent variable model $I_{j,t}^{crisis} = 1$ ($W_{jt}^{*} > 0$) for $t = 1, 2, 3$ following the onset of the systemic banking crisis in country j at time t (see Appendix B), 0 otherwise (including all countries that did not experience the crisis).

A number of bank specific and country specific control variables are included in our model. In the productivity growth equation, following prior studies that have examined bank TFP growth (see, e.g., Delis et al., 2011), we include a series of theory-based regressors that have sometimes been found to have explanatory power in its determination. These include bank specific variables, such as equity over assets (EQAS) and the natural logarithm of real total assets (SIZE), as well as their squared terms (EQAS2 and SIZE2) to capture potential nonlinearities in their relationship with productivity growth. Regarding country specific controls we include real GDP growth (GDPG), inflation (INF), the level of financial development/depth (CLAIM), and a set of regulatory variables, obtained from the Barth et al. (2013) database, representing capital stringency requirements (CAPR), supervisory power (SUP), and market discipline (MARDIS). Furthermore, we include a dummy variable (DEVEL) to account for differences between developed and developing countries in their level of economic development. Finally, as a robustness check, we also account for differences in institutional development across countries.

In the crisis equation, following Demirgüç-Kunt and Detragiache (1999), the canonical control variables include real GDP growth (GDPG), inflation (INF) and changes in the terms of trade (TOT CHANGE) to account for differences in economic and competitive conditions. Furthermore, we add the three regulatory variables (CAPR, SUP and MARDIS) to establish their influence on the probability of crisis. Additionally, we account for the influence of credit booms by including real domestic credit growth (CREDIT GRO) as a bank level control. It should be noted that in order to avoid problems of weak identification (see, for example, Arellano, 2006), following Ranciere et al. (2006), two variables are excluded from the growth equation but are included in the crisis equation. These variables are changes in the terms of trade (TOT CHANGE) and real domestic credit growth (CREDIT GRO),

which prior studies have included as relevant covariates in determining the likelihood of banking crises (Ranciere et al, 2008; Fielding and Rewilak, 2015; Caballero, 2016).[15]

3. Estimation results

3.1. Stage 1 – TFP results

Table 2 reports the geometric means of TFP growth estimates obtained using the intermediation approach. These are measured relative to a common global frontier by pooling the data across all 88 countries**,** but presented as annualised averages and for the sub-groups of 22 developed and 66 developing countries. Given our multi-country sample, we consider it appropriate to use a global frontier against which the productivity of each bank is assessed, the implied TFP growth estimates are then utilised in second-stage regressions where we control appropriately for bank level and country level differences.[16] It should be noted that for each year the estimates are calculated relative to the previous year as the base year (i.e., using successive reference technologies).[17] The last row presents the geometric mean of bank TFP growth for the whole period. As mentioned above, a value of the

[15] The selection of the probit specification could be based on the Akaike information criterion by considering dynamic lags of all the country level variables included in the growth equation in addition to the excluded variables, as suggested by Ranciere et al. (2006). Our approach, however, differs since we have bank-specific variables in the productivity growth equation and hence we follow prior studies in representing our choice, by including lags of those variables that, in addition to financial liberalization, are predicted to have explanatory power.

[16] We also considered the use of separate frontiers for developed and developing countries but found the results to be mostly unaffected as the Malmquist indices for these country groups are broadly similar to those of the combined sample, as confirmed by Spearman's rho correlations of 0.8763 and 0.8833, respectively, both statistically significant at the 1% level.

[17] The productivity change index requires that a bank included in the sample has survived for at least one previous year, which permits the use of an unbalanced panel. As Table 2 shows, an average of 644 banks are represented in the sample for the calculation of the Malmquist index, although there is a noticeable increase in the actual number of banks from 2002 to 2009, followed by a decline thereafter.

Malmquist index greater than one indicates positive TFP growth whereas a value less than one, denotes a decline in TFP.

[Insert Table 2 here]

The results in Table 2 indicate that for most of the years during the sample period, banks experienced positive TFP growth on average, consistent with banking systems worldwide benefiting from technological advances in globalised financial markets, the exception being the last two years which reveal a slight productivity decline. The results for developed and developing country banks, however, exhibit slight differences in productivity changes over time. In particular, developed banking systems experienced productivity slowdown in the years 2000-01 and 2007-08. The former could be associated with the early 2000s recession (when banks experienced efficiency losses) while the latter is likely to be linked to the onset of the systemic banking crisis (when banks suffered technical regress). In contrast, developing country banks have experienced a productivity loss in the aftermath of the crisis, although the results indicate technical regress during 2007-08.

Overall, despite the marginal loss of productivity in some years, the results show an average productivity gain of 1.59% over the whole period, while the productivity gains for developed and developing country banks are 1.49% and 1.67%, respectively. The evidence in favour of positive TFP growth is consistent with the pace of financial liberalization (and underlying financial reforms) sustained by most economies over the sample period, while the marginal decline in productivity observed in some years, particularly over the last two years, can be associated with systemic banking crises. However, a more formal investigation is warranted using a treatment effect model to attribute the positive and negative outcomes of bank TFP growth to the effects of financial liberalization and the associated banking crises.

