ESSAYS ON INTERNATIONAL CAPITAL AND THE FINANCIAL SECTOR

by

GEORGIA R. BUSH

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ABSTRACT OF THE DISSERTATION

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Dissertation Director: Professor Roberto Chang

Chapter 2 of the dissertation analyzes the relationship between *de jure* financial openness and *de facto* financial openness. When a country changes its policy towards foreign financial transactions, do actual capital flows respond? I use the Chinn-Ito index to proxy a country's legal regime regarding external transactions, and examine its relationship to realized international capital flows disaggregated by type and direction. Panel data estimation methods are used to explicitly assess the interaction of country development characteristics with policy. I find that in general the relation between legal openness and realized international financial flows is weak. However looking at the decomposition, I find policy does affect Foreign Direct Investment and debt outflows. Furthermore, I find that country attributes play a key role in the efficacy of the policy stance, in particular a country's level of domestic financial development. Turning to time series methods, I then estimate a VEC model and analyze the variance decompositions of five Asian economies' bank lending rates. I find that the experience of Japan, South Korea and Indonesia support the conclusions arising from the panel analysis that greater financial development enhances realized financial openness.

Focusing on determinants of financial development, Chapter 3 and 4 test for empirical evidence of experience effects in banking. The hypothesis is that firm-specific or sector-wide learning, via knowledge spillovers, improves bank cost efficiency. Chapter

3 constructs a bank cost function extended to include firm-specific experience. Using a sample of US banks and applying a two-step correction procedure to my bank cost function, I correct for endogeneity as well as selection biases. I find that experience is associated with reduced costs: the experience effect is decreasing and fades after around 10 years. Chapter 4 extends the analysis to a sample of international banks and tests for knowledge spillovers. First a simple learning curve model is estimated. Next, the international sample is used to estimate the bank-specific cost function developed in Chapter 3. The estimated experience effects vary depending on the experience proxy and econometric model used, potentially due to data limitations. Nevertheless, the results suggest some evidence of firm-specific learning by doing and international knowledge spillovers in banking.

Acknowledgements

I would like to thank my advisor Professor Roberto Chang for his guidance, support and sense of humor throughout.

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Chapter 1

Introduction

The financial sector plays the key role of channeling capital from savers to entrepreneurs, allocating capital among firms and between countries. In this process, Financial Intermediaries overcome and reduce the costs of asymmetric information between lenders and borrowers. In theory, access to capital for entrepreneurs allows financially constrained agents to borrow, invest and go forward with economically viable projects that would otherwise go unfunded. Efficient allocation of capital ensures correctly priced funding for those projects with the best expected outcome. Furthermore, an effective financial sector can channel the proceeds from the entrepreneurial activities to households, resulting in welfare gains for the overall economy.

Empirical research, identified with Ross Levine, has shown that financial sector development has a positive effect on economic growth. Private credit creation via an active banking system and funding channels using capital market capabilities both facilitate entrepreneurial activity, promoting economic growth. Two related factors are at play: the overall supply of savings into the financial sector, and the efficiency with which this capital is allocated. Financial liberalization policies to foster financial sector development can target either of these elements.

However, liberalizing the financial sector can increase vulnerability to crises. Because of increased competition, privately-owned (non-state-owned) profit seeking financial intermediaries may choose excessively risky business practices resulting in banking crises of various kinds. For example, opponents of the repeal of the Glass-Steagall Act in 1999 argue that the US policy of financial liberalization in the 1990s is in part to blame for the severity of the 2008-09 US financial crisis. Furthermore, in the international context, opening up to international capital flows can expose countries to "sudden stops" and capital flight when foreign investors choose to repatriate or re-allocate their funds elsewhere. These crises episodes can undermine the growth enhancing aspects of financial liberalization.

One of the explicit goals of policies to liberalize international financial transactions is to access global savings and increase international financial integration. Neoclassical theory suggests that capital scarce countries should open to foreign capital flows to increase the supply of capital available for domestic entrepreneurial activity. The expected increase in supply should also reduce the cost of capital in the capital scarce country as interest rates converge. The first essay analyzes empirically the efficacy of policies to liberalize international financial flows, examining the relationship between *de jure* and *de facto* measures of financial openness. The analysis addresses two questions: First, is the relationship between *de jure* and *de facto* economically significant? More specifically, does increasing legal openness increase observed capital flows? Is the response symmetric across asset classes (debt and equity) and direction (inflows and outflows)? Second, does legal openness generate different effects on country groups with different characteristics, for example more developed countries versus less developed?

I find that the relationship between *de jure* and *de facto* financial openness is weak and the country's legal policy affects different types of capital flows differently.

Also, a country's level of financial development and institutional quality were both significant variables in this relationship. However I find that a country's level of financial development, whether measured by stockmarket turnover or private credit to GDP, had the greatest impact on how a country's policy stance related to realized flows. To access global capital a liberalized capital account policy is necessary but not sufficient, a well-developed domestic financial system plays a key role. Given the findings of the first chapter, financial liberalization policies aimed at accessing global savings must also consider the strength of their domestic financial sector.

The second essay is agnostic about the sources of financial capital, and focuses on the strength and efficiency of the domestic banking channel in particular. A macro literature has highlighted institutional and political factors, as well as regulatory conditions. I hypothesize a firm-level mechanism whereby financial intermediaries learn from experience. A bank's efficiencies then would not only depend on scale or scope, but would be path dependent. Experience accumulated by an individual bank indeed includes more information about specific counterparties, but also more knowledge about the business of banking. To the extent that financial firms could capture knowledge gained from experience, changing business processes and organizational structure, learning could increase the strength and efficiency of the banking sector, reducing its vulnerability to crises and promoting economic growth. Furthermore, these gains would not necessarily disappear if a bank down-sized. However bank failure could entail the additional cost of losing this knowledge.

To test for experience effects in banking, the second chapter constructs and estimates a bank-specific cost function augmented to include experience proxies. Using a sample of US banks, I found that for younger banks, firm-specific experience was associated with lower costs of production.

Continuing the analysis of bank efficiency, the third essay takes the question of

experience effects in banking to an international sample of banks, including banks from 88 countries. This dataset allows me to ask whether the results in the second essay apply more generally. I use two approaches, first estimating a learning curve model, and then using a cost function approach similar to that used in the second essay but addressing country heterogeneity.

The third essay also raises the question of knowledge spillovers among banks. Does the experience of the domestic banking sector as a whole improve individual bank's efficiency, for example via imitation, or via intentional knowledge transfers among banks? Do innovations in another part of the world travel? International imitation might be more challenging. Nevertheless, clients might demand what they have experienced elsewhere, or bank managers might observe directly practices in other parts of the world and implement these at home. Potential channels are similar to those discussed in the arms-length trade and Foreign Direct Investment spillover literature, for example imitation, labor mobility, and customer and supplier linkages. The empirical analysis tests for the presence of positive spillovers defined as an increase in the cost efficiency of individual banks as a consequence of knowledge spillovers.

Previewing the results from the final chapter, I find some evidence of experience effects in the international sample of banks. Using a learning curve model, estimates of the elasticity of cost with respect to a bank's own cumulative output are negative, however the results are not robust to the choice of bank output measure. Using the cost efficiency approach, I find some evidence that for banks at the younger end of the age distribution, firm-specific experience is associated with lower bank production costs. I did not find evidence of knowledge spillovers within a country between banks, however international financial activity did have a negative effect on bank production costs, and this effect was driven mainly by foreign asset holdings.

Chapter 2

De jure vs. *de facto* financial openness

2.1 Introduction

This paper explores the effect of loosening capital controls on observed international transactions. Growth theory suggests a win-win outcome from opening the economy to international markets. Savers, or the owners of capital will earn higher returns investing abroad alleviating firms' financial constraints in the recipient economies, and workers in the recipient economy end up with better job opportunities and higher income. The direct channel is via the cost of capital. Neo-classical theory predicts countries with relatively high interest rates (capital scarce), benefit from opening because their higher interest rate attracts capital inflows, and domestic interest rates are predicted to move towards a lower world interest rate. The lower domestic interest rate stimulates investment and thus growth. Residents of countries with relatively low interest rates can now invest in the country and earn higher returns on those foreign assets than they would on domestic assets. Thus for a country opening its capital

account, theory suggests legal changes lead to realized inflows which reduces the cost of capital which increases investment and thus growth. This argument supports increasing international financial integration.

Motivated by this theory, the so-called Washington Consensus promoted privatization, trade liberalization and opening to financial flows during the 1980s and 1990s. However after the financial crises of the late 1990s much debate focused on whether capital-account opening in itself was in fact beneficial. A literature, both academic and non-academic,[1] developed critiquing the earlier consensus that benefits from capital-account opening outweighed expected costs.

A key reason for the lack of consensus stems from the multiple measures of financial openness. Some measure policy defined as legal conditions, others use the level or growth rates of international capital flows. International financial integration may measure financial openness or it may be a distinct concept concerned with convergence of the cost of capital or parity conditions. Considering *de facto* openness, flows could be adjusted for valuation changes or scaled using country GDP or populations, or the degree to which the country participates in international networks. Alternatively one could use changes in asset price spreads, or some estimate of the cost of capital itself. From the legal point of view, financial openness is an ambiguous condition. The capital account consists of many component transactions only some of which may be restricted. In addition, governments could choose to impose controls on current-account transactions either as a way to prevent circumvention or as a separate policy measure.[2] In addition, the intensity of capital controls is difficult to measure. For example, are certain transactions completely disallowed, or are restrictions in the form of taxes or holding period requirements.

[1] For example Rodrik (1998).

[2] Restrictions on the current account relate to foreign exchange payments for imports and earnings from exports, and repatriation of earnings and profits by foreign investors.

In the literature, researchers proxy financial openness using two types of measures: one group using measures based on laws, and the other based on observed outcomes. *De jure* measures tabulate government regulations and restrictions and formulate an index as a proxy for the degree of legislated capital-account openness. Most of these are based on reports submitted to the IMF by individual countries and research conducted by IMF staff. *De facto* measures use observed prices or quantities to represent a country's realized financial openness.

There is no consensus on which type of measure should be used to assess the effects of financial openness and how to match measures to the research question at hand.[3] Both types of measures have drawbacks. Nevertheless these are all usable proxies for financial openness and it would be helpful to know how these measures relate. For example, are they easy substitutes in empirical regressions or does the choice imply different interpretations of results.

This paper adds an explicit analysis of the relationship between policy (as measured by laws) and actual international financial transactions. The analysis addresses two key questions: First, is the relationship between *de jure* and *de facto* economically significant: does increasing legal openness increase observed capital flows? Equally for all asset types, and for flows in both directions? Second: does legal openness generate different effects on country groups with different characteristics. Lastly the paper will look at financial market integration of a subgroup of countries to explore the dynamics of these effects.

2.1.1 Antecedents

Eichengreen (2001) and Kose et al. (2006) discuss how measuring the intensity and

[3] An exception is Henry (2007) and Kose et al. (2006) who recommend a particular measure over others.

effectiveness of legal barriers to international capital flows is problematic. To measure intensity, Eichengreen points out that some researchers include restrictions on the current account in their index measuring capital controls arguing these are attempts to prevent the circumvention of capital-account controls through misreporting export and import transactions.[4] Thus the current-account restrictions contain information about the intensity of controls. However, these current-account controls may not be aimed at deterring evasion, and may in fact reflect deeper policy issues.[5]

With regards to *de facto* measures, Eichengreen points out that actual flows are driven by a range of factors besides the relevant laws,[6] and therefore flows actually only capture information on whether a country enforces financial autarky or not. Once flows do occur, the magnitude depends on other factors. Furthermore, Edwards (2001) reports that actual capital mobility is often higher than the legal regime would suggest. Cavoli et al. (2003) and Takagi and Hirose (2004) discuss this leakage phenomenon.

The discussion in Kose et al. (2006) on measuring financial openness states both *de jure* and *de facto* measures contain important information. However, the authors argue for using *de facto* measures. They favor quantity measures and argue against using asset price convergence based measures. Their preferred measure is the sum of gross inflows and outflows as a ratio to GDP, however because of the volatility of

[4]For example a firm can adjust the timing and quantity of foreign exchange transactions in their accounts in order to avoid surrendering foreign exchange to authorities. An export will earn foreign exchange, an import will require the use of foreign exchange. Thus an exporter could undervalue its export or an importer could overvalue the cost of its imports, and keep the excess foreign exchange.

[5]Klein (2012) discusses the capital control regime types.

[6]A similar critique holds for asset prices. Eichengreen points out many variables drive asset prices (the characteristics of the asset, the issuers, the various country specific premia). Hence for example using the correlation of stock market returns across countries does little to measure international financial integration. More generally, isolating the effects of capital-account liberalization from a broader liberalization and reform program is challenging. As noted by Kose et al. (2006), an array of liquidity and risk premia apply to developing economy financial securities and separating these out empirically is challenging, complicating the interpretation of these measure.

flows they prefer the stocks measure developed in Lane and Milesi-Ferretti (2003). The authors write the distinction between *de jure* and *de facto* is crucial, and in fact when analyzing the effects of financial globalization, the key variable is not how financially open a country is on paper, but how much in practice.[7] This argument is supported by the key result in this paper: capital-account liberalization does not necessarily lead to increased *de facto* financial openness.

With regards to the particular question of this paper — how do *de jure* and *de facto* relate — Quinn and Toyoda (2008) in their appendix, do compare various *de jure* and *de facto* measures. They look at correlations among them and compare how countries rank using the different measures. They compare among others, Quinn's 1997 CAPITAL measure, KAOPEN from Chinn and Ito (2007), the measure constructed in Miniane (2004), EQUITY (*de jure*) from Bekaert et al. (2005), and TOTAL (*de facto*) from Lane and Milesi-Ferretti (2003). They report that the overall correlations between and among their set of variables are generally low.[8] Binici et al. (2010), presents a table of the partial correlations between a range of *de jure* measures.

While Quinn and Toyoda (2008) are primarily concerned with comparing *de jure* measures, Binici et al. (2010) is most similar to the initial panel analysis in this paper in that the authors use regression analysis to assess the effect of legal changes on observed capital flows. They focus on the relation between disaggregated flows and measures of subcategories of legal restrictions using panel regression methods and a dataset ranging from 1995-2005. Their motivation is to understand the impact of

[7]They list shortcomings of *de jure* measures similar to those brought up by Eichengreen and Edwards (they don't capture intensity or enforcement of controls, and don't reflect the actual degree of international financial integration) and suggest that restrictions on foreign exchange transactions may not impede capital flows.

[8]For the period 1970 to 1999 correlations between CAPITAL and TOTAL: 0.4; CAPITAL and EQUITY: 0.56; and TOTAL and EQUITY: 0.12. However, the correlation between CAPITAL and KAOPEN is larger at 0.74.

surgical controls, aimed at reducing particular types of flows deemed undesireable. Because the IMF reversed its earlier anti-capital controls stance, and because developing countries have used surgical controls, Binici et al. (2010) examine the impact of targetted controls on their target. Their *de jure* index is from Schindler (2009) which uses the more granular AREAER data, and as such they are limited in the number of years they can include in their panel.Fernandez et al. (2006) have since extended and broadened the *de jure* index in Schindler (2009).

This paper's concern is if a country's laws become increasingly open, does the market respond? And if so is the response symmetric across asset classes (debt and equity) and direction (inflows vs. outflows)? If the answer is "it depends", then what factors lead to a strong connection between *de jure* openness and realized financial openness? Do developed economies have a different experience than emerging, and if so what in particular about being under-developed alters the connection. The main novelty of this paper is to use a long panel and econometric techniques that explore whether particular country attributes amplify or offset the effects of legal financial opening. In addition, time series methods (in particular variance decompositions) are used to examine the financial integration of a subgroup of countries.