3.2. Stage 2 - main results

The second stage of our empirical analysis examines the decomposed effects of financial liberalization (FL) on bank productivity growth through a direct TFP growth channel, and an indirect effect stemming from the banking crisis channel. The indirect channel captures the higher likelihood of banking crises via FL and the associated costs in terms of lower productivity growth.

Table 3 reports the estimation results based on a TFP change and a crisis model estimated using 6,651 bank-year observations while allowing for country and year fixed effects.[18] Panel A in Table 3 reports the results from the regression in which TFP change is the dependent variable and Panel B shows the results from the probit equation in which the systemic banking crisis dummy is the dependent variable. Specification [1] includes the *de jure* FL measure while specification [2] includes the *de facto* one. In each model standard errors are calculated using the heteroskedasticity robust cluster method with clustering at bank level (see Thompson, 2011).

[Insert Table 3 here]

The results in Panel A show that FL has a direct, positive and statistically significant effect (at the 1% level) on TFP growth in both specifications. The point estimates for two FL indicators are 0.0191 for the *de jure* measure and 0.0205 for the *de facto* measure. The results also indicate that a banking crisis has a negative and significant effect (at the 1% level) on TFP growth in both equations. The point estimates are -0.3806 (column [1]) and -0.3879 (column [2]). With regard to the control variables, bank capitalization (EQAS) is negatively and significantly related to TFP growth. In contrast, the impact of EQAS2 is positive and significant. These results suggest that, if starting from relatively high capital levels, a reduction in capital strength improves bank productivity.

[18] Although the full sample includes 8,370 observations covering the period 1999-2010, the inclusion of dynamic lags in the probit specification inevitably reduces the number of observations available for estimation.

With regard to the results reported in Panel B, financial liberalization positively and significantly increases the probability of banking crises (with point estimates 0.2473 for *de jure* and 0.1427 for *de facto*). The other control variables – GDP growth (GDPG) and credit growth (CREDIT GRO) – positively and significantly increase the probability of banking crises, while inflation (INF) is found to have the opposite effect. Among the regulatory variables, higher supervisory power (SUP) has a significant influence in reducing the probability of banking crises.

Table 4 reports the decomposition of the effects of FL on bank TFP growth. As per *a priori* expectations, we find a positive direct bank TFP growth effect and a negative indirect effect – due to a higher probability of a banking crisis. The *direct effect* of FL on bank productivity is 1.91% for the *de jure* measure and 2.05% for the *de facto* measure. The corresponding *indirect effects*, computed by multiplying the point estimate of the crisis effect in the TFP growth equation by the average partial effect of FL on the crisis probability, are -0.69% (*de jure)* and -0.41% (*de facto*).[19] Although the indirect effects of FL on bank TFP growth cannot be directly benchmarked against previous studies (which have not employed this unique methodological framework), they seem plausible to us when considering that they specifically pertain to the deleterious impact on banking sector productivity of systemic banking crises. In interpreting the results of Table 4, our interest inevitably centres upon the (net) total effect. We find that the total (net) productivity growth effect of FL is positive, ranging from 1.22% in the *de jure* case to 1.64% under the *de facto* measure. We take the latter as the most reliable estimate.[20]

[19] As the probit model is nonlinear, the partial effect of FL on crisis probability depends on the value of the other variables**.** The average partial effect (based on the formula specified in equation 3 above) is 0.01814 for *de jure* and 0.01056 for the *de facto* measure. Hence, the indirect productivity growth effects are, respectively: -0.3806*0.01814 = -0.0069 (*de jure*) and -0.3879*0.01056 = -0.0041 (*de facto*).

[20] Significant discrepancies between estimates of *de jure* vs. *de facto* measures are not uncommon since differences between the policy regimes reported, and those in place *de facto,* can be

[Insert Table 4 here]

3.3. Robustness tests

In an attempt to address potential endogeneity concerns, as well as possible omitted variable or sample selection biases, we conduct a series of robustness checks in this section thereby verifying the sensitivity of the results to changes in the estimation method, model specification and sample size.

A standard critique of OLS estimation (of the TFP growth model, in the present analysis) is that it captures a correlation that may in fact be driven by reverse causality – the possibility that higher productivity growth of banks attracts more foreign capital. While it is difficult to establish how bank productivity growth could be linked to incentives explaining a country's tendency to be financially more liberalized, or its higher propensity to systemic crises,[21] we nevertheless address the potential reverse causality – and the associated endogeneity of financial liberalization and crises – by using two-stage least squares instrumental variables (2SLS-IV) estimation of the TFP growth model, combined with maximum likelihood estimation of the probit model (as before). The instruments of the TFP growth regression, in this instance, are the lagged values of the explanatory variables in the probit model, which are confirmed as valid instruments by using a Sargan test for over-identifying restrictions.

considerable, as is well documented in the literature also across a wider range of economy-wide policies reported by countries to the IMF, such as exchange rate regimes (see, e.g., Abbott et al., 2012).