My dataset includes developed and developing economies and ranges from 1980 - 2008 with a minimum of 119 countries in a given year. I used a general *de jure* index, the Chinn-Ito index of capital-account openness. For *de facto* variables I looked at flows data from IFS and stock data from Lane and Milesi-Ferretti (2006). Because I am interested in gauging the market response for different types of flows, I used FDI, portfolio equity and debt data. I also looked at sub-categories based on direction both for theoretical reasons (growth theory emphasizes inflows, household risk-sharing motives suggest outflows) and to compare with other work on this topic (Binici et al. (2010) report evidence that outflows are more affected by targetted

capital controls than inflows.).

In my panel analysis, I used Ordinary Least Square regression on the cross-section (period averages). Then I exploited the full panel, first running a pooled regression and then controlling for country fixed effects and year-specific dynamics. I also test for non-linearity in the relationship between *de jure* and *de facto* financial openness grouping countries by proxies for financial development and institutional quality. For the period average, I find a weak relationship between legal openness and *de facto* financial openness. For the panel model with country and time controls, I also cannot reject the hypothesis that *de jure* openness has no influence on the stock of aggregate capital flows. However, disaggregating by type and direction of flow suggests capital account openness does have some effect on certain flows.

In answer to the first question, reducing capital controls does not always increase observed capital flows. Legal openness affects different types of capital flows differently. Also, legal openness has different effects on country groups with different development characteristics, in particular financial development. Opening the capital account induces greater international financial transactions only for more developed countries. In sum, legal openness on its own does not translate into greater realized financial openness. The country context matters.

In my time series analysis I estimate a VAR system comprising the bank lending rates of five Asian economies and the US. I consider the influence of countries' lending rates on each other to gauge the degree of financial integration. Five countries from a similar regional context are considered: three financially developed countries (Japan, South Korea, and Singapore), and two less developed (Malaysia and Indonesia). The US lending rate is included as well, and the primary tool for analysis is variance decomposition. The basic hypothesis is that more financially open and financially developed countries should see a larger proportion of the variability in their lending

rate being accounted for by the other countries in the group.

The paper is organized as follows. First in section 2, I describe the data and my quantitative approach. In Section 3, I report results examining the relationship between the *de jure* (legal) measure and *de facto* (observed) financial openness in the following order: section 3.1 the period average relationship, 3.2 basic panel regressions, 3.3 regressions with interactions between *de jure* and country attributes. Subsection 3.4 discusses implications for the literature on growth and capital-account liberalization. Section 4 covers the time series analysis of bank lending rates of five Asian countries. Section 5 concludes.

2.2 Data and methodology

2.2.1 Measures of legal and realized financial openness

Legal, *de jure*, measures of financial openness are based on the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). The IMF started publishing the AREAER in 1950 providing a long history and consistent qualitative assessment of each country's restrictions on exchange payments (imports of goods, imports of invisibles (services) and capital) and receipts (exports of goods, exports of invisibles (services), and capital).[9] *De jure* measures of financial openness differ in whether they are a binary measure or an index, and what categories of restrictions they include.

I will use the Chinn-Ito index (Chinn and Ito (2007), updated in 2008) for this

[9]The IMF report since 1967 also includes a table summarizing a country's exchange and trade system. A binary variable records the absence or presence of restrictions. Alesina et al. (1993) and other political economy and growth researchers use this measure. The drawback of a binary variable is the lack of any information on the intensity of restrictions if they are present. In particular, this measure does not capture policy changes made as a country transitions to full openness.

analysis. This *de jure* measure attempts to capture the magnitude of capital controls, and also the country trend, i.e. how long restrictions have been in place or have been declining. The authors construct a measure based on principal component analysis of four binary AREAER indicators: the presence of multiple exchange rates (k_1), restrictions on current-account transactions (k_2) and/or on capital-account transactions (k_3), and requirement of the surrender of export proceeds (k_4). These four variables are extended after 1996 following Mody and Murshid (2005) to adapt to the more finely disaggregated reports in the AREAR from 1996 onwards. The variables are "reversed" so that positive numbers reflect more openness. Also, for capital-account transactions, they use the share of a 5-year window that restrictions were not in effect ($share_{k_3}$) thus capturing some of the intensity of capital-account restrictions.

$$share_{k_{3,t}} = (\frac{k_{3,t} + k_{3,t-1} + k_{3,t-2} + k_{3,t-3} + k_{3,t-4}}{5})$$

$Kaopen_t$ is the first standardized principal component of $k_{1,t}$, $k_{2,t}$, $sharek_{3,t}$, and $k_{4,t}$. Higher values of *kaopen* represent more openness. By construction the series has a mean of zero. The first eigenvector for *kaopen* was found to be $(share_{k_3}, k_1, k_2, k_4) = (0.57, 0.25, 0.52, 0.58)$, indicating that the $share_{k_{3,t}}$ series is not the only driver of the variability of *kaopen*. In particular, significant weight is put on k_2 restrictions on the current account[10] and k_4, the requirement that export proceeds be surrendered. Including these other variables captures the full range of restrictions on international financial transactions, measuring what Chinn and Ito call the *extensity* of capital controls. I use the Chinn-Ito index (*kaopen*) to measure legal arrangements because it is publicly available, and is the most extensive across both country and time dimensions. The Chinn-Ito index goes back to 1980 and for any given year comprises

[10]The current account includes transactions involved in payment for international trade in goods and services.

a maximum of 178 countries and a minimum of 119.[11]

Actual, *de facto*, financial openness can be measured in many ways using data on international financial transactions. Extensive data on capital flows, grouped by type and/or direction, are reported in the IMF's International Financial Statistics database. Various categories have been the focus of earlier research depending on the authors' motivation. Henry (2007) provides a thorough survey of the growth and financial opening literature. He argues equity flows or stockmarket liberalization dates should be used to test whether financial openness effects growth as predicted by the neo-classical growth theory. Those interested in financial openess and vulnerability to external shocks, have used capital inflows. For example, DeGregorio et al. (2000) consider two measures of flows, short-term debt to GDP and total debt to GDP, and their impact on Chile's exchange rate.

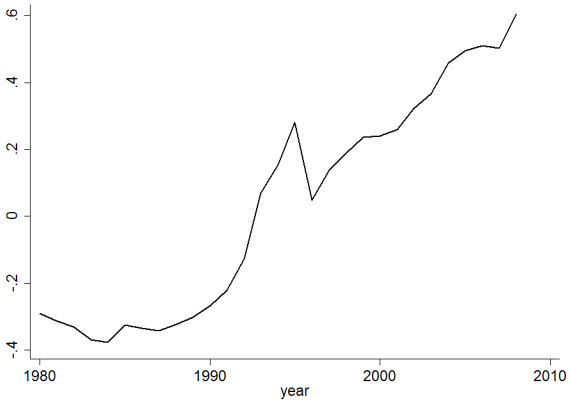
In an effort to capture the state of international balance sheets, Lane and Milesi-Ferretti (2001) constructed a database of foreign assets and liabilities based on observed flows, and updated this data in 2009. The authors use Balance of Payments data from the IMF and estimates of a country's International Investment Position to back out asset and liability positions for previous years. Importantly, they take into account valuation changes due to capital gains and losses. A standard balance sheet *de facto* measure uses the sum of the absolute value of the country's assets and liabilities, scaled by the country's gross domestic product. Kose et al. (2006) argues this gross measure most accurately captures overall financial openness. Edison et al. (2002) use this gross stock measure and accumulated FDI plus portfolio liabilities to evaluate the impact of international financial integration on domestic economic growth.[12]

[11] A newer *de jure* index, constructed by Schindler (2009) to measure capital-account restrictions, goes back to 1995 and includes 74 countries.

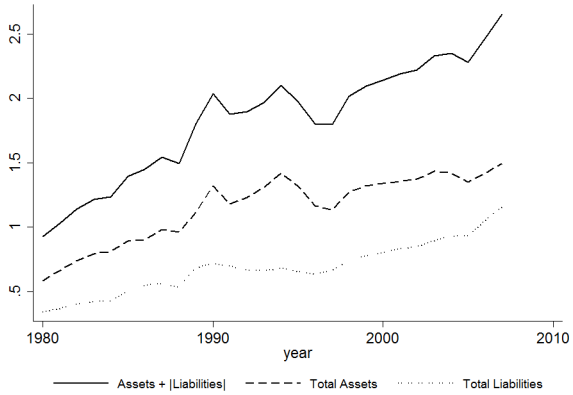
[12] Analogous to these balance sheet measures, the authors also use a "flow of capital" measure

Figure 2.1: Evolution of financial openness measures

(a) *De jure* measure



(b) *De facto* measures



In this analysis, I will use the standard gross stock measure described above, and measures of subcategories of assets and liabilities defined by type and direction in Lane and Milesi-Ferretti (2003). For flows, I will use the IFS data disaggregated by direction: total inflows versus total outflows, and by type: direct investment, portfolio equity and debt. (See appendix for a complete list and brief description.)

The evolution of average *de jure* financial openness across countries is plotted in Figure 2.1a for the full sample. The trend towards more legal openness is mirrored by a general rise in *de facto* openness, with liabilities about twice as large as assets (as a share of GDP). Similarly, domestic agents' purchases of foreign assets (outflows) are below foreigners' purchases of domestic assets (inflows) for the entire period. (See Figure 2.1b.)

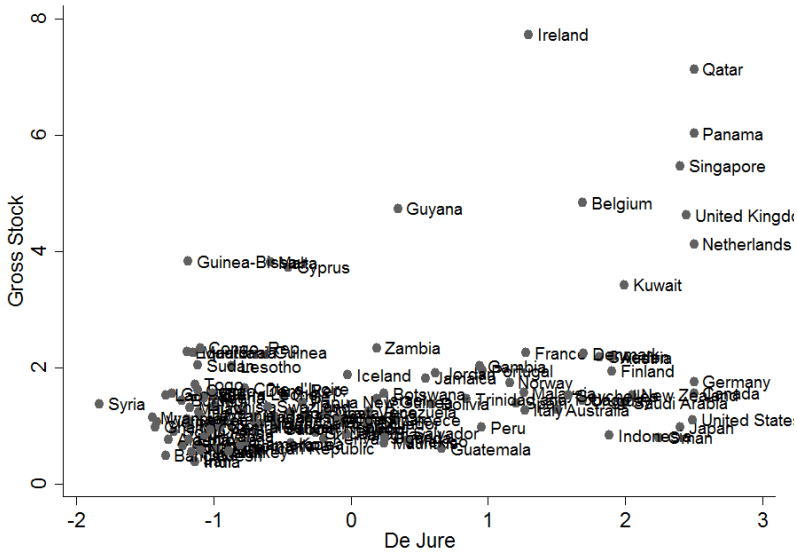
In the appendix, Table 2.6 reports simple correlations between the period average *de jure* measure and the various *de facto* measures. Overall legal openness is positively correlated with realized financial openness for all the *de facto* measures.

(FDI and portfolio inflows and outflows as a share of GDP) and an "inflow of capital" measure. Edison et al. (2002) add capital inflow measures because of the predicted boost to growth from inflows to capital scarce countries.

For the period average, Gross stocks ($ggross$), and in particular gross equity ($seqty$), show correlations to $kaopen$ of about 0.42. It is interesting to note that total assets, $gsttla$, shows the highest correlation with $kaopen$, and both total assets and outward flows, $odipflout$ are more correlated with the *de jure* measure than total liabilities, $gsttll$, and inflows, $fdipflin$. This very basic data analysis does not contradict the hypothesis that outflows are more responsive to restrictions than inflows.[13]

Figure 2.2 shows a plot of countries' period average legal measure of financial openness $DeJure$, against their gross asset and liability position (Gross Stock), suggesting possibly a positive relationship.

Figure 2.2: *De jure* financial openness vs. *de facto*



[13]In Schindler (2009), the authors construct *de jure* measures of capital controls and analyse trends in controls on inflows versus outflows. For their sample covering 1995-2005, the trend suggests countries loosened restrictions on outflows and inflows symmetrically. Thus, *kaopen* does not necessarily measure only the loosening of outflow restrictions (which would have explained its higher correlation with realized outflows).

2.2.2 Basic model

While explaining the observed pattern of international capital flows remains challenging, several variables have been shown to be significant drivers.

First, *natural resources*, when they account for a large fraction of a country's export trade, earn relatively substantial foreign exchange that must then be spent or invested abroad. Empirically, Faria and Mauro (2005) find a positive relationship between natural resource endowment and the external capital structure of emerging economies. I include this in my regression model. Following Faria and Mauro (2005), I use the sum of fuels, ores and minerals exports as a percent of GDP, computed using the World Bank's Development Indicators dataset.

Second, a country's *openness to trade* influences its financial relations. International trade requires international capital flows directly through the current-account. In addition, indirect effects on capital flows may be important. Portes et al. (2001) find that a gravity model often used to explain trade, explains the pattern of capital flows comparatively well. They argue capital flows may be facilitated by cultural or informational proximity. This informational closeness may come about because of existing trade relations. Thus openness to trade leads to familiarity with trading partners which are then more likely to engage in financial "trade". Network analysis of international banking relationships also suggests that despite the intangibility of financial flows, border effects and other geographic distance measures do matter (See Arribas et al. (2011)). To capture this, I include a country's trade to GDP ratio in my regression model.

Third, several empirical studies examine the role of *domestic financial development*. Alfaro et al. (2004), Kose et al. (2006), Prasad et al. (2007) find better financial intermediation and more channels for capital flows increases the absorptive capacity

of a country, thus increasing international financial transactions. Two standard variables used to proxy for financial development are private credit to GDP and stock market turnover. Private credit creation measures the role of banking intermediaries. Stock market turnover gives a sense of how active a country's equity capital market is without the valuation issues of market capitalization measures. These two variables measure the degree of financial sector activity in an economy, although not the efficiency of the financial sector in allocating capital (i.e. the "quality" of the country's financial sector).

Fourth, *institutional quality* in general is likely to influence international financial transactions. Effective law enforcement and low levels of corruption facilitate capital flows by reducing the risk of expropriation and unequal legal treatment. In general, better institutions ameliorate problems arising from asymmetric information and ensure contract enforcement. Empirically, I use two scores, one from the ICRG's law and order index, the other from their corruption index[14] to capture the quality of domestic institutions. The maximum score for each of these is 6, representing the least corrupt and best law and order environment.

I also considered including a measure of *government policy quality.* High and sustained periods of inflation, and/or fiscal imbalances would likely deter inward investment and perhaps prompt capital flight. (See Montiel and Reinhart (1999) for a discussion of macroeconomic policy and capital controls.) I used two policy variables: government balance for fiscal policy and log of inflation for monetary policy. However when these variables were included in the regression model, their coefficients were insignificant, and the number of usable observations dropped without any improvement in the overall model.[15]. (Table 1.4 of the attachment reports summary statistics for

[14]See appendix for ICRG descriptions. Data kindly provided by Hali Edison.
[15]See appendix: Comparing models

these control variables.)

2.2.3 Estimation approach

The general hypothesis is that legal openness, along with the factors listed above, have a positive relationship with capital flows. This paper aims to assess the best model of the relationship between *de jure* and *de facto* measures of financial openness answering two questions. First, is the relationship economically significant: does increasing legal openness increase realized financial openness? In particular, how does overall legal openness affect different *de facto* measures (e.g gross capital flows, accumulated flows, directional flows, debt, equity)? Second, does legal openness have different effects on country groups with different development characteristics?

Relating *de jure* to *de facto*

To address the first question, I start by looking at the cross-section, regressing a country's period average level of legal openness onto its capital flow measures. Over the period 1980 to 2008, does a higher level of legal openness translate into a higher degree of observed international financial integration?

$$\overline{deFacto}_i = \beta_0 + \beta_1 \overline{deJure}_i + \beta_2 \overline{Controls}_i + \epsilon_i \tag{2.1}$$

where $deFacto$ is the observed capital flow or stock and $deJure$ is the index measuring legal arrangements.