[21] It could be argued that more efficient or productive banks have larger foreign assets or liabilities because their home countries aim to maintain increased cross-border operations through trade (see Niepmann, 2015). Alternatively, it may be presumed that countries with more productive banks are less prone to banking crises owing to better regulatory systems. These arguments, while not strictly implying that financial integration or crises are directly associated with bank productivity, make it apparent that reverse causality cannot be ruled out completely.

The results of this estimation are shown in Table 5, where we report only the estimates of the TFP growth model (since the probit results are the same as those in Table 4). Apart from a higher negative impact of banking crises and a higher positive impact of financial liberalization, the results are generally robust to this estimation method. Consequently, as reported in Table 6, the total net effect of FL on bank TFP growth remains positive (for both measures) although the direct and indirect effects are more pronounced compared to the values reported in Table 4. These results indicate that the cyclical 'boom-bust' impact on bank productivity growth is relatively stronger, although the net effect is slightly lower (higher) for the *de jure* (*de facto*) measure of FL.

[Insert Tables 5 and 6 here]

To investigate possible omitted variable bias, we consider two extensions of the TFP growth specification. In the first permutation, we allow for the influence of institutional environment by including a proxy for institutional quality. Following Kose et al. (2009), Bekaert et al. (2005, 2011) and others, this measure was constructed using data from the International Country Risk Guide (ICRG) - a monthly publication of Political Risk Services (PRS) – using three PRS indicators: corruption, rule of law, and bureaucratic quality (for explanations of these components, see Law et al., 2013). These indicators, the first two of which are scaled from 1 to 6 and the third from 1 to 4, were summed to obtain an overall proxy for institutional quality (INS), with higher values implying better institutional quality. The results, reported in Table 7, show a positive and significant effect of institutions on bank TFP growth. Apart from the significance of the development dummy (DEVEL), the results with regard to other variables are robust to this change of specification. The significance of DEVEL confirms that banks in developing countries are more productive, after controlling for institutional quality, consistent with the findings from the DEA analysis which revealed higher average TFP growth of these banks. Significantly, in this extended specification, the

net effect of financial liberalization on bank productivity remains positive and almost identical to the values of Table 4.

[Insert Table 7 here]

In the second permutation, following Ranciere et al. (2006), we include measures of credit growth (CREDIT GRO) and a change in the external terms of trade (TOT CHANGE) in the TFP growth model (1). Apart from a marginally positive the effect of credit growth on TFP growth, the main results obtained without these two measures survive in this specification (the results in this case are not reported to conserve space).

Finally, although the two-stage estimation of the treatment effect model addresses the potential issue of sample selection bias (Heckman, 1979; Angkinand, 2009), following Cubillas and González (2014), we perform a check on the extent to which the dispersion in the number of banks per country may affect our main results. With this aim in mind, first, we eliminated 39 countries from the sample with less than 10 banks, including 2 countries (Ireland and Portugal) which suffered a systemic crisis in 2008. Second, we excluded 66 countries with less than 100 observations, but this sub-sample of 22 countries still retained 11 countries with systemic crises. In each case, due to the change in sample size, we re-estimated both the probit and TFP growth regressions. The results, not shown to conserve space, are, once again, consistent with those obtained for the full sample (Table 3), hence offering further reassurances.

4. Conclusion

This study examines the relationship between financial liberalization and bank-level productivity. We first use the Malmquist index to estimate the TFP growth of 1,530 banks operating in 88 countries between 1999 and 2011. Then, following the model employed by Ranciere et al. (2006), we use a treatment effect model to examine the decomposed impact of

financial liberalization on bank productivity growth into two channels: a direct bank TFP growth channel and an indirect productivity banking crises channel. To the best of our knowledge, this is the first study that investigates the decomposition of the effects of financial liberalization on bank TFP growth and the incidence of banking crises to quantify the net effect.

Overall, our results confirm the findings of much of the previous literature which suggest that financial liberalization leads to a higher propensity to banking crises, which, in turn, affects bank productivity negatively. However, we unveil that, in net terms, financial liberalization has led to a faster average bank TFP growth, resulting in a positive net effect. In terms of the impact of control variables, bank capitalisation is found to have a significant influence on bank productivity growth whereas the country level influences (credit growth, terms of trade and regulations) operate indirectly through their impact on banking crises. Our results survive a battery of robustness tests catering for potential endogeneity and reverse causality concerns as well as possible omitted variable and sample selection biases.

While our central purpose has been to quantify the net effect of financial liberalization on bank TFP growth, and not the underlying mechanisms through which liberalization affects productivity at the bank level, the literature highlights several possible channels through which productivity improvements may result from financial integration. These include, for example, greater possibilities for enhanced capital allocation to productive investments, improved economies of scale and scope, reduced transaction, overhead and information costs, better quality and availability of financial services, new and more advanced technologies, in addition to indirect mechanisms which may operate through competition, financial depth or institutional development (see, for example, Levine, 2001; and Kose et al., 2009). On the other hand, the crises-induced negative effects on productivity can be attributed to implicit costs stemming from consolidation or restructuring of banking operations (especially given

the decline in the number of banks from 2009 onwards), the consequences of which (as outlined in the introduction) are generally more widespread. However, since these negative effects are likely to reign for a shorter period, and because crises occur rarely, the longer term net impact of financial liberalization on bank productivity could reasonably be expected to be positive, as confirmed by our empirical results.

The main implication that flows from our findings concerns the policy debate about whether greater banking regulation (statutory, administrative as well as government's discretionary 'informal' regulation) is needed to influence banking sector outcomes. We find that, under a liberalized financial regime, bank TFP growth and a more fragile banking system go hand in hand but, in net terms, and over a sufficiently long time span, the positive financial liberalization effect on bank TFP growth more than outweighs the indirect negative effect stemming from a higher propensity to systemic banking crises. Our findings, therefore, imply that limiting further banks' operations in terms, for example, of more restrictive compliance and operational risk management in order to promote a more stable and less fragile banking system that is less susceptible to a systemic banking crisis, cannot be pursued without at least some costs for bank TFP growth. On this account, it should also be borne in mind that although banking crises are costly, and they can have significant economy-wide consequences, their occurrence remains a rare event (see, for example, Boissay et al., 2013).

Although we used both *de jure* and *de facto* measures of financial liberalization, future studies, particularly if interested in investigating the underlying channels contributing to the net effect unveiled (which were beyond the scope of this paper), could employ the recently developed more granular financial liberalization measure that reports capital controls separately for inflows and outflows and for different asset categories (see Fernández et al., 2015). Future work may also wish to use our analytical blueprint to investigate the net effect

of the dichotomous impact of financial liberalization on other bank performance measures, besides TFP growth.

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Appendix A: Sample composition

Country	Number of Banks	Number of Observations	Systemic Banking Crisis (start year)	Development Level
Albania	3	18		Developing
Algeria	8	40		Developing
Argentina	45	165	2001	Developing
Armenia	4	23		Developing
Australia	10	26		Developed
Austria	36	229	2008	Developed
Bangladesh	14	111		Developing
Belgium	18	73	2008	Developed
Benin	5	31		Developing
Bolivia	7	58		Developing
Botswana	3	24		Developing
Brazil	53	223		Developing
Bulgaria	11	61		Developing
Cameroon	7	42		Developing
Canada	13	52		Developed
Chile	2	6		Developing
Colombia	20	91		Developing
Costa Rica	14	72		Developing
Cote d'Ivoire	6	31		Developing
Croatia	27	207		Developing
Cyprus	10	62		Developed
Czech Republic	16	78		Developing
Denmark	40	271	2008	Developed
Dominican Republic	15	77	2003	Developing
Ecuador	15	99		Developing
El Salvador	8	44		Developing
Estonia	6	28		Developed
Ethiopia	6	49		Developing
Finland	3	8		Developed
France	77	487	2008	Developed
Georgia	7	40		Developing
Germany	70	412	2008	Developed
Guatemala	2	19		Developing
Guyana	2	21		Developing
Honduras	14	53		Developing
China	16	37		Developing
Hungary	15	102	2008	Developing
India	53	415		Developing
Indonesia	47	260		Developing
Ireland	3	6	2008	Developed
Israel	8	76		Developed
Italy	66	206	2008	Developed
Japan	6	19		Developed

Jordan	10	96		Developing
Kazakhstan	17	96	2008	Developing
Kenya	19	97		Developing
Kuwait	5	51		Developing
Latvia	13	65	2008	Developing
Lithuania	9	62		Developing
Madagascar	3	14		Developing
Malawi	2	19		Developing
Malaysia	24	115		Developing
Mali	4	25		Developing
Malta	2	26		Developed
Mauritius	6	30		Developing
Mexico	4	4		Developing
Moldova	9	40		Developing
Morocco	4	18		Developing
Mozambique	3	24		Developing
Nepal	10	62		Developing
Netherlands	18	63	2008	Developed
Niger	3	12		Developing
Nigeria	22	68	2009	Developing
Pakistan	18	97		Developing
Panama	19	110		Developing
Paraguay	9	78		Developing
Peru	10	76		Developing
Philippines	20	76		Developing
Poland	17	76		Developing
Portugal	8	22	2008	Developed
Romania	19	105		Developing
Saudi Arabia	9	104		Developing
Senegal	8	51		Developing
Singapore	4	14		Developed
Slovenia	12	116	2008	Developed
South Africa	5	20		Developing
Spain	21	55	2008	Developed
Sri Lanka	9	42		Developing
Sweden	13	84	2008	Developed
Switzerland	82	642	2008	Developed
Thailand	15	101		Developing
Tunisia	12	59		Developing
Turkey	16	67	2000	Developing
United Kingdom	46	219	2007	Developed
United States	114	487	2007	Developed
Venezuela	22	130		Developing
Vietnam	17	45		Developing
Zambia	7	55		Developing

Note: Total sample is 1,530 banks from 88 countries (686 from 22 developed and 844 from 66 developing countries).

Appendix B: Variable descriptions and data sources.