After looking at period averages, I move on to exploit the panel. To select the best estimation approach, I begin with a pooled regression as the baseline.

$$deFacto_{it} = \alpha_0 + \alpha_1 deJure_{it} + \alpha_2 Controls_{it} + v_{it} \tag{2.2}$$

The residuals of this model may have autocorrelation and consequently the pooled estimation would overstate the significance of the coefficients. Thus at a minimum, I expect the coefficient on the *de jure* measure (*kaopen*) to be significant in this regression.

To control for unobserved effects of global dynamics on international financial transactions in a given year, I add year dummies. Similarly, capital flows could theoretically be driven by persistent country attributes not included in this analysis. Then for a given country the model errors are likely to be correlated over time. If we think of $\epsilon_{it} = C_i + u_{it}$, and omitted country attributes affect the other regressors, then the OLS assumption that the model errors are not correlated with the regressors would be violated. For comparison, I run a regression with country fixed effects (allowing intercepts to differ from country to country) and find a majority of the coefficients on the country dummies are significant.[16] Thus to gauge the effect of legal financial openness on realized, I estimate the following model:

$$deFacto_{it} = \alpha_0 + \alpha_1 deJure_{it} + \alpha_2 Controls_{it} + Y_t + C_i + u_{it} \tag{2.3}$$

controlling for effects on observed capital flows due to conditions in a particular year (adding dummies Y_t) and unobserved country fixed effects (C_i for country i).

Given the heterogeneity of country experiences, I expect to find a weak relation between the *de jure* measure and gross *de facto* measure. However disaggregating by type and direction, I expect to see evidence of policy influence. During the time period under consideration, a general trend of moving away from capital controls to

[16] An F-test comparing model specification could give statistical guidance on whether the pooled regression estimate of 0.210 is significantly different from the estimate from the regression including country FE and year dummies, 0.046. Since many of the coefficients on the country dummies are highly significant, and those on the year dummies as well, I expect the F-test to favour the country FE and year dummies specification.

liberalized open capital accounts began in the 1980s. Long-standing capital control regimes, to quote Klein (2012) "'are like walls that attempt to erect a more or less permanent barrier against the vicissitudes of international capital markets."' Dismantling these walls could be interpreted as a signal that the country is committed to a broad set of liberalization policies, including trade and privatization.Bartolini and Drazen (1997) argue that capital account liberalization is a signal. One could thus expect foreign multinationals to respond to this signal not only because of the financial feasibility of obtaining equity stakes, but also because of the opportunities in the real economy arising from a country's commitment to these other liberalization policies.

Furthermore different asset types have different characteristics and functions and thus different mechanisms are at work. For example direct investments, which are equity flows where the investor owns at least a 10% stake in the targetted firm, are a longer-term type of commitment, in contrast to arms-length portfolio equity. Often direct investments are joint-ventures where the foreign investor has management influence and shares distribution or other business functions with the target firm. From a foreign investor's perspective, the targeted firm may provide access to that local market, or act as an important link in a manufacturing supply chain. From the recipient firm's perspective, they receive a capital infusion, and the relationship has potential for knowledge spillovers. This type of investment is lauded as most desirable for liberalizing economies, both because of the potential for spillovers in the real economy, and the longer-term commitment. Contrast equity direct investments with debt: domestic households with high savings and a limited set of domestic savings opportunities to choose from, may want to diversify and access opportunities via accumulating foreign debt assets. Conversely, countries with advanced financial sectors may expect debt inflows because of the liquidity and diversity of their domestic

financial system.[17]

Other authors have used similar estimation methods and models on smaller datasets. Lane and Milesi-Ferretti (2003), in section 3 of their paper, use a basic model similar to the above[18] but only on 18 OECD member countries. The paper tries to identify the determinants of changes in gross assets and liabilities (Gross Stock in this paper) and portfolio equity and FDI (Gross Equity in this paper). They used fixed effects least squares estimation on first differenced data covering 1978-2001.[19] Their *de jure* measure of financial openness is a capital-account liberalization index from Mody and Murshid (2005) which is the sum of four binary variables reported in the AREAER (and used in *kaopen*). This *de jure* measure in contrast to *kaopen*, does not include the share of a 5-year window that restrictions were not in effect for capital-account transactions. The authors find that for the 18 OECD country sample, the *de jure* measure loses explanatory power with the addition of multiple regressors.

In a later paper, Lane and Milesi-Ferretti (2008) run a regression using end-2006 data for a broader set of countries with *kaopen* as their *de jure* measure, and Foreign Assets to GDP and Foreign Liabilities to GDP as their dependent variables. They add dummy variables for financial center status and EU15 membership. Other regressors again include trade openness, a measure of domestic financial development, GDP per capita; and they add population. For their end-2006 analysis, none of the estimated coefficients on *kaopen* were significant.

Binici et al. (2010) exploit the finer reporting in AREAER from 1995 onwards to examine the effect of capital controls on the composition of capital flows. Their full sample consists of 74 countries over a 10-year period, 1995-2005. Their *de jure*

[17]The global savings glut literature discusses this, suggesting the US has a comparative advantage in producing safe assets, and thus has experienced debt inflows.

[18]Regressors in addition to a *de jure* measure, include trade openness, three measures of domestic financial development, log of GDP per capita, Tax policy, and Insider Trading laws.

[19]The time dimension consisted of 6 observations, six 4-year averages.

measure is from Schindler (2009) which constructs an index using reported controls on individual transactions. They thus match capital control type to capital flow type in their regressions. Their *de facto* flow measures are the first difference of the asset and liability data from Lane and Milesi-Ferretti (2006) divided by country population. This paper uses actual flows data from IFS as well as assets and liabilities from Lane and Milesi-Ferretti (2006). Also different, this paper scales these variables by country output (GDP) not population. Binici et al. (2010) include covariates similar to Lane and Milesi-Ferretti (2003) and this paper: financial development, trade openness, institutional quality, GDP per capita and natural resource endowment.[20] Estimation is by Least Square Dummy Variables, using Country fixed effects. In contrast to Lane and Milesi-Ferretti (2003, 2008) , the authors find their bottom up aggregated *de jure* measure strongly influences aggregate *de facto* openness. It may be that these results rest on the fact that for 0ime period after 1995, the reimposition of targeted capital controls became more prevalent, as discussed in Klein (2012).

The role of country attributes

To answer my second question, does the relationship between capital controls and actual capital flows differ for different types of countries, I focus on the interaction between legal openness and development attributes. First by recovering the coefficients on the country dummies, I can check that unobserved country fixed effects are significant and vary in magnitude.

[20]Binici et al. (2010) and Lane and Milesi-Ferretti (2003, 2008) use real GDP per capita as a control variable for general economic development. (Because in Binici et al. (2010), their dependent variable (capital flows) are per capita as well, this is equivalent to including real GDP.) I am interested in identifying particular development attributes that might hinder or facilitate capital flows and thus only include domestic financial development and institutional quality explicitly. GDP per capita effects would be captured in the country dummies. Also, I use capital flow variables that have been divided by GDP, so the direct importance of a country's income level on flows has been subsumed. Future work would see if including per capita income or running the Binici et al. (2010) model specification on the fuller dataset would change the results significantly.

Having identified significant country effects, I investigate whether groups of countries with certain attributes have different relationships between legal openness and actual openness. I consider two characteristics: level of domestic financial development and institutional quality.[21] These choices are motivated by the theoretical model presented in Antras and Caballero (2009). The authors argue financial development determines whether trade and capital mobility are substitutes or complements. Heterogeneous financial development with trade integration increases the return to capital and thus incentivizes capital flows from capital rich to capital scarce countries. Financial development as characterized in Antras-Caballero model could encompass a broad set of country attributes, anything that causes financial trade to be inefficient. In this setting both of my measures of financial development, as well as my measures of institutional quality could contribute to the heterogeneity, and thus to the incentive for capital flows complementary to trade flows.

My first approach is to estimate my model with an additional term representing the interaction between the *de jure* measure and time varying development attribute A_i.[22]

$$deFacto_{it} = \alpha_0 + \alpha_1 deJure_{it} + \alpha_2 deJure_{it} * A_{it} + \alpha_3 Controls_{it} + Y_t + C_i + u_{it} \quad (2.4)$$

This regression tests whether policies to change legal openness interact with country development levels.

To my knowledge, only Mody and Murshid (2005) have included interactions of this kind (i.e. with a *de jure* measure). They consider whether capital flows to an individual country are persistant and, among other regresors, include an interaction

[21] I proxy the level of domestic financial development with private credit and stock-market turnover. Institutional quality is measured by ICRG's Corruption and Law and Order scores.

[22] The attribute is also included in the Controls. The actual variables are Private Credit to GDP, Stock-market Turnover, ICRG Law and Order and Corruption scores.

between their *de jure* financial integration measure and capital flows to developing economies as a group. They use a dataset of 60 developing countries for 1981-1998. They find that the *de jure* measure is not significant. The authors state there is weak, if any at all, evidence that liberalization can "pull in" flows on its own, but capital will react positively to increased openness and improvements in macro policy when outflows from developed countries increase.[23]

The model above however assumes a continuous relationship, i.e. it does not matter whether a country is extremely underdeveloped. A one-point improvement in institutional quality for example, will amplify the impact of a change in financial laws to the same degree for both a highly advanced economy and an undeveloped country. It may be the case that instead, below a certain level of development, steady improvement has little amplifying effect. Or above a certain development threshold, small changes in legal openness dramatically effect capital flows.[24] Kose et al. (2009a, 2006) suggest certain pre-requisite threshold levels of institutional development and government policy quality, may determine whether opening the capital-account leads to growth benefits or crises.

To analyse the possibility of threshold effects, I divide up the sample sorting countries into groups by development attribute (eg. Top 10pct and Bottom 10pct of countries sorted by financial development). I first look at plots to see if different groups show distinct slopes. Next I discretize the development attribute in my regression model by including a dummy variable T_i and an interaction term T_i x

[23]Future work could look at the interaction of system wide or regional variables with domestic financial openness and the effect on realized capital flows. For example, does increased global or regional integration magnify or dampen the impact of changes in the laws governing international transactions.

[24]This type of dynamic has been discussed in the growth literature. For example, Deidda and Fattouh (2002) model non-linearity in the finance and growth relationship and find empirical evidence: in high-income countries financial development was positively linked to growth, but no such relation emerges for low-income countries.

$deJure_{it}$ where T_i is a dummy for being above or below the threshold level of the sorting variable.[25] For example for domestic financial development, if the country is in the bottom 10th percentile, and the rest is my benchmark, then $T_i = 1$ for that less-developed country and the coefficient on the interaction term is interpreted as the distinct slope effect of being less-developed financially.

Both Lane and Milesi-Ferretti (2008) and Binici et al. (2010) run their regressions on sub groups. Lane and Milesi-Ferretti (2008), for end-2006 data, estimate their model on Advanced Economies and Emerging Markets as well as the full sample. Differences in significance and coefficient magnitudes do arise. In Binici et al. (2010) extensions section, they estimate their model using High Income countries (including Hong Kong, South Korea and Singapore) and then on Low/Middle Income countries. The High Income sample gives similar results to the full sample: targetted controls affect outflows but not inflows, and debt outflows more than gross equity outflows. For Middle and Low Income countries, legal restrictions affect gross equity outflows only. The authors note that on average the level of restrictions in High Income countries is significantly lower than for Low/Middle Income countries. However their results suggest High Income countries' minimal legal regime has more impact on realized flows. These results suggests the relation between *de jure* and *de facto* financial

[25]It may be the case that more developed economies open their capital accounts. Or in response to actual increases in international financial transactions (higher *de facto* openness), governments may put on protective capital controls in an attempt to reduce external vulnerability. For now, I am assuming endogeneity does not dominate the dataset. From 1980-2008 one could argue several more powerful dynamics incentivized and facilitated legal financial openness: not wanting to be left behind in the globalization process, a policy trend towards trade openness, and subsequently capital-account liberalization, the desire for export-oriented economies to facilitate international transactions, firms' drive to gain market share through FDI and governments' desire to import foreign technology, the development of international capital markets and innovations in international financial assets, the information technology boom reducing international transaction and information costs. Surgical reactive capital controls, most notably used by Chile in early 90s, to my knowledge did not become "acceptable" or common until more recently. Future work could examine this issue further, possibly using colonial legal heritage as an instrument for legal openness using the work of LaPorta et al. (2008).

openness may differ for different country groups. What exactly is it about being High Income or not, that drives these differences in the relation between *de jure* and *de facto* financial openness?

2.3 Results

2.3.1 Cross-section results

Looking at the relation between the gross stock of foreign assets and liabilities averaged over a 30-year period, the coefficient on the index of legal restrictions on international financial transactions is significantly different from 0, and has the correct sign (0.533). Interestingly the only other significant variable is the trade openness indicator, a result that persists with different *de facto* measures; evidence that trade openness is the dominating factor, at least during this 30-year period for these 76 countries.

Disaggregating by type and direction, the effect of *de jure* on *de facto* is evident for Gross Debt (a coefficient estimate of (0.520) but not Gross Equity, and when considering direction, for Assets (0.367) but not Liabilities. Given these results, debt transactions and asset accumulation seem to be driving the Gross Stock result. The effect of the *de jure* variable on the flow *de facto* measures (Gross Flows, Portfolio In/Out etc) was not significantly different from zero. The explanatory power of the Gross Stocks regression was the highest with an adjusted r-square of 0.455. These regression results suggest opening the capital account does not predict uniform increases in international financial transactions.

2.3.2 Panel results

Controlling for time and country fixed effects, the panel regression results imply the relationship between legal regime and observed financial openness is weak.

Looking at the aggregate stock measure as the dependent variable, the impact of the *de jure* variable is not different from zero. The estimate for the coefficient on *kaopen* is 0.046 with a 95 percent confidence interval of $[-0.01, 0.10]$. (See Panel Results: Table 2.7.) Disaggregating by direction, neither Liabilities (inward) nor Assets (outward) show an influence from the *de jure* measure.

Looking at whether legal openness effects some asset categories but not others, the estimated coefficients on the *de jure* measure vary in magnitude and statistical significance. Neither Gross Debt nor Gross Equity seem affected by the degree of *de jure* openness (Table 2.8). Looking at debt and direction (Table 2.9), legal capital account openness does affect the accumulation of foreign Debt Assets (outflows), but not accumulated inflows. With regards to equity and direction (Table 2.10), the opposite occurs. The coefficient on $DeJure$ is not significantly different from 0 for Equity Assets (outflows), but is significant and positively signed (0.024), for Equity Liabilities (inflows). Changing the legal regime seems to attract international equity investors.

Breaking out Equity portfolio and direct investment, the largest statistically significant effect of legal financial openness is on accumulated FDI. The coefficient estimate is 0.024 and significant with a p-value less than 0.001.[26] Notably the *de jure* variable is insignificant for portfolio equity liabilities, assets, and outward direct investment. Thus when breaking out accumulated equity flows, it becomes evident that FDI is the key asset type. In sum, the measurable outcome of legal capital account opening

[26]The explanatory power of the model with FDI as the *de facto* measure is also among the highest with an adjusted R-squared of 0.88.

does depend on the type and direction of international transaction. (See Table 2.1.)