Variables	Description	Source
Stage 1: DEA Malmquist index		
A. Bank inputs		
Fixed assets (FA)	Assets related to physical capital.	BankScope
Deposits and short-term funding (DSTF)	Incoming funds used to generate bank outputs.	BankScope
Personnel expenses (PE)	Including wages and salaries, social security costs, pension expenses and other personnel costs.	BankScope
B. Bank outputs		BankScope
Loans (LOAN)	Bank gross loans net of reserves for impaired loans.	BankScope
Other earning assets (OEA)	Including securities and investment income.	BankScope
Non-interest income (NII)	Net gains from trading, insurance, fees and commissions, and non-banking business.	BankScope
Stage 2: Treatment effect model		
De jure financial liberalization (*De jure* FL)	A policy based measure of capital account liberalization. On a scale of 0-4, higher implies more openness of the countries' capital account transactions.	Chinn and Ito (2008)
De facto financial liberalization (*De facto* FL)	The ratio of sum of the gross stocks of foreign assets and liabilities to GDP	Kose et al. (2009); Lane and Milesi–Ferretti (2007)
Ratio of equity to total assets (EQAS)	Proxy for bank capitalization, with EQAS2 representing its squared value.	BankScope
Logarithm of total assets (SIZE)	Proxy for bank size, with SIZE2 representing its squared value.	BankScope
GDP growth (GDPG)	Real GDP growth (per cent)	Global Market Information Database (GMID)
Inflation (INF)	CPI inflation rate (per cent).	GMID
Ratio of claims to banking sector over GDP (CLAIM)	Proxy for the development of the banking sector.	GMID
Systemic banking crises (CRISIS)	Systemic banking crises dummy, which takes the value 1 in the year that the crisis occurs in a country and for 2 years after, 0 otherwise.	Author's calculations using data from Laeven and Valencia (2012, 2013)
Credit growth (CREDIT GRO)	Real domestic credit growth (per cent).	World Economic Outlook
Terms of trade change (TOT CHANGE)	Change in the terms of trade.	World Economic Outlook
Capital requirements (CAPR)	Index of capital requirements, measuring both initial and overall capital stringency. On a scale of 0-10, larger values indicate more stringent capital regulation.	Barth et al. (2013)
Supervisory power (SUP)	Index of official supervisory power, ranging from 0 to 14, which captures the power of supervisors to take prompt corrective action, to restructure and reorganize troubled banks,	Barth et al. (2013)

	and to declare a troubled bank insolvent. Higher values indicate greater power of supervisors.	
Market discipline (MARDIS)	Index of market discipline, ranging from 0-12, which captures the degree to which banks are required to release accurate and comprehensive information to the public. Higher values indicate greater regulatory empowerment of the monitoring of banks by private investors.	Barth et al. (2013)
Institutional Quality (INS)	Sum of the index of corruption (scaled 1 to 6), rule of law (1 to 6), and bureaucratic quality (1 to 4).	International Country Risk Guide (ICRG)
Development (DEVEL)	Country dummy taking value 0 for developed, and 1 for developing.	IMF

Table 1
Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: Bank inputs and outputs (1998 to 2011)					
Inputs					
FA	8,878	53.1000	91.2900	1.0000	646.0000
DSTF	8,878	3,478.4800	5822.0000	1.0000	49,546.0000
PE	8,878	53.9100	84.0700	1.0000	644.0000
Outputs					
LOAN	8,878	2,591.3200	4,758.1400	1.0000	38,605.0000
OEA	8,878	1,396.4300	2,594.3400	1.0000	20,676.0000
NII	8,878	69.6900	115.4800	1.0000	943.0000
Panel B : Second stage variables (1999 to 2011)					
TFPCH	8,370	1.0160	0.1900	0.1350	6.4410
De jure FL	8,370	1.2511	1.4519	-1.8639	2.4390
De facto FL	8,370	3.3319	4.5323	0.3660	75.7574
EQAS	8,370	0.1073	0.0703	0.0015	0.9166
SIZE	8,370	7.3617	1.4991	2.9957	11.0191
GDPG	8,370	3.3292	3.7759	-17.7000	21.2000
INF	8,370	4.5914	4.9824	-8.2000	52.4000
CLAIM	8,370	82.6595	55.9029	3.7250	315.4940
CRISIS	8,370	0.0436	0.2042	0.0000	1.0000
CREDIT GRO	8,370	85.5442	60.3468	3.8401	296.4590
TOT CHANGE	8,370	-0.7963	9.8038	-66.8040	102.1260
CAPR	8,370	6.7943	1.7203	2.0000	10.0000
SUP	8,370	11.2841	2.3350	4.0000	14.0000
MARDIS	8,370	8.0536	1.4105	4.0000	11.0000
INS	8,207	10.2200	3.2573	3.0000	16.0000
DEVEL	8,370	0.5600	0.4964	0.0000	1.0000

Note: The table reports summary statistics for the variables used in the empirical analysis. FA represents fixed assets; DSTF stands for deposits and short-term funding; PE is personnel expenses; LOAN refers to loans; OEA refers to other earning assets; NII refers to non-interest income; TFPCH represents bank total factor productivity growth; *De jure* FL corresponds to the *de jure* measure of financial liberalization; *De facto* FL corresponds to *de facto* financial liberalization; EQAS is the ratio of equity to total assets; SIZE represents the logarithm of total assets; GDPG refers to real GDP growth; INF denotes the CPI inflation rate; CLAIM refers to the ratio of claims to banking sector over GDP; CRISIS corresponds to systemic banking crises; CREDIT GRO refers to real domestic credit growth; TOT CHANGE refers to terms of trade change; CAPR is a proxy for capital requirements; SUP is a measure of official supervisory power; MARDIS refers to the index of market discipline; INS is an indicator of institutional quality; and DEVEL is a dummy variable to denote the state of economic development (1= developing; 0 = developed).

Table 2

Bank total factor productivity growth (TFPCH) and decomposition

Year	No. of Banks	Malmquist index (TFPCH)	Technical change (TECH)	Efficiency change (TEFCH)	No. of Banks	Malmquist index (TFPCH)	Technical change (TECH)	Efficiency change (TEFCH)	No. of Banks	Malmquist index (TFPCH))	Technical change (TECH)	Efficiency change (TEFCH)
	All countries				*Developed countries*				*Developing countries*			
1999	489	1.0164	1.0592	0.9714	243	1.0119	1.0558	0.971	246	1.0209	1.0625	0.9718
2000	334	1.0154	1.0086	1.0086	180	1.0227	1.0173	1.007	154	1.0068	0.9985	1.0105
2001	315	1.0003	1.0886	0.9208	178	0.9859	1.0606	0.9311	137	1.0191	1.1251	0.9075
2002	336	1.0453	0.8363	1.2717	173	1.0103	0.8691	1.1869	163	1.0824	0.8015	1.3618
2003	608	1.0327	0.8947	1.1661	264	1.0314	0.9078	1.147	344	1.0337	0.8846	1.1807
2004	655	1.0363	1.0776	0.9766	283	1.0463	1.0495	1.013	372	1.0286	1.099	0.949
2005	674	1.0146	1.0030	1.0208	287	1.0224	0.9864	1.0431	387	1.0089	1.0152	1.0043
2006	714	1.0273	1.1147	0.9385	296	1.034	1.1057	0.9502	418	1.0225	1.1211	0.9302
2007	833	1.0122	1.0799	0.9484	327	1.0217	1.0719	0.9655	506	1.0062	1.085	0.9373
2008	941	1.0026	0.8402	1.2051	400	0.9863	0.8367	1.1896	541	1.0145	0.8428	1.2165
2009	977	1.0232	1.1984	0.8665	398	1.022	1.1534	0.9039	579	1.0240	1.2293	0.8407
2010	744	0.9955	1.0840	0.9255	328	1.0046	1.0911	0.9297	416	0.9884	1.0785	0.9221
2011	750	0.9994	0.9618	1.0459	326	0.9960	0.9682	1.0384	424	1.0020	0.9568	1.0516
Mean	644	1.0159	1.0262	1.0131	283	1.0149	1.0165	1.0191	361	1.0167	1.0338	1.0084

Note: The mean scores of the total factor productivity change (TFPCH) index and its components, technical change (TECH) and efficiency change (TEFCH) for all countries, developed countries, and developing countries. TFPCH = TECH*TEFCH. The table indicates the number of banks accounted for in the calculation of TFPCH for each year.

Table 3
Financial liberalization, crisis and bank TFP growth (OLS estimation)

	[1] *De jure* FL	[2] *De facto* FL
Panel A: Bank TFP growth equation (dependent variable: TFPCH)		
FL	0.0191**	0.0205**
	(0.0095)	(0.0095)
EQAS	-0.3598***	-0.3500***
	(0.1164)	(0.1166)
EQAS2	0.8492***	0.8366***
	(0.2354)	(0.2369)
SIZE	-0.0118	-0.0103
	(0.0154)	(0.0150)
SIZE2	0.0007	0.0006
	(0.0010)	(0.0010)
GDPG	0.0014	0.0016
	(0.0012)	(0.0012)
INF	-0.0015	-0.0021**
	(0.0011)	(0.0011)
CLAIM	0.0000	0.0000
	(0.0001)	(0.0001)
CAPR	0.0026	0.0029
	(0.0021)	(0.0022)
SUP	-0.0016	-0.0014
	(0.0016)	(0.0016)
MARDIS	0.0009	0.0003
	(0.0020)	(0.0021)
DEVEL	0.0405	0.0293
	(0.0524)	(0.0480)
CRISIS	-0.3806***	-0.3879***
	(0.1354)	(0.1356)
First step hazard (Lambda)	0.1739**	0.1739***
	(0.0678)	(0.0674)
Panel B: Crisis (probit) equation (Dependent variable: CRISIS)		
FL	0.2473***	0.1427***
	(0.0400)	(0.0389)
GDPG (lag)	0.0894***	0.0798***
	(0.0123)	(0.0120)
INF (lag)	-0.0385***	-0.0557***
	(0.0147)	(0.0143)
CREDIT GRO (lag)	0.0051***	0.0053***
	(0.0008)	(0.0008)
TOT CHANGE (lag)	0.0137***	0.0103**
	(0.0050)	(0.0048)
CAPR (lag)	0.0223	0.0032
	(0.0206)	(0.0196)
SUP (lag)	-0.0698***	-0.0710***
	(0.0135)	(0.0132)