Table 2.1: Estimated marginal effect of *de jure* on *de facto* measures

	All types	Debt	Equity		
Gross	**0.046**	0.024	-0.003	Equity	
(Assets + |Liabilities|)	**(0.026)**	(0.022)	(0.005)	Direct	Portfolio
Liabilities	0.022	-0.001	**0.024*****	**0.024*****	-0.001
(inflows)	(0.014)	(0.012)	**(0.006)**	**(0.004)**	(0.003)
Assets	0.024	**0.025***	0.001	0.003	-0.001
(outflows)	(0.014)	**(0.011)**	(0.006)	(0.003)	(0.003)

Country and year FE. Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Binici et al. (2010) also find heterogeneity. For example their *de jure* index of capital controls affects FDI plus Equity, but not Debt.[27] In contrast to my analysis, they argue FDI should not be separated out from portfolio equity transactions. However there are theoretical reasons to distinguish the two.[28] Long-term flows, such as FDI, are less susceptible to sudden reversals in international liquidity[29] in the sense that short-term liabilities must be rolled over or replaced by fresh liquidity. In addition, FDI in the form of a foreign joint venture or greenfield investment theoretically brings positive spillover effects such as technological transfer.[30] If as my results suggest, FDI is the most significant outcome of greater legal openness, then assessing the effects of the *de jure* measure would be picking up effects of accumulated realized FDI. The empirical evidence of positive spillover effects from FDI is mixed.[31] Thus looking for positive benefits from capital-account opening is likely to be mixed, and would depend on the effectiveness of the FDI channel.

[27]In contrast I find neither Gross Debt nor Gross Equity is affected. Their regression specification is slightly different than mine in that they use the first difference of Lane and Milesi-Ferretti stocks as a flow *de facto* measure and divide this by country population rather than country GDP. They include GDP per capita as a control variable. Also, they use the Schindler (2009) *de jure* capital control measure matching the relevant control with the type of asset.

[28]For example, Ostry et al. (2010) discuss how FDI is distinct from portfolio equity, and may be more debt-like if the FDI is in the form of transfers from parent foreign banks to local branches.

[29]See Chang and Velasco (2001) for a theoretical discussion.

[30]For example, Kose et al. (2006) discuss the hypothetically positive effects of foreign bank ownership.

[31]See for example Kinoshita (2001) for discussion of general FDI spillover effects.

2.3.3 Interaction between legal policy and development

As expected, recovering the coefficients on the country dummies from the least squares, dummy variable regressions, suggests there are significant country specific effects on the dependent variable, *de facto* measures of financial openness. 79 out of 116 country coefficients were statistically significant. What follows is an investigation of the impact of *de jure* financial openness on *de facto* measures taking into consideration the interaction of country attributes with policy.

Amplification

Considering the regression models that include an interaction term between *de jure* openness and country development attributes, financial sector development and institutional quality seem to amplify the effect of legal openness. I report the estimation results in Table 2.12. Financial development seems to have the greatest amplifying effect. The coefficient on the interaction between legal openness and domestic financial development, whether measured by private credit or stockmarket turnover, is statistically significant at the 1pct level. For private credit, the interaction term coefficient is estimated at 0.563 which is large enough to offset the now negative coefficient estimate on the $DeJure$ variable alone. The coefficient on stock market turnover interacted with legal openness is estimated to be 0.210. In sum the total marginal effect of greater legal openness on realized financial openness is 0.334 with private credit, and 0.210 with stockmarket turnover. Institutional quality also interacts positively with legal openness, when measured by the Law and Order score, however not at all by much when compared to the financial development variables.

This result highlights that domestic financial development may be crucial to the success of capital-account opening leading to increased financial integration. Once a

country departs from financial autarky, a more proficient financial sector is likely to raise the absorptive capacity of the economy and once the flows have arrived reduce distortions in the domestic capital allocation process. My results also suggest that capital-account opening successfully attracts investors when combined with a well-functioning perhaps recently liberalized domestic financal sector.[32] Thus financial development acts both as a channel for greater financial flows and a promoter of financial integration itself.

Along these lines, note that trade openness is also significant in the regressions. It may be the case that trade liberalization also acts as a signal of general reform momentum and boosts investment inflows. A formal model of trade and financial flows presented in Antras and Caballero (2009) argues that in a world with heterogeneous financial development, for less financially developed countries, capital-account opening without trade liberalization could in fact lead to outflows. They argue trade mobility complements capital flow mobility.[33] Deepening trade integration increases the return to capital and thus raises net capital inflows. If capital scarce countries are also financially underdeveloped, this model theorizes trade openness explains why capital may or may not flow to those countries. In conclusion, my result that financial development interacted with legal opening generates a positive effect on realized financial openness, supports the view that the success of capital-account opening depends on country attributes, in particular domestic financial development. Changing the laws alone does not necessarily induce changes in international financial integration.

[32]See Bartolini and Drazen (1997) for a discussion of capital-account opening as a signal of policy reform.

[33]Martin and Rey (2006) also argue that trade openness complements financial openness in that trade channels can ameliorate the effects of an a financial crisis.

Non-linearity

Kose et al. (2009a, 2006) argue that countries must surpass a development threshold in order to attain any benefits from capital-account opening. Looking at plots of period average data, grouping countries by institutional quality[34], and financial development, it does seem to matter whether a country is in the top 10th percentile versus the bottom 10th. The slopes and intercepts vary.

Using regression analysis with dummies for country groups and the full panel data set, evidence suggests being in the top 10th percentile of financial development or institutional quality does matter. For this group, the effect of legal openness on *de facto* openness is positive, whereas for the bottom 10th or below the median, it is negative or insignificant.[35]

The most striking differences in the *de jure* - *de facto* relationship arise when countries are grouped by domestic financial development. Figure 2.3 hints at this.[36] Period average $DeJure$ openness plotted against $GrossStocks$ shows the Top 10th percentile of countries that are more open legally, seem to mostly have higher $GrossStocks$, which is not the case for countries in the bottom 10th.

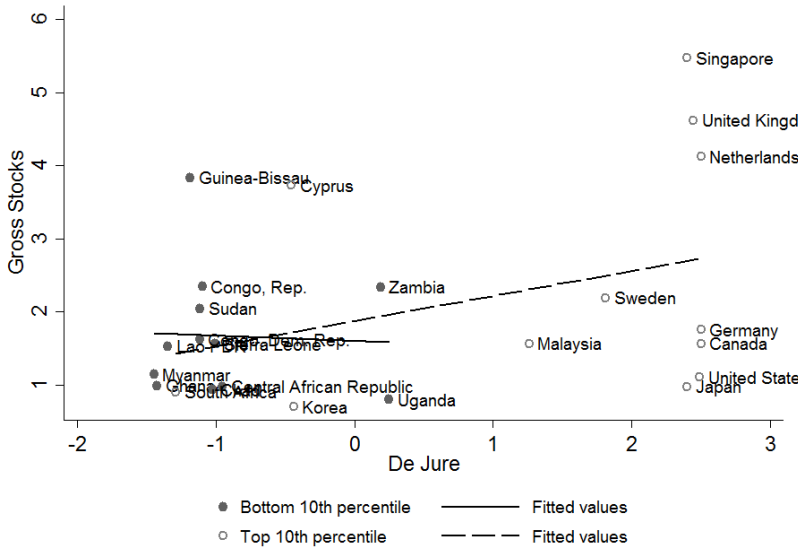
Looking at the regression results reported in Table 2.13, being in the top 10th percentile of financial development, proxied by private credit, an increase of one unit in *de jure* yields around an additional 0.39 increase in $GrossStocks$. For perspective, the mean country period average value of this *de facto* measure of financial openness is 2.62, the minimum is 0.38. In contrast, estimates for countries in the bottom 10th and below the median groups suggest a **negative** marginal effect of increased *de jure*

[34]Measured by the sum of International Country Risk Guide's (ICRG) Corruption and Law and Order scores. ICRG data kindly supplied by Hali Edison.

[35]The overall explanatory power of the models is not diminished when country group dummies are added. Adjusted R-squares are around 0.88.

[36]Hong Kong was dropped from the graph as an outlier with high financial development, and *de jure* and *de facto* financial openness.

Figure 2.3: Sorted by period average Private Credit to GDP

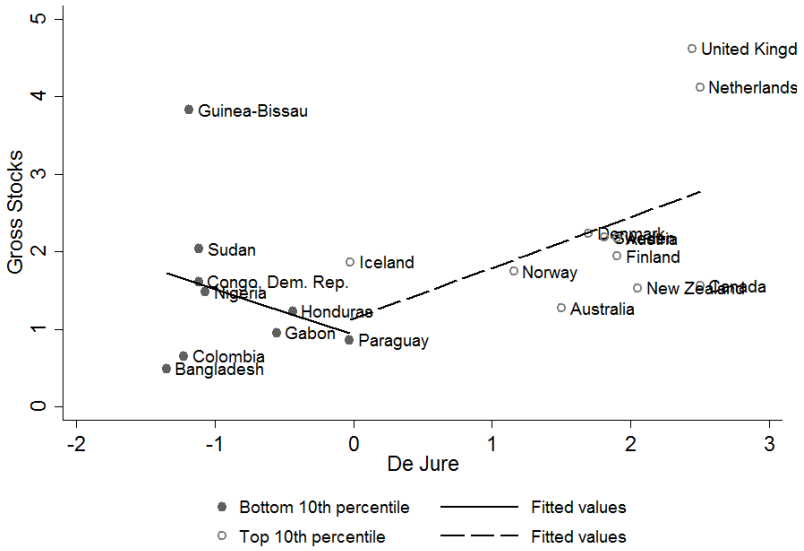


openness on *de facto* financial openness.[37] This difference persists when using stock market turnover as a proxy for financial development. For the top 10th percentile, coefficients are positive and statistically significant, while for the below the median group the effect is again negative, and for the bottom 10th, financial development adds nothing. In sum, this evidence suggests that for countries with the highest relative domestic financial development (top 10th percentile), the total marginal effect of increased legal openness on gross stocks is **positive**. In contrast, for countries below the median level, legal openness has a **negative or negligible** effect on accumulated foreign assets and liabilities.

Turning to institutional quality, do laws regarding capital flows have a greater effect in countries above a threshold level of bureaucratic development? Comparing the bottom 10th percentile to the top 10th sorted by institutional quality measures,

[37] The coefficient on the interaction between legal openness and bottom 10th percentile of domestic financial development is -0.210 and for below the median is -0.336. Thus the estimated total marginal effect of legal openness on *de facto* is -0.210 for bottom 10th and -0.156 for below the median.

Figure 2.4: Sorted by period average Law and Order + Corruption scores



plots of period average *DeJure* and *GrossStocks* suggest that for the countries with the weakest institutions, reduced legal restrictions on capital flows do nothing to increase realized capital flows. However, the top 10th percentile have a positive relation between legal openness and realized openness. Figure 2.4 shows the stark contrast between the top and bottom deciles using a combined institutional quality score.[38]

Using regressions with dummies for country groups, the relationship between legal openness and actual international financial integration is significantly different for the group of countries with the highest institutional quality. In Table 2.15, I report regression results for various percentile breaks. Institutionally advanced countries (in the top 10th percentile) experience an estimated **positive** effect of 0.522. For countries below the median, the interaction term coefficient is actually **negative** resulting in a total marginal effect of *de jure* on *de facto* of -0.081 for the underdeveloped group.

[38]Liberia was dropped from the plot as an outlier in the bottom decile of institutional quality.

2.3.4 Implications

One implication of the above analysis is that growth regression results are likely to vary depending on which measure of financial openness is used (and whether the countries included in the sample set are financially and institutionally developed. The heterogeneity in the relationships between *de jure* and *de facto* variables provides support for the conjecture in Quinn and Toyoda (2008) that the lack of consensus on the benefits of financial openness stems from measurement issues. In trying to understand the effect of capital controls on growth, a strand of empirical literature runs regressions with growth as the endogenous variable, and the candidate growth promoting variable on the right-hand side. When researchers have looked at the growth and international financial integration connection, they add controls for variables that have been shown to correlate with GDP growth in an attempt to identify a distinct positive effect from financial openness[39]. When both *de jure* and *de facto* measures are used interchangeably, the implicit assumption is that they are positively and significantly related, i.e. greater financial openness in the laws yields a noticeably larger realized *de facto* measure, controlling for other variables. From the analysis above, this assumption seems problematic. The relationship between gross stocks and the Chinn-Ito *de jure* index was weak. Developed countries' capital account laws do seem to have a positive and significant effect on observed capital flows, but there is little evidence supporting this relationship holds for underdeveloped countries.[40] Therefore studies that use *de facto* measures of financial openness would be identifying the effects of capital account legal openness in countries that have developed beyond some threshold level of financial development and institutional quality.

[39]For example see Edison et al. (2002), Rodrik (1998) among others.

[40]This matches results found by Edwards (2001) which discusses how emerging countries are different.

Using some of the same *de facto* and *de jure* measures as above, Table 2.2 illustrates that the significance of "financial openness" on per capita GDP growth does in fact vary with the measure used.[41] Notably, the Chinn-Ito *de jure* measure is not significant, while some of the *de facto* measures are. The models suggest Inflows, (portfolio and FDI), have the strongest effect on per capita GDP growth.

Threshold effects and interactions have been looked at in the empirical growth literature. For example, Edison et al. (2002) and Rodrik (1998) do not find that financial development interacted with financial openness has a significant impact on growth. From the analysis above it seems that capital controls in fact do interact with domestic development characteristics. A country with better institutions, will generate higher international financial integration (greater *de facto* openness) by loosening capital controls, but below the median countries are unlikely to see such a change in openness. Thus any realized growth benefits through the neo-classical channel would be coming from the more developed country group alone. The Prasad et al. (2007) finding that countries with below average financial development seem to not gain from financial openness goes along with this paper's results.

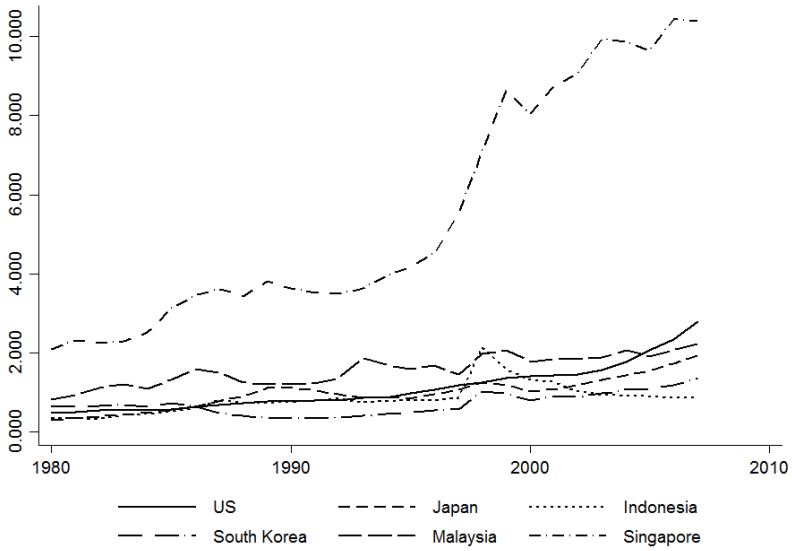
[41] I include the controls typically used in growth regressions: initial GDP per capita, initial level of schooling, measures of monetary and fiscal policy quality (Inflation Measure and Government Balance), and the measures of financial development and institutional quality used in Section 3.

Table 2.2: Growth regression comparison

	Dependent variable Real per capita GDP growth 1980-2009.				
	(1)	(2)	(3)	(4)	(5)
Initial Income	-0.446**	-0.483***	-0.471***	-0.480 ***	-0.483***
	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)
Initial Schooling	0.383	0.328	0.334	0.317	0.314
	(0.21)	(0.20)	(0.20)	(0.20)	(0.20)
Private Credit	0.775	0.582	0.595	0.680	0.666
	(0.44)	(0.41)	(0.41)	(0.40)	(0.40)
Stockmarket Turnover	0.597*	0.758**	0.672**	0.697**	0.731**
	(0.26)	(0.25)	(0.24)	(0.24)	(0.24)
Corruption	-0.021	-0.014	-0.023	-0.007	0.006
	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)
Law and Order	0.011	-0.019	-0.016	-0.020	-0.027
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)
Inflation Measure	-0.236	-0.049	-0.118	-0.072	-0.086
	(0.72)	(0.69)	(0.69)	(0.68)	(0.67)
Government Balance	0.077**	0.068**	0.070**	0.068**	0.068**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
De Jure	-0.072				
	(0.11)				
Gross Stock		0.134			
		(0.07)			
Gross Equity			0.564		
			(0.31)		
Gross Flows				1.573*	
				(0.77)	
Inflows					3.467*
					(1.53)
Intercept	2.432**	2.807***	2.864***	2.892***	2.863***
	(0.79)	(0.65)	(0.65)	(0.64)	(0.64)

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Figure 2.5: *De facto* financial openness, Gross Stocks

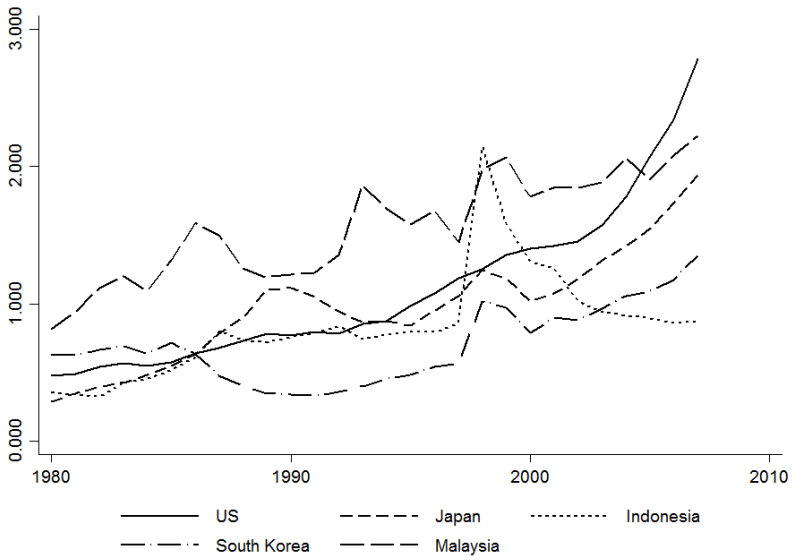


2.4 Time series analysis

Coming at the question of financial integration from a different angle, this section exploits the time series aspect of the data using a single cost of capital variable, the bank lending rate. One could focus on convergence or parity conditions. Instead using time series methods and analyze the influence of countries' lending rates on each other to gauge the degree of financial integration. Five countries from a similar regional context are considered: three financially developed countries (Japan, South Korea, and Singapore), and two less developed (Malaysia and Indonesia). The US lending rate is included as well, and the primary tool for analysis is variance decomposition. The hypothesis is that more financially open and financially developed countries should see a larger proportion of the variability in their lending rate being accounted for by the other countries in the group. (See Diebold and Yilmaz (2011), Landon-Lane and Rockoff (2008) for arguments of why variance decomposition is a good tool to investigate inter-connectedness.)

Historically, one could expect to see greater inter-connectedness in the later period (2001-2011) than in the earlier period (1986-1996) given a general policy trend towards financial liberalization and capital-account opening begun in the 1990s Rodrik (1998), and given the increasingly global nature of financial markets.

Figure 2.6: *De facto* financial openness, excluding Singapore

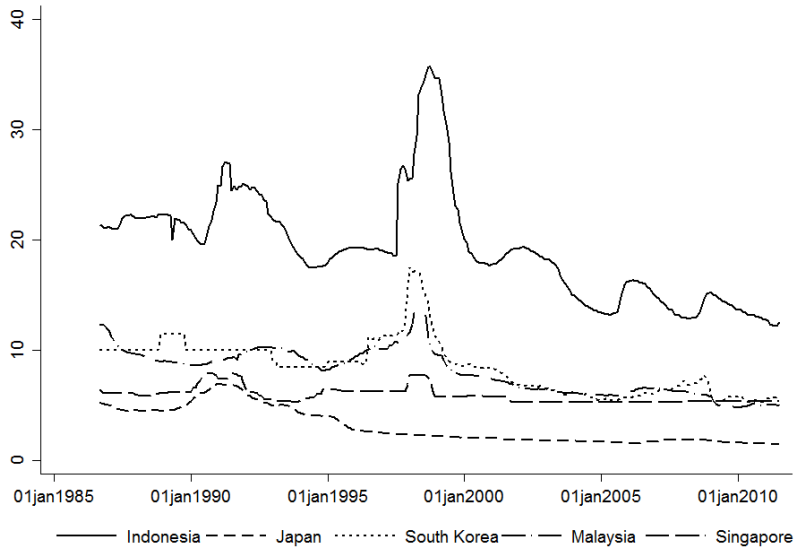


Looking at a graph of the gross stock of foreign assets (assets plus the value of liabilities, divided by GDP Lane and Milesi-Ferretti (2008)) in Figure 2.5 for the five Asian countries, for all countries, *de facto* financial openness was higher during the second period. Singapore experienced the most dramatic change, while Indonesia's gross assets were only slightly higher in the later period.

2.4.1 Time series data and methodology

The bank lending rate data is monthly and taken from the IMF's International Financial Statistics. September 1986 is the first month from when all countries have monthly data, plotted in Figure 2.7. Splitting the data into two sub-periods (early

Figure 2.7: Bank lending rate (1980-2011), Source: IFS



and late) with enough observations to estimate, I use September 1986 - December 1996 for the early period, and July 2001 - July 2011 for the late period.

I expect to see that during the early period, outside influences are negligible and shocks to the domestic lending rate are the primary driver of variability in the domestic rate. For the later period I expect to see greater influence from shocks to other countries' rates, in particular in the case of the most financially open and the most financially developed countries.

Identifying the structural shocks requires ordering the countries lending rates with the assumption that the first may influence later shocks but any later shocks do not influence their predecessors. Thus using this Cholesky identification method, for this exercise the first structural shock is to the US lending rate. The second structural shock is to the Japanese lending rate and this is assumed to be orthogonal to the shock to the US. The third shock is to the South Korean rate, which is orthogonal to both the Japanese and the US shocks. The fourth shock is to the Singaporean rate and is orthogonal to the South Korean, Japanese and US shocks. Similarly,

the fifth and sixth shocks are to Malaysia and Indonesia respectively. The shock to Indonesia is assumed to be orthogonal to the five other shocks.[42] This identification technique is sensitive to the ordering. The logic of this hierarchy follows from the size and relative development of each of these countries. I checked results with different orderings (swapping Malaysia and Indonesia, and swapping Singapore and South Korea) and the results were similar. Additionally, as argued in Diebold and Yilmaz (2011), aggregated connectedness, or as used in this paper the max proportion of influence of foreign shocks, is relatively robust to Cholesky ordering.

Before estimating a VAR, we need to investigate stationarity. Checking for unit roots in the univariate levels time series, I used the Augmented Dickey-Fuller test (Dickey and Fuller (1979)) specifying a non-zero mean and no trend. The null hypothesis of this test is that the series contains a unit root. We reject the null by comparing the test-statistic to the appropriate small sample critical value. A table summarizing the results for each country's lending rate series for each of the two periods is included in the appendix. Except for Malaysia during the early period, the test results suggest the series contain unit roots in both periods. Time series can often be made stationary by taking the first difference. Running the ADF test on the first-differenced series, results suggest the first-differenced series are stationary.[43]

Given the results of the unit root tests, I tested for co-integrating relationships in both periods using Johansen's trace statistic (Johansen (1991), see Table 2.3.) in order to determine whether to estimate a vector-error correction (VEC) model or a vector auto-regressive (VAR) model. Johansen's sequential procedure allows one to test at the same time the presence of none or multiple co-integrating relationships. The null is that there is at most r co-integrating equations. The test starts with the

[42]The structural shocks were constructed to have unit variance.

[43]See appendix for ADF tests on first-differenced series.

null of $r = 0$, and progresses to $r = 1$ if that is rejected; $r = 2$ if $r = 1$ is rejected, and so on.

Table 2.3: Johansen cointegration tests

	No. of cointegrating equations				
Period	None	≤ 1	≤ 2	≤ 3	≤ 4
Early period: Sep 1986 - Dec 1996	0.0438	0.2269	0.4846	0.6388	0.6310
Late period: Jul 2001 - Jul 2011	0.0000	0.0004	0.0809	0.2132	0.3921

Mackinnon-Haug-Michelis (1999) sample size corrected test statistic p-values.

For the early period, the test results suggest $r = 1$, at the 0.05 rejection level. For the second period, results suggest the presence of 2 co-integrating relations.[44]

For the first period, lag specification criteria (See appendix for details.) suggest a maximum of 4 lags in the VAR (which is equivalent to 3 lags for a VEC specification). Estimating a VEC of order 3 and rank 1, we can interpret the t-statistics on the estimated coefficients in the usual way. Since several of the coefficients on the 3rd lag are significant and all but one of the single equation adjusted R-squared do rise for the order 3 compared to the order 2, I use the VEC(3) rank 1 specification. For the second period, information criteria tests select 2 lags in the underlying VAR. I will estimate a VEC of order 2 and rank 2. [45]

2.4.2 Influence of outside shocks: variance decomposition

Using a particular forecast horizon, we can inspect the variance decomposition for the five Asian countries using the VEC models specified above.[46] In particular, looking

[44]The test assumed for both periods, no deterministic trend, just a constant (allowing the levels series to have non-zero means).

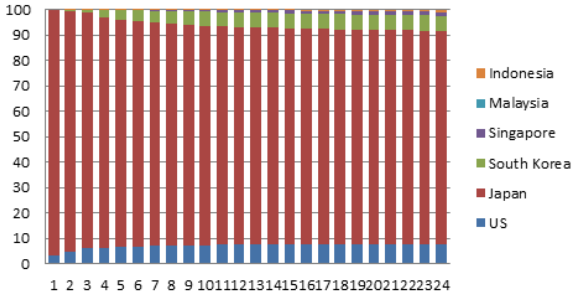
[45]It is interesting to note that the Johansen test results imply that the second period has a greater number of co-integrating relations. A co-integrating relationship entails a stationary linear combination of two or more non-stationary time series. Thus the co-integrating equation can be interpreted as a long-run relationship between the time series.

[46]The decomposition will differ with different horizons. I report the results for a 24-step (month) horizon. The results were not that different than for other horizon choices.

at a chart of the forecast error for a given country, we can see the influence of other countries on the variance in that country's lending rate. (Applied to the country context, this is similar to Diebold and Yilmaz's horizontal or "into" directional connectedness statistic in Diebold and Yilmaz (2011) which would capture the effect of an "outside" shock "into" the country. For a given country those statistics plus the country's own shock, (the row statistics) sum to 1, or equivalently 100pct.) Below are charts representing these dynamics, each country's contribution is a different color, and the bar for each step sums to 1 or 100pct.

Figure 2.8: Variance decomposition: Japan

(a) Early period



(b) Late period

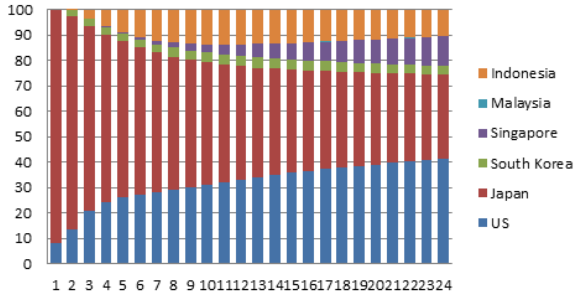
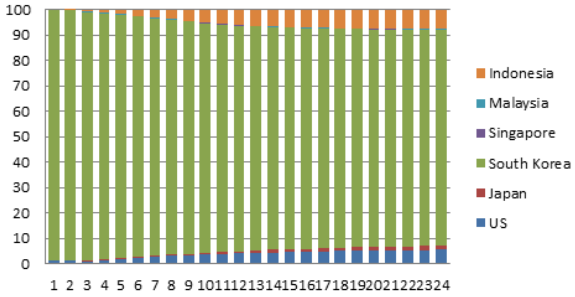
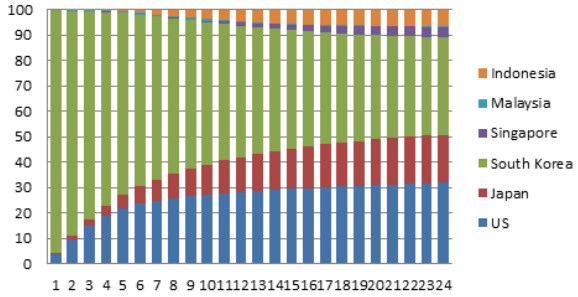


Figure 2.9: Variance decomposition: South Korea

(a) Early period



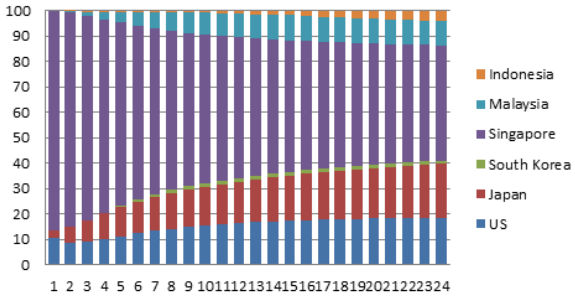
(b) Late period



Comparing the later period charts to the early period charts country by country, we observe substantive changes. For Japan, overall foreign influence seems higher,

Figure 2.10: Variance decomposition: Singapore

(a) Early period



(b) Late period

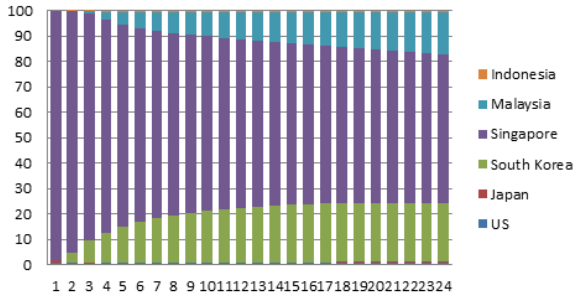
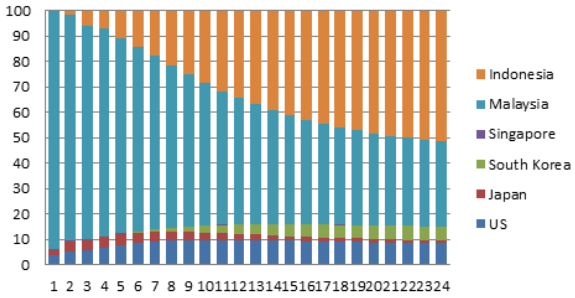


Figure 2.11: Variance decomposition: Malaysia

(a) Early period



(b) Late period

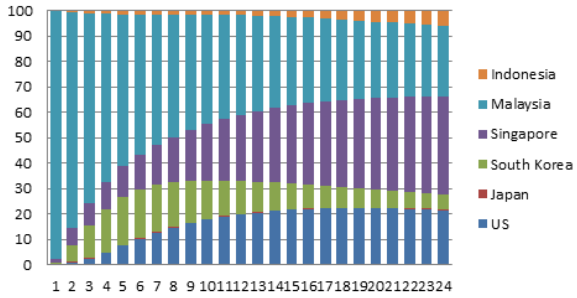
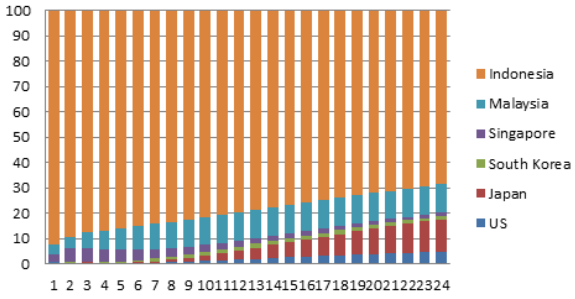
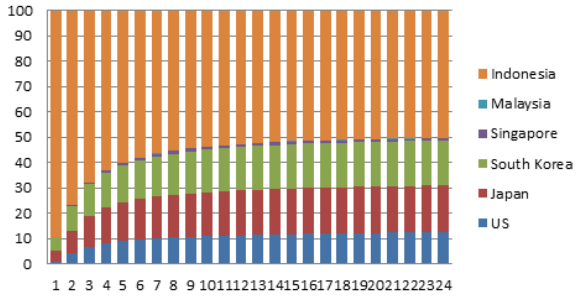


Figure 2.12: Variance decomposition: Indonesia

(a) Early period



(b) Late period



with shocks to the US lending rate in particular more influential in the later period. South Korea's variance decomposition shows the most dramatic change with foreign shocks, in particular to both the US and Japan, clearly more important components of the forecast error of the later period. Indonesia shows greater influence from foreign shocks, with the US, Japan and South Korea most prominent in the later period. Malaysia's forecast errors in the later period show higher outside influence than in the early period, but the most substantive change is in the country composition. In the early period Indonesia accounted for an average of around 30pct of Malaysia's forecast error. In the later period this average is only around 3pct, and Singapore, and the US are much more prominent accounting for around 40pct together. Singapore interestingly does not show greater integration in the later period. Shocks to South Korea and Malaysia account for an average of around 28pct of the late period forecast errors, while in the early period Japan and the US show the most influence together accounting for an average of around 30pct of the errors.