MARDIS (lag)	-0.0191	-0.0191
	(0.0242)	(0.0240)
Rho	0.8765	0.8750
Sigma	0.1985	0.1988
Year fixed effect	Yes	Yes
Country fixed effect	Yes	Yes
Number of observations	6651	6651

Note: The TFP growth estimation includes year and country fixed effects, with robust standard errors clustered at the bank level (reported in parentheses). Panel A reports the results from the regression in which bank productivity change (TFPCH) is the dependent variable. Panel B shows the results from the probit equation in which bank crisis dummy (CRISIS) is the dependent variable. The control variables in this equation enter with one-period lag. ***, ** and * denote statistical significance at the 1, 5 and 10% level, respectively. Specification [1] includes the de jure financial liberalization measure (*De jure* FL), while specification [2] includes the de facto one (*De facto* FL). EQAS is the ratio of equity to total assets (with EQAS2 representing its squared value); SIZE represents the logarithm of total assets (with SIZE2 its squared value); GDPG refers to real GDP growth; INF denotes the CPI inflation rate; CLAIM refers to the ratio of claims to banking sector over GDP; CRISIS corresponds to systemic banking crises; CREDIT GRO refers to real domestic credit growth; TOT CHANGE refers to terms of trade change; CAPR is a proxy for capital requirements; SUP is a measure of official supervisory power; MARDIS refers to the index of market discipline; and DEVEL is a dummy variable to denote the state of economic development (1= developing; 0 = developed).

Table 4

Decomposition of the effects of financial liberalization on bank TFP growth.

	De jure FL	*De facto* FL
Direct productivity growth effect	+1.91%	+2.05%
Indirect productivity growth effect	-0.69%	-0.41%
Total productivity growth effect	+1.22%	+1.64%

Table 5
Financial liberalization, crisis and bank TFP growth (Probit-2SLS estimation).

	[1] *De jure* FL	[2] *De facto* FL
Dependent variable: Bank TFP growth (TFPCH)		
FL	0.0212***	0.0285***
	(0.0074)	(0.0078)
EQAS	-0.3755***	-0.3633***
	(0.0895)	(0.0892)
EQAS2	0.8666***	0.8524***
	(0.1537)	(0.1537)
SIZE	-0.0130	-0.0098
	(0.0158)	(0.0158)
SIZE2	0.0008	0.0006
	(0.0010)	(0.0010)
GDPG	0.0018*	0.0020*
	(0.0011)	(0.0011)
INF	-0.0015*	-0.0023***
	(0.0009)	(0.0008)
CLAIM	0.0000	0.0000
	(0.0001)	(0.0001)
CAPR	0.0023	0.0024
	(0.0027)	(0.0028)
SUP	-0.0029	-0.0029
	(0.0022)	(0.0022)
MARDIS	0.0004	-0.0006
	(0.0031)	(0.0031)
DEVEL	0.0203	0.0114
	(0.0604)	(0.0572)
CRISIS	-0.6773***	-0.7969***
	(0.2078)	(0.2387)
First step hazard (Lambda)	0.3102***	0.3620***
	(0.0957)	(0.1100)
Year fixed effect	Yes	Yes
Country fixed effect	Yes	Yes
Wald (p-value)	0.0000	0.0000
Sargan (p-value)	0.2923	0.4894
Number of observations	6,651	6,651

Note: The TFP growth estimation includes year and country fixed effects, with robust standard errors clustered at bank level (reported in parentheses). Probit results (not reported) are the same as in Table 3. Wald is a test indicating goodness of fit of the regression. Sargan is a test for over-identifying restrictions. ***, ** and * denote statistical significance at the 1, 5 and 10% level, respectively. Specification [1] includes the de jure financial liberalization measure (*De jure* FL), while specification [2] includes the de facto one (*De facto* FL). EQAS is the ratio of equity to total assets (with EQAS2 representing its squared value); SIZE represents the logarithm of total assets (with SIZE2 its squared value); GDPG refers to real GDP growth; INF denotes the CPI inflation rate; CLAIM refers to the ratio of claims to banking sector over GDP; CRISIS corresponds to systemic banking crises; CAPR is a proxy for capital requirements; SUP is a measure of official supervisory power; MARDIS refers to the index of market discipline; and DEVEL is a dummy variable to denote the state of economic development (1= developing; 0 = developed).

Table 6

Decomposition of the effects of financial liberalization on bank TFP growth.

	De jure FL	*De facto* FL
Direct productivity growth effect	+2.12%	+2.85%
Indirect productivity growth effect	-1.23%	-0.84%
Total productivity growth effect	+0.89%	+2.01%