I expected to see during the early period less evidence of integration among the chosen subgroup of countries than during the later period. In general, the charts do suggest a rise in the influence of "into" shocks. In other words shocks to other countries' lending rates play a more prominent role in the later period suggesting a greater degree of international financial integration. The Table 2.4 reports two statistics for each period for each country i. The first involves taking the average of each foreign countries' contribution over the 24 step forecast horizon, and then summing these, excluding country i's. The second is the maximum value of the sum of country forecast errors excluding country i's, for a given step. (Also refer to Figure 2.15.) These are meant to assess the influence of outside countries, how much country i is integrated with the other countries in the system.

Table 2.4: Forecast error variance decomposition statistics

		Japan	South Korea	Singapore	Malaysia	Indonesia
Early period	Avg	13.02	14.90	41.04	45.30	20.75
Late period	Avg	50.83	44.11	30.19	54.62	43.54
	difference	*37.81*	*29.21*	*-10.85*	*9.32*	*22.79*
Early period	Max	16.11	9.93	54.69	66.58	31.29
	(rank)	(4)	(5)	(2)	(1)	(3)
Late period	Max	66.49	61.88	41.49	72.10	49.54
	(rank)	(2)	(3)	(5)	(1)	(4)
	difference	*50.38*	*51.95*	*-13.20*	*5.52*	*18.25*

2.4.3 Integration and financial development

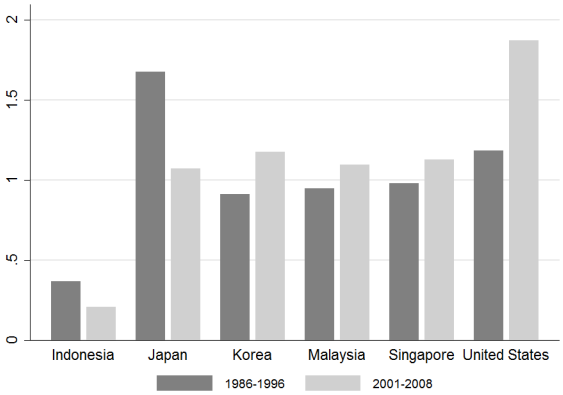
Let us now relate these results to the financial development and financial globalization story coming from the panel analysis. For the later period, I expected to see greater influence from foreign shocks (i.e. evidence of increased financial openness) in particular in the case of the most financially open and the most financially developed countries.

With regards to financial development, the countries I chose to look at all have a banking sector and a stock market and thus would not be grouped with the least financially developed of countries. However, Figure 2.13 graphs the two measures of domestic financial development used in the panel analysis averaged over the two periods. Japan and South Korea look relatively more developed, while Indonesia is relatively less developed.

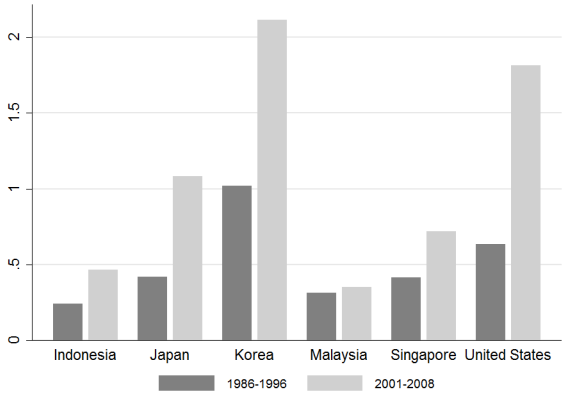
Of the five Asian countries, Japan, South Korea and Singapore in both periods ranked high in terms of private credit to GDP. For both periods South Korea had the highest stock market turnover to GDP ratio. Whereas, Indonesia ranked a distant fifth in both periods with regards to the private credit measure, and for the stock-

Figure 2.13: Financial development

(a) Private credit to GDP



(b) Stockmarket turnover to GDP



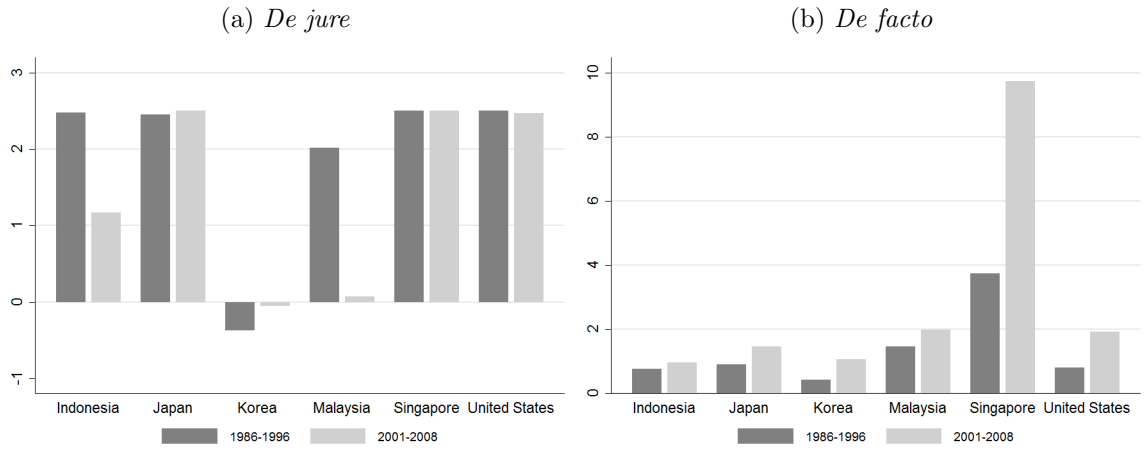
market turnover measure, fifth in the first period and fourth in the later period. If all five countries experienced the same level of financial openness, I would expect Japan and South Korean lending rates to show more foreign influence than say Indonesia's. One can see that from the late period variance decomposition charts, Japan and South Korea do show higher inter-connectedness than Indonesia. Indonesia's Max statistic is 49, while Japan's is 66 and South Korea's is 62.

South Korea, in terms of openness, in both periods ranked last for *de jure* openness, and for *de facto* openness, fifth in the early period and fourth in the later period. (See Figure 2.14.) So South Korea, while financially relatively developed, is relatively less open.

The latter characteristic dominates South Korea's early period variance decomposition where very little foreign influence is observed.[47] However in the later period we do see greater foreign influence. South Korea's reform process begun in the late 1980s may have driven the second period rise in financial development. These domestic developments may have facilitated South Korea's integration into international

[47]South Korea ranked 5th with respect to the Max statistic (the maximum foreign influence over the forecast period).

Figure 2.14: Financial openness

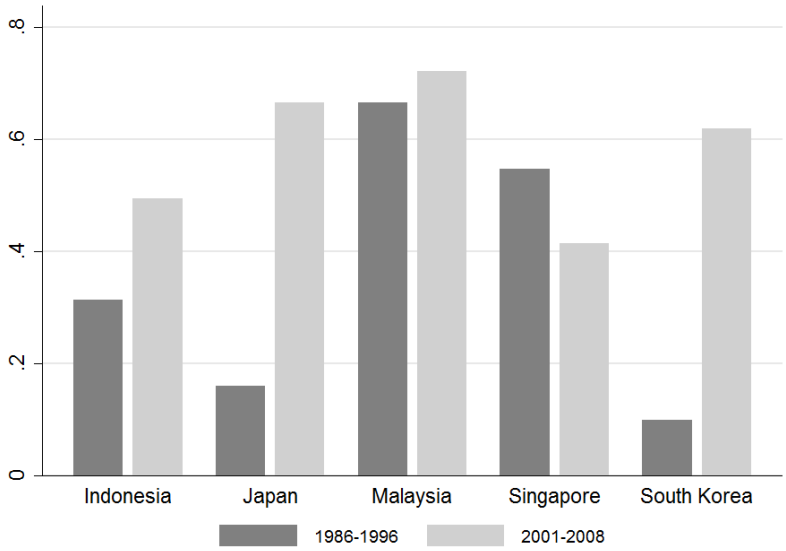


financial markets and thus we saw the rise in the influence of US and Japan in the later period.

Japan, during the time periods considered, became increasingly financially open from a legal perspective both in absolute terms and relative to the other countries in the sample. Actual realized financial openness also rose, however in both periods Japan ranked third relative to the other countries in the sample. In terms of financial development, the decline in the private credit to GDP measure may be capturing the dysfunction of Japan's banking sector in the latter period. The stock market turnover to GDP measure shows that capital markets may have stepped in to fill the void: the later period average is notably higher than the 1986-1996 period. So with a more welcoming legal regime, middling *de facto* openness, and a challenged but evolving financial sector, Japan in absolute terms showed considerably more foreign influence in the later period. In relative terms Japan ranked second in terms of the Max foreign influence statistic in the later period, compared to fourth in the early period.

For Indonesia, the variance decomposition, or forecast error statistics were as expected. With comparatively low *de facto* financial openness, and financial develop-

Figure 2.15: Maximum proportion of foreign shocks in any given step



ment, Indonesia although in absolute terms showed a rise in foreign influence in the later period, in relative terms foreign influence was low. Indonesia ranked fourth in the late period in terms of the Max proportion of Indonesia's forecast error accounted for by shocks to other countries' lending rates.

For realized financial openness, Singapore and Malaysia rank the highest in both periods. In the case of Malaysia, with a relatively unwelcoming legal regime (second most closed after South Korea), and middling financial development, foreign influence as measured by the Max statistic was the highest among the five countries in both periods. This suggests with a basic level of financial development, actual capital flows do in fact lead to greater influence from foreign financing conditions (a higher level of financial market integration). However Singapore with slightly better financial development than Malaysia, and by far the greatest level of *de facto* financial openness (and a welcoming legal regime to boot), actually showed a slight absolute decline in foreign influence, and ranked fifth by the Max statistic in the later period. Thus making it hard to draw any conclusions.

2.5 Conclusion

In conclusion, legal financial openness does not necessarily induce higher realized financial openness. Furthermore, different types of assets respond differently to general legal opening. Thus finding evidence for benefits of capital-account opening will depend on the measure used, and the country context. In particular, the panel analysis country attribute results suggest that for financially and institutionally underdeveloped countries, opening the capital account does not on its own generate significant increases in international capital flows. Given this, for these countries, the stand-alone policy of capital-account liberalization is unlikely to induce the investment and growth benefits predicted by neo-classical theory. Threshold levels of financial development in particular seem to be prerequisites for legal opening to have measurable effects. The time series analysis of five middle or highly financially developed economies suggested liberalization and domestic financial sector conditions do influence international financial integration, but the case of Malaysia and Singapore highlighted the difficulties of making generalizations.

2.6 Appendix

Table 2.5: *De facto* financial openness measures

Stocks	
Gross Stock	*ggross*, foreign assets + |foreign liabilities|
Liabilities	*gsttll*, total foreign liabilities
Assets	*gsttla*, total foreign assets
Gross Debt	*sdebt*, debt assets + |liabilities|
Debt Liabilities	*gsipfld*, foreign debt liabilities
Debt Assets	*gsopfld*, foreign debt assets
Gross Equity	*seqty*, equity assets + |liabilities|
Equity Liabilities	*sfdieqtyin*, FDI + foreign portfolio equity liabilities
Equity Assets	*sodieqtyout*, ODI + foreign portfolio equity assets
ODI	*gsodi*, overseas direct investment assets
FDI	*gsfdi*, foreign direct investment liabilities
Portfolio Liabilities	*gsipfle*, portfolio equity liabilities
Portfolio Assets	*gsopfle*, portfolio equity assets
Flows	
Gross Flows	*ggrossfl*, inflows and outflows of direct + portfolio investment
Inflows	*fdipflin*, FDI + total portfolio inflows
Outflows	*odipflout*, ODI + total portfolio outflows
Portfolio In (Out)	*gipfl* (*gopfl*), debt plus portfolio equity inflows (outflows)
FDI (ODI) Flows	*gfdi* (*godi*), inward (outward) investments with equity stake above 10pct

All variables divided by national GDP.

Table 2.6: Cross-correlations of period average variables

Variables	DeJure	Gross Stock	Liabilities	Assets	Gross Flows	Inflows	Outflows	Gross Debt	Gross Eqty
DeJure	1.00								
Gross Stock	0.45	1.0							
Liabilities	0.13	0.77	1.00						
Assets	0.55	0.83	0.29	1.00					
Gross Flows	0.36	0.61	0.48	0.72	1.00				
Inflows	0.24	0.60	0.51	0.52	0.92	1.00			
Outflows	0.40	0.69	0.41	0.79	0.93	0.73	1.00		
Gross Debt	0.35	0.95	0.74	0.78	0.55	0.47	0.54	1.00	
Gross P.Eqty	0.45	0.54	0.31	0.55	0.77	0.62	0.83	0.33	1.00

Table 2.7: Gross Stocks, Liabilities, Assets

	(1) Gross Stock	(2) Liabilities	(3) Assets
De Jure	0.046	0.022	0.024
	(0.026)	(0.014)	(0.014)
Natural Resources	-0.009	-0.002	-0.008*
	(0.005)	(0.003)	(0.004)
Trade to GDP	0.012***	0.006***	0.006***
	(0.003)	(0.002)	(0.002)
Private Credit	1.635***	0.888***	0.747***
	(0.272)	(0.146)	(0.131)
Stockmarket Turnover	0.209**	0.106**	0.103**
	(0.067)	(0.037)	(0.032)
Corruption	0.076	0.028	0.049
	(0.058)	(0.030)	(0.029)
Law and Order	-0.124**	-0.061**	-0.063**
	(0.038)	(0.020)	(0.020)
Observations	1319	1319	1319
Adjusted R^2	0.887	0.856	0.908

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.8: Debt vs. Equity

	(1) Gross Debt	(2) Gross Equity
De Jure	0.024	-0.003
	(0.022)	(0.005)
Natural Resources	-0.009	0.001
	(0.005)	(0.001)
Trade to GDP	-0.000	0.004**
	(0.003)	(0.001)
Private Credit	1.284***	0.207**
	(0.195)	(0.072)
Stockmarket Turnover	0.197***	0.015
	(0.055)	(0.013)
Corruption	0.057	0.013
	(0.044)	(0.017)
Law and Order	-0.132***	0.006
	(0.028)	(0.011)
Observations	1319	1303
Adjusted R^2	0.853	0.792

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.9: Accumulated Debt by direction

	(1) Debt Liabilities	(2) Debt Assets
De Jure	-0.001	0.025*
	(0.012)	(0.011)
Natural Resources	0.000	-0.009**
	(0.002)	(0.003)
Trade to GDP	0.000	-0.000
	(0.002)	(0.001)
Private Credit	0.751***	0.533***
	(0.113)	(0.092)
Stockmarket Turnover	0.116***	0.081**
	(0.031)	(0.025)
Corruption	0.021	0.036
	(0.021)	(0.024)
Law and Order	-0.072***	-0.060***
	(0.015)	(0.015)
Observations	1319	1319
Adjusted R^2	0.808	0.881

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.10: Accumulated Equity by direction

	(1) Equity Liabilities	(2) Equity Assets
De Jure	0.024***	0.001
	(0.006)	(0.006)
Natural Resources	-0.002**	0.002***
	(0.001)	(0.001)
Trade to GDP	0.005***	0.005**
	(0.001)	(0.002)
Private Credit	0.134**	0.247***
	(0.048)	(0.048)
Stockmarket Turnover	-0.015	0.024*
	(0.011)	(0.012)
Corruption	0.005	0.017
	(0.015)	(0.012)
Law and Order	0.013	-0.013
	(0.011)	(0.011)
Observations	1317	1305
Adjusted R^2	0.840	0.826

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Country FE and year dummies included.