Table 7

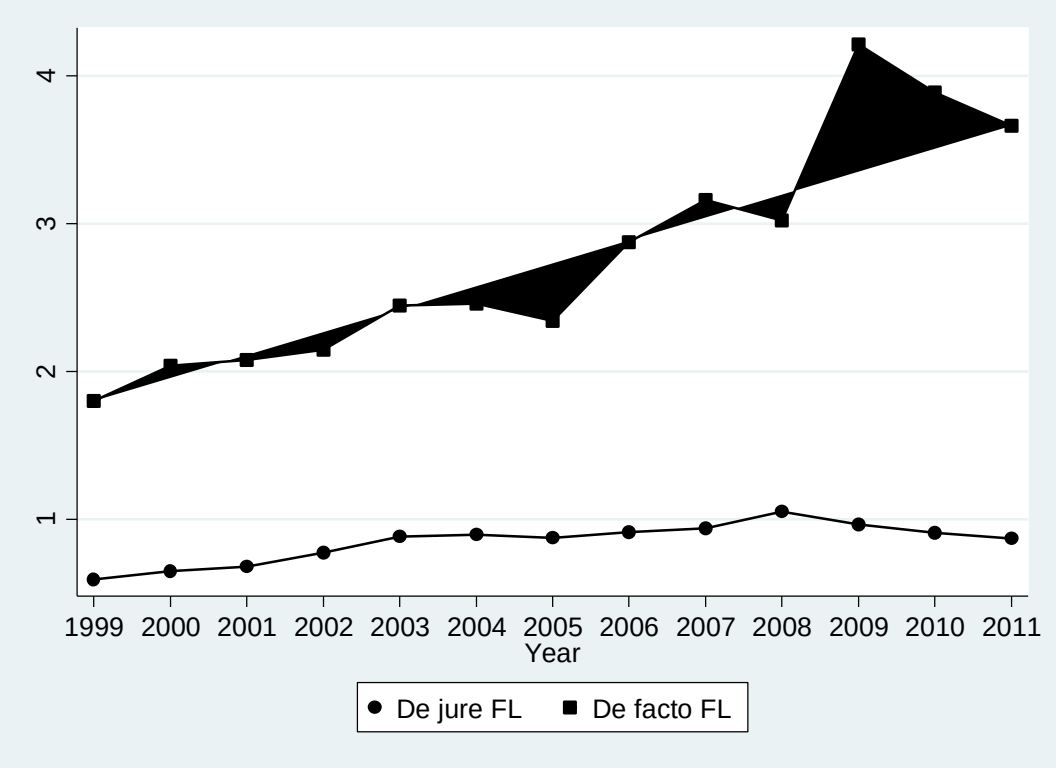
Financial liberalization, crisis and bank TFP growth (Controlling for institutional quality).

	[1] *De jure* FL	[2] *De facto* FL
Dependent variable: Bank TFP growth (TFPCH)		
FL	0.0194**	0.0263**
	(0.0098)	(0.0111)
EQAS	-0.3803***	-0.3735***
	(0.1170)	(0.1171)
EQAS2	0.8756***	0.8674***
	(0.2363)	(0.2380)
SIZE	-0.0163	-0.0142
	(0.0157)	(0.0152)
SIZE2	0.0010	0.0008
	(0.0010)	(0.0010)
GDPG	0.0010	0.0012
	(0.0012)	(0.0012)
INF	-0.0017	-0.0023**
	(0.0012)	(0.0011)
CLAIM	0.0000	0.0000
	(0.0001)	(0.0001)
CAPR	0.0015	0.0015
	(0.0022)	(0.0022)
SUP	-0.0019	-0.0017
	(0.0016)	(0.0016)
MARDIS	-0.0001	-0.0012
	(0.0022)	(0.0023)
DEVEL	0.1084*	0.1206*
	(0.0647)	(0.0648)
INS	0.0084*	0.0100**
	(0.0043)	(0.0043)
CRISIS	-0.3757***	-0.3934***
	(0.1371)	(0.1375)
First step hazard (Lambda)	0.1701**	0.1752**
	(0.0687)	(0.0684)
Year fixed effect	Yes	Yes
Country fixed effect	Yes	Yes
Number of observations	6,518	6,518

Note: The TFP growth estimation includes year and country fixed effects, with robust standard errors clustered at the bank level (reported in parentheses). Probit results (not reported) are the same as in Table 3. ***, ** and * denote statistical significance at the 1, 5 and 10% level, respectively. Specification [1] includes the de jure financial liberalization measure (*De jure* FL), while specification [2] includes the de facto one (*De facto* FL). EQAS is the ratio of equity to total assets (with EQAS2 representing its squared value); SIZE represents the logarithm of total assets (with

SIZE2 its squared value); GDPG refers to real GDP growth; INF denotes the CPI inflation rate; CLAIM refers to the ratio of claims to banking sector over GDP; CRISIS corresponds to systemic banking crises; CAPR is a proxy for capital requirements; SUP is a measure of official supervisory power; MARDIS refers to the index of market discipline; INS is an indicator of institutional quality; and DEVEL is a dummy variable to denote the state of economic development (1= developing; 0 = developed).

Figure 1: Evolution of the *de jure* and *de facto* measures of financial liberalization.



Note: *De jure* FL corresponds to the *de jure* measure of financial liberalization, constructed on the basis of the information published in the IMF annual report on the Exchange Arrangements and Exchange Restrictions (AREAER) to capture the degree of capital market liberalization. *De facto* FL corresponds to the *de facto* measure of financial liberalization, computed from the ratio of sum of the gross stocks of foreign assets and liabilities to GDP, based on Lane and Milesi–Ferretti (2007). The vertical axis denotes the scale of computed country-year averages for both measures.