Equity includes Portfolio Equity plus FDI or ODI.

Table 2.11: Equity decomposed into portfolio and direct investment

	(1) FDI	(2) ODI	(3) Portfolio Liabilities	(4) Portfolio Assets
De Jure	0.024***	0.003	-0.001	-0.001
	(0.004)	(0.003)	(0.003)	(0.003)
Natural Resources	-0.001*	0.001*	-0.001*	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Trade to GDP	0.004***	0.003**	0.002***	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Private Credit	0.056**	0.118***	0.078	0.129***
	(0.019)	(0.024)	(0.045)	(0.030)
Stockmarket Turnover	-0.021***	0.015*	0.006	0.010
	(0.006)	(0.006)	(0.008)	(0.006)
Corruption	0.003	0.006	0.002	0.011
	(0.007)	(0.007)	(0.011)	(0.007)
Law and Order	0.005	-0.010	0.007	-0.005
	(0.006)	(0.007)	(0.007)	(0.005)
Observations	1319	1319	1317	1305
Adjusted R^2	0.884	0.818	0.755	0.811

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Country FE and year dummies included.

Equity positions greater than 10 pct are classified as direct investments.

Table 2.12: Interactions of *de jure* financial openness with development attributes

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock	(4) Gross Stock
De Jure	-0.229***	-0.014	-0.028	-0.288***
	(0.052)	(0.030)	(0.089)	(0.063)
Natural Resources	-0.009	-0.008	-0.009	-0.010*
	(0.005)	(0.005)	(0.005)	(0.005)
Trade to GDP	0.015***	0.012***	0.012***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)
Private Credit	0.723*	1.562***	1.652***	1.606***
	(0.302)	(0.274)	(0.273)	(0.272)
Stockmarket Turnover	0.179**	0.209**	0.207**	0.202**
	(0.065)	(0.066)	(0.067)	(0.066)
Corruption	0.048	0.075	0.062	0.087
	(0.057)	(0.058)	(0.046)	(0.058)
Law and Order	-0.068	-0.092*	-0.120***	-0.116**
	(0.039)	(0.038)	(0.035)	(0.038)
PrivateCredit*DeJ	0.563***			
	(0.107)			
StckMrktTurnover*DeJ		0.210***		
		(0.038)		
Corruption*DeJ			0.022	
			(0.027)	
Law Order*DeJ				0.083***
				(0.016)
Observations	1319	1319	1319	1319
Adjusted R^2	0.892	0.889	0.887	0.889

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Country FE and year dummies included.

Table 2.13: Financial development, private credit

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock
De Jure	0.016	0.099***	0.015
	(0.027)	(0.029)	(0.027)
Natural Resources	-0.011	-0.010	-0.011
	(0.007)	(0.007)	(0.007)
Trade to GDP	0.010***	0.010**	0.010***
	(0.003)	(0.003)	(0.003)
Corruption	0.065	0.073	0.042
	(0.052)	(0.052)	(0.052)
Law and Order	-0.044	-0.037	-0.031
	(0.035)	(0.035)	(0.035)
Bottom10pct	0.141		
	(0.078)		
Bottom10pct*DeJ	-0.099		
	(0.053)		
Bottom50pct		-0.100	
		(0.064)	
Bottom50pct*DeJ		-0.143***	
		(0.037)	
Top10pct			0.255**
			(0.088)
Top10pct*DeJ			0.257***
			(0.052)
Observations	1428	1428	1428
Adjusted R^2	0.889	0.891	0.893

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.14: Financial development, stockmarket turnover

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock
De Jure	0.058	0.180**	0.061
	(0.042)	(0.057)	(0.039)
Natural Resources	-0.015**	-0.015**	-0.013*
	(0.005)	(0.005)	(0.005)
Trade to GDP	0.009	0.009*	0.009*
	(0.005)	(0.005)	(0.004)
Corruption	-0.139*	-0.141**	-0.127*
	(0.056)	(0.055)	(0.050)
Law and Order	0.140**	0.155**	0.094*
	(0.051)	(0.051)	(0.045)
Bottom10pct	0.232*		
	(0.115)		
Bottom10pct*DeJ	-0.210**		
	(0.073)		
Bottom50pct		0.323**	
		(0.115)	
Bottom50pct*DeJ		-0.336***	
		(0.072)	
Top10pct			1.058***
			(0.207)
Top10pct*DeJ			0.393**
			(0.120)
Observations	1879	1879	1879
Adjusted R^2	0.698	0.702	0.717

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.15: Institutional quality

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock
De Jure	0.046	0.102***	0.033
	(0.027)	(0.031)	(0.027)
Natural Resources	-0.010*	-0.012*	-0.012**
	(0.005)	(0.005)	(0.005)
Trade to GDP	0.013***	0.013***	0.013***
	(0.003)	(0.003)	(0.003)
Private Credit	1.563***	1.552***	1.611***
	(0.274)	(0.274)	(0.292)
Stockmarket Turnover	0.216**	0.194**	0.195**
	(0.067)	(0.066)	(0.063)
Bottom10pct	0.118		
	(0.081)		
Bottom10pct*DeJ	-0.059		
	(0.053)		
Bottom50pct		-0.058	
		(0.059)	
Bottom50pct*DeJ		-0.183***	
		(0.033)	
Top10pct			-1.807***
			(0.253)
Top10pct*DeJ			0.522***
			(0.144)
Observations	1317	1317	1317
Adjusted R^2	0.886	0.888	0.890

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Country FE and year dummies included.

Institutional quality = Law and Order + Corruption scores

Table 2.16: Institutional quality, Law and Order

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock
De Jure	0.048	0.102**	0.046
	(0.027)	(0.031)	(0.027)
Natural Resources	-0.010*	-0.010*	-0.010*
	(0.005)	(0.005)	(0.005)
Trade to GDP	0.013***	0.012***	0.013***
	(0.003)	(0.003)	(0.003)
Private Credit	1.563***	1.580***	1.561***
	(0.274)	(0.275)	(0.273)
Stockmarket Turnover	0.210**	0.211**	0.211**
	(0.067)	(0.066)	(0.067)
Bottom10pct	0.208**		
	(0.077)		
Bottom10pct*DeJ	-0.043		
	(0.058)		
Bottom50pct		0.182**	
		(0.062)	
Bottom50pct*DeJ		-0.173***	
		(0.035)	
Top10pct			0.000
			(.)
Top10pct*DeJ			0.000
			(.)
Observations	1314	1314	1314
Adjusted R^2	0.887	0.888	0.887

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

Table 2.17: Institutional quality, Corruption

	(1) Gross Stock	(2) Gross Stock	(3) Gross Stock
De Jure	0.043	0.068*	0.031
	(0.027)	(0.032)	(0.027)
Natural Resources	-0.010*	-0.008	-0.012**
	(0.005)	(0.005)	(0.005)
Trade to GDP	0.013***	0.014***	0.013***
	(0.003)	(0.003)	(0.003)
Private Credit	1.554***	1.505***	1.604***
	(0.275)	(0.270)	(0.293)
Stockmarket Turnover	0.209**	0.151*	0.195**
	(0.067)	(0.066)	(0.063)
Bottom10pct	-0.096		
	(0.111)		
Bottom10pct*DeJ	-0.013		
	(0.072)		
Bottom50pct		-0.389***	
		(0.068)	
Bottom50pct*DeJ		-0.079	
		(0.055)	
Top10pct			-1.813***
			(0.245)
Top10pct*DeJ			0.481***
			(0.138)
Observations	1312	1312	1312
Adjusted R^2	0.886	0.889	0.890

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Country FE and year dummies included.

2.6.1 International Country Risk Guide (ICRG)

Corruption index score: max 6 points

This is an assessment of corruption within the political system. Such corruption is a threat to foreign investment for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability; and, last but not least, introduces an inherent instability into the political process.

The most common form of corruption met directly by business is financial corruption in the form of demands for special payments and bribes connected with import and export licenses, exchange controls, tax assessments, police protection, or loans. Such corruption can make it difficult to conduct business effectively, and in some cases my force the withdrawal or withholding of an investment.

Although our measure takes such corruption into account, it is more concerned with actual or potential corruption in the form of excessive patronage, nepotism, job reservations, favor-for-favors, secret party funding, and suspiciously close ties between politics and business. In our view these insidious sorts of corruption are potentially of much greater risk to foreign business in that they can lead to popular discontent, unrealistic and inefficient controls on the state economy, and encourage the development of the black market.

The greatest risk in such corruption is that at some time it will become so overweening, or some major scandal will be suddenly revealed, as to provoke a popular backlash, resulting in a fall or overthrow of the government, a major reorganizing or restructuring of the country's political institutions, or, at worst, a breakdown in law and order, rendering the country ungovernable

Law and Order index score: max 6 points

Law and Order are assessed separately, with each sub-component comprising zero to three points. The Law sub-component is an assessment of the strength and impartiality of the legal system, while the Order sub-component is an assessment of popular observance of the law. Thus, a country can enjoy a high rating – 3 – in terms of its judicial system, but a low rating – 1 – if it suffers from a very high crime rate of if the law is routinely ignored without effective sanction (for example, widespread illegal strikes).

2.6.2 Panel data analysis

Table 2.18 shows results for different sets of control variables, using Gross Stocks as the *de facto* measure. The paper reports results using the variables in Model(4). Including measures of monetary and fiscal policy quality reduces R-square, loses observations, and the policy variable coefficients are not significantly different from 0.

Table 2.18: Choice of basic estimation model,
Dependent variable: Gross Stocks

	(1)	(2)	(3)	(4)	(5)
De Jure	0.021	0.037	0.039	0.046	-0.076
	(0.036)	(0.037)	(0.025)	(0.026)	(0.048)
Natural Resources	0.001	0.003	-0.006	-0.009	-0.042***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.012)
Trade to GDP		0.010	0.016***	0.012***	0.014*
		(0.005)	(0.005)	(0.003)	(0.006)
Private Credit			1.382***	1.635***	2.108***
			(0.245)	(0.272)	(0.465)
Stockmarket Turnover			0.101*	0.209**	0.077
			(0.049)	(0.067)	(0.075)
Corruption				0.076	0.199
				(0.058)	(0.148)
Law and Order				-0.124**	0.059
				(0.038)	(0.084)
Observations	2949	2875	1525	1319	679
Adjusted R^2	0.619	0.625	0.878	0.887	0.884

Standard errors in parentheses. Country and year FE.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.19 shows estimation results for different estimation procedures. Model(1) uses period average variables (crossection), Model(2) uses all observations (pooled), Model(3) uses country fixed effects and year dummies.

Table 2.19: Comparing estimation approaches,
Dependent variable: Gross Stocks

	(1)	(2)	(3)
De Jure	0.533*	0.210***	0.046
	(0.224)	(0.028)	(0.026)
Natural Resources	0.003	0.004	-0.009
	(0.009)	(0.002)	(0.005)
Trade to GDP	0.022***	0.025***	0.012***
	(0.004)	(0.002)	(0.003)
Private Credit	0.515	1.630***	1.635***
	(1.010)	(0.185)	(0.272)
Stockmarket Turnover	-0.964	0.065	0.209**
	(0.799)	(0.086)	(0.067)
Corruption	-0.373	-0.088	0.076
	(0.344)	(0.059)	(0.058)
Law and Order	0.372	0.073	-0.124**
	(0.332)	(0.050)	(0.038)
Observations	77	1319	1319
Adjusted R^2	0.460	0.482	0.887

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2.6.3 Time series analysis

Unit root tests for bank lending rates, Augmented Dickey-Fuller statistics for levels, reported below. Lag criteria diagnostics reported in Tables 2.22 and 2.23.

Table 2.20: Unit root tests, Early period: Sep 1986 - Dec 1996

	Deterministic term	No. of lagged differences	Test stat
US	constant	8	-2.1646
		2	-1.4221
Japan	constant	4	-0.8136
		3	-1.0334
Singapore	constant	3	-2.2076
		2	-2.2003
South Korea	constant	3	-1.7270
		2	-1.7528
Malaysia	constant	5	-2.7116
		4	-3.6420
		3	-3.6730
Indonesia	constant	3	-1.8434
		2	-1.5898

Table 2.21: Unit root tests, Late period: Jul 2001 - Jul 2011

	Deterministic term	No. of lagged differences	Test stat
US	constant	9	-2.3868
		2	-1.3581
Japan	constant	7	-1.8310
		4	-1.8399
Singapore	constant	3	-1.2895
		2	-1.9769
		1	-13.4053
South Korea	constant	2	-2.5643
		1	-2.8735
Malaysia	constant	4	-0.9474
		3	-1.195
		2	-0.9424
Indonesia	constant	3	-2.4736
		2	-2.5009

Table 2.22: Lag criteria, Early period: Sep 1986 – Dec 1996

Sample: 9 to 124, Number of obs. = 116								
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-826.033	.	.	.	.068435	14.3454	14.4032	14.4878
1	265.618	2183.3	36	0.000	8.5e-10	-3.85548	-3.45076*	-2.85849*
2	305.845	80.455	36	0.000	8.0e-10*	-3.92837*	-3.17674	-2.07682
3	328.231	44.772	36	0.150	1.0e-09	-3.69364	-2.59511	-.987526
4	362.952	69.443	36	0.001	1.1e-09	-3.67159	-2.22616	-.110917
5	393.979	62.053	36	0.004	1.2e-09	-3.58584	-1.79351	.829397
6	427.199	66.441	36	0.001	1.3e-09	-3.53792	-1.39868	1.73188
7	454.116	53.833*	36	0.028	1.7e-09	-3.38131	-.895165	2.74306
8	477.344	46.457	36	0.114	2.4e-09	-3.16111	-.328064	3.81782

Endogenous: United States Japan South Korea Malaysia Singapore Indonesia
Exogenous: Constant

Table 2.23: Lag criteria, Late period: Jul 2001 - Jul 2011

Sample: 9 to 121, Number of obs. = 113								
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-106.1	.	.	.	2.9e-07	1.98407	2.04284	2.12889
1	1115.18	2442.6	36	0.000	2.3e-16	-18.9943	-18.5829	-17.9805*
2	1199.47	168.6	36	0.000	9.7e-17*	-19.8491*	-19.0851*	-17.9665
3	1227.3	55.651	36	0.019	1.1e-16	-19.7044	-18.5879	-16.9529
4	1249.81	45.017	36	0.144	1.5e-16	-19.4656	-17.9965	-15.8452
5	1286.18	72.742	36	0.000	1.5e-16	-19.4722	-17.6505	-14.9829
6	1324.86	77.358	36	0.000	1.6e-16	-19.5196	-17.3453	-14.1614
7	1362.71	75.709	36	0.000	1.7e-16	-19.5524	-17.0255	-13.3253
8	1391.4	57.383*	36	0.013	2.1e-16	-19.4231	-16.5436	-12.327

Endogenous: United States Japan South Korea Malaysia Singapore Indonesia
Exogenous: Constant

Chapter 3

Learning by banking: testing for experience effects in the financial sector

3.1 Introduction

This paper hypothesizes that through financial intermediaries learning by doing, there exists a firm-level mechanism for financial sector development. Typically in the macro literature, financial development is measured by financial depth and breadth, eg. as private credit to GDP and stockmarket value to GDP. Taking a different approach here, financial development is measured by the efficiency of the banking sector and in particular the costs of producing financial services: lower costs imply a more developed financial sector. Learning by doing is a mechanism that reduces the costs of production, thus banks' experience may be one determinant of financial development. To the extent that financial firms can capture knowledge gained from experience, changing processes and organizational structure, policymakers would not

want these experienced firms to disappear. Furthermore, if experience does affect banks' efficiency, liberalizing the financial sector in order to encourage banking activity, whether via liberalizing domestic financial markets or opening up to global trade and global capital flows, would allow for these gains. To test for experience effects, this paper constructs and estimates a bank-specific cost function augmented to include experience proxies. It is not obvious to what degree banks would pass on cost savings to users of financial intermediation services given regulatory heterogeneity and competitive factors. As such, this paper looks at self-reported production costs and tests for experience effects on cost efficiency.

Using US bank data, and adjusting the model to account for non-linearity, experience was associated with lower cost for banks up to around 2 years of age. However, a key concern with banking efficiency studies as well as cost function estimation is the difficulty with dealing with sample dependence and endogeneity issues. This paper explicitly corrects for endogeneity as well as selection biases by applying a two-step correction procedure based on Heckman (1979) and Olley and Pakes (1996). The corrected model implies this experience effect continues up to around 10 years of age, about 5 times as long as estimated by the uncorrected model. For example, on average, a 10 percent increase in experience, for a bank of around 1 year of age is associated with a 10.9 percent decline in cost; for a 5-year old bank, that becomes a 2 percent decline in cost. These results suggest experience can have a positive effect on banking efficiency, and consequently on financial sector development.

From a supervisory perspective, to the degree that learning and innovations are institutionalized within the bank, experience effects generate an information cost to bank failure in addition to the costs emphasized in Bernanke (1983). These authors emphasized that bank failures destroyed information about borrowers that had been captured within these banks, and this loss of "'information capital"' worsened the

Great Depression. Furthermore, disentangling scale efficiencies from experience effects helps to clarify the determinants of large banks' advantages. The result that gains from experience accrue in the early years of a bank's operations would imply that policymakers may want to differentiate requirements for young banks in order for these gains to be realized.

From a macroeconomic perspective, financial development is a policy goal. A vulnerable financial sector can cause or exacerbate economic crises. A well-developed financial sector facilitates welfare enhancing interactions between savers and entrepreneurs, reducing the costs of asymmetric information between lenders and borrowers. Access to capital for entrepreneurs allows financially constrained agents to borrow, invest and go forward with economically viable projects. Efficient allocation of capital ensures correctly priced funding for those projects with the best expected outcome. An effective financial sector can channel the proceeds from the entrepreneurial activities to households, resulting in welfare gains for the overall economy.

Research on the growth and finance link has shown that domestic financial development has a positive effect on economic growth. King and Levine (1993), Levine et al. (2000) used panel data to show well-developed financial systems can boost growth, and Levine and Zervos (1998) demonstrated both banking and stockmarket capabilities positively affected growth. Updating this line of research, Deidda and Fattouh (2002), Rioja and Valev (2004) found a positive but non-linear relationship between financial development and growth. Cecchetti and Kharroubi (2012) using a sample of developed and developing economies, showed that financial development promotes aggregate productivity growth, but only up to a certain point.[1] For those economies

[1]The authors argue that there comes a point when the financial sector draws resources away from other industries and becomes a drag on overall productivity growth.

below this threshold, financial development is desirable.

Other researchers have highlighted institutional and political characteristics, as well as economic openness, as factors influencing financial sector development. Levine et al. (2000) establishes that laws that strengthen creditors' rights, contract enforcement and accounting practices facilitate financial development. In LaPorta et al. (2008), the authors argue that capital market development depends on institutional quality and regulatory conditions, which are related to the origins of a country's legal system. Rajan and Zingales (2003) focuses on political economy issues making the case that domestic incumbents oppose financial development, and, that this incumbent opposition can be overcome by allowing cross-border trade and capital flows. Baltagi et al. (2009) empirically validates that closed economies can spur banking sector development in their economy by opening up, and Chinn and Ito (2005) caveats this by arguing that a poor legal and institutional environment will eliminate the capital-account openness effect on financial development. This paper's results imply banking experience is also a factor influencing banking efficiency and thus financial development.

In the banking literature, both economies of scope and scale have been theorized as sources of banking efficiency. Theoretical financial intermediation models predict economies of scale in the presence of fixed financial transaction costs, portfolio diversification, or a fractional reserves banking set up.[2] An empirical literature on banking efficiency[3] estimates X-efficiency and tests for evidence of economies of scale in banking. Hughes and Mester (1993, 1998, 2011) taking a structural approach, found scale economies are evident for all size banks when risk (asset quality) is incorporated into the bank production technology. The economies of scale result alone would imply

[2]For an overview and textbook treatment of these banking models, see Freixas and Rochet (2008).
[3]For a survey, please see Hughes and Mester (2010).

that larger banks, no matter whether from mergers, acquisitions or organic growth, would all have lower unit costs than smaller banks. However bank efficiency may also be influenced by experience, as distinct from scale.[4] The history of a bank's operational activities could have an impact on its current level of proficiency. As banks grow larger they gain experience from building their asset portfolio and managing their liabilities. Learning from their production of financial services could lead to successful process innovations or organizational improvements, which in turn could lead to more production which yields more learning, suggesting a cycle of learning and innovation.[5]

In industries other than banking, a firm's investment in research and development, innovation, and experience have all been shown to drive efficiency. Laboratory based and formalized research and development are often a separate identifiable activity where firm knowledge is captured and valued. However for services industries like banking, improvements are likely to arise from more organic feedback processes during the customer experience, more along the lines of learning. Anecdotal evidence suggests banks invest little in what economists identify as R&D, thus learning may be of more importance to these types of institutions. The degree to which the bank is able to capture learning and institutionalize that knowledge across the organization will vary.[6]

For an example of learning in banking, consider a standard loan contract. Given the classic scale economy example of one ideal loan contract being similarly costly to use for 1 borrower as for 1,000, what explains how this contract came to be produced?

[4]Hunter and Timme (1986) find that *ceteris paribus*, banks with greater output realized more technological change over the period studied.

[5]Homma et al. (2014) although focused on market structure mechanisms, find that more efficient banks grow larger.

[6]See HBS Review 2003 for a case study illustrating a bank attempting to formalize a learning by doing process.

A bank's team of lawyers do not draft an entirely new contract for every loan, an ideal template contract is developed. Perhaps the first loan contract worked well, but the experience motivated a few changes in the covenants and authorization process. With these improvements, the second loan contract required fewer labor hours and achieved a similar result. The next was improved further, until a standardized loan contract could be implemented with a predictable and efficient level of labor input. The standard loan contract is then scalable. In this way, learning precedes gains from scale; and these effects are distinct. Experience involves learning with each unit produced and thus sequential improvements. And, unlike scale effects, gains from experience are not reversed when output is reduced.

For manufacturing firms, learning by doing has been modeled and studied since the mid 1930s. Arrow (1962) developed a theoretical model with learning embodied in successive vintages of capital motivated by empirical studies of ship building and other industrial manufacturing processes. For example, Wright (1936) documented a learning curve in the manufacture of air frames and other researchers subsequently found evidence of this learning-by-doing relationship in a range of industries (for a survey see Ghemawat (1985)). More recently, Bahk and Gort (1993), Barrios and Strobl (2004) analyzed data on manufacturing plants and Irwin and Klenow (1994) examined the semiconductor industry for firm-specific learning by doing and knowledge spillovers to the sector as a whole and the global semiconductor industry.[7]

Drawing on this literature, the focus of this paper will be on firm-specific learning: a firm's cost to produce one unit of output declines as the firm accumulates production experience, given production technology and firm size. The goal is to assess whether this mechanism might contribute to banking sector efficiency. In research related to

[7]Empirical studies of learning by doing in manufacturing identify firm-specific learning, and sector-wide as well as international knowledge spillovers of various magnitudes using cumulative output (of the firm or of the national and global sectors) as a proxy for production experience.

this question, DeYoung and Hasan (1998) find that new banks have a profitability curve: start up banks in the 1990s on average took nine years to become as profitable as an established bank, with more than half of the gains made during the first three years of operation. The authors do not explicitly discuss or test for a learning curve, however their results would fit with the hypothesis that experience effects exists in banking.

The rest of the paper proceeds as follows: the next section develops a bank-specific production and cost function incorporating learning by doing. Section three discusses the econometric issues and approach to testing for experience effects in banking, and reports the econometric results. Section four concludes and discusses implications of evidence of learning in banking.

3.2 Incorporating experience into banking

Much of the research on learning by doing uses industrial manufacturing production specifications with Cobb-Douglas functional forms. To analyze experience effects in banking, I extend this approach drawing on the banking efficiency literature to model banking activity. This yields the following description of bank technology as a transformation function $T(.)$ characterized by optimized production:

$$T(Q, X, K, R, E) = Q - f(Q, X, K, R, E) = 0$$

where Q is the quantity of output, X is a vector of production inputs, R is a measure of asset quality, K is bank equity capital, and E is experience, the variable of interest. From this formulation a cost function is then derived.

3.2.1 Experience

This paper focuses in on the extent of firm-specific learning in banking, ie how a bank's own experience affects that financial intermediary's efficiency. Furthermore, the notion of experience is broad and crucially is not restricted to a lender-single borrower relationship. Experience in credit activities with *any* borrower is counted as experience. Several financial intermediary models address the issue of gains from experience with a particular counter-party. For example, Diamond (1991) shows in a simple 2-period model how a particular borrower can build a reputation by successfully repaying an initial loan. Relationship banking models involve the bank paying a one time sunk cost associated with monitoring with the first loan to a particular counter-party. Future loans to that particular borrower would not incur this cost.[8] These models imply counter-party specific cost-dynamics. I am looking at a different question: whether *all* credit creation experience can increase bank efficiency, reducing costs. With each transaction, the bank learns some new information and efficiency in collecting and effectively analyzing and using that information may rise.

For example, one theorized loan management cost involves *monitoring* activities to address the moral hazard problem. In Diamond (1984), banks arise to perform delegated monitoring. In Boot and Thakor (1997) a subset of firms with good reputations can go to the debt markets directly, but others require monitoring to obtain credit and thus need banks. The efficiency gains from experience could be reflected in a decline in the amount of monitoring labor required for the same volume of loans as the bank recognizes what information is crucial and sufficient for efficient monitoring. Similarly, *screening* potential borrowers is theorized as a key function of financial intermediaries to address the adverse selection problem. One could expect this work

[8]See Freixas and Rochet (2008) page 99-100 for a simple example.

to become less intensive as more effective screening technologies and characteristics of the applicant population are learned over time.

Or, one can think of a *cost of default* incurred by the bank when a portion of borrowers are unable to repay and the bank then must collect and liquidate assets.[9] Increased experience could lead to an increase in efficient foreclosure execution (or decrease in labor needed to process the same-sized default).[10]

The paper thus hypothesizes that increased experience of a general kind reduces the bank's cost to create credit. This conjecture parallels the learning by doing hypothesis that manufacturing production cost declines because on-the-job experience reduces the amount of labor or other inputs required to produce the same amount of output. Thus following the learning by doing literature, a measure of experience is included in the bank production (and cost function).

3.2.2 Asset quality and bank equity

Distinct from manufacturing production processes, the primary function of financial intermediaries is transforming assets, taking in short-term deposits and other borrowed funds and creating longer or more risky credit contracts. The quality of those loan contracts may affect the bank's cost of borrowing funds.[11] For example when a bank manager chooses to pursue higher expected revenue, both the payoff size and the probability of payoff can be targetted. The risk-return trade off can lead to riskier assets on the balance sheet. If the bank's creditors see this as a deterioration in the

[9]For example see Jappelli and Pagano (2005) in which the authors model repayment with recovery rates (less than one) for the firm's cash flow and the pledged collateral. Or, in Townsend (1979), verification of a borrower's revenues requires a fixed auditing cost. Bernanke et al. (1999) model this auditing cost as the cost incurred by the financial intermediary when the entrepreneur defaults.

[10]Bank experience could alternatively lead to a reduction in collateral requirements for the same loan, but this outcome reduces the borrower's "costs" and in this paper the focus is on the production costs of the bank.

[11]See Hughes and Mester (1998).

quality of the bank's asset portfolio, they may charge more to extend credit to that bank (or withdraw their deposits).[12] Because of this relation between output quality and input costs, the model for financial intermediary "production" should capture this distinct aspect of credit creation by including a risk term, R, in the production function. Also particular to finance, bank equity capital K can both substitute for borrowed funds and influence borrowing costs—a higher capital cushion suggests a safer bank, and can lead to lower rates demanded by creditors. Hence we need to include bank equity in the transformation function.

3.2.3 Inputs

A financial intermediary's inputs include physical capital and labor as is typical of other firm types. However a decision must be made on how to classify deposits, as inputs or as an indicator of financial services output.[13] Sealey and Lindley (1977) make the argument that for financial intermediaries, a distinction must be made between "technical" vs. "economic" production in order to classify inputs versus outputs. While a bank technically produces deposits, deposits are economic inputs to the production of credit. For a profit maximizing firm, the output must be of higher value than the input, when measured in market prices. Banks "pay" depositors both via servicing and paid interest, but primarily earn their revenue from assets. Thus applying a financial intermediation approach, deposits should be considered an input.

From this perspective, funding for a bank is a key production input, unlike in corporate finance theory for typical firms, where the firm's financing decisions are

[12] A bank run, or counter-party risk, would be an extreme version of this dynamic, whereby a bank's lenders and depositors fear the bank's assets are of such poor quality they refuse to roll-over or extend new credit to that bank, and/or this precipitates a run on the bank. The experience of Lehman Brothers in the interbank market illustrates this dynamic unfolding in the shadow banking sector.

[13] See Holod and Lewis (2011) for a recent take on this dilemma.

usually distinguished from production decisions. Deposits provide one relatively stable source of funding. In addition, other methods of bank borrowing provide other sources each with their own attributes and associated cost.[14]

3.2.4 Output

Unlike manufacturing, for which the learning-by-doing theory was developed, financial services suffer a peculiarity in that output is ill-defined.[15] A widget produced from a set of inputs, is clearly a unit of output and that unit when sold for a given price generates revenue for the manufacturing firm. It is straightforward to define current output (the widgets produced this year) versus cumulative output (the widgets produced up to the end of last year). Taking a financial intermediation approach, banks produce credit. As discussed in Sealey and Lindley (1977), the process of asset transformation yields "earning assets" which generate revenue streams for the bank based on the interest charged on those assets.[16] In banking, Q can be defined as earning assets. However note that, using this definition, a loan produced for example 2 years ago is likely to still be providing revenue to the bank and is therefore measured as current output.[17]

[14]Banks can borrow in a variety of ways via Fed Funds and repo markets, or negotiable certificates of deposits for example.

[15]For an overview of different approaches to bank production function specifications, see Mlima and Hjalmarsson (2002).

[16]Banks also book income from fees and off-balance sheet activities. The latter can be important revenue generators for larger banks.

[17]This issue is not unique to banks; service provision businesses may not define output as simply as manufacturers because of the duration of the contract and the revenue stream.

3.2.5 The cost function

Total cost of producing output Q is the sum of the bank specific inputs times their prices,

$$TC = W_p' X_p + W_d' X_d + W_k K$$

where X_d includes the finance specific inputs: deposits and other borrowed funds, and X_p represents the usual physical inputs: labor and physical capital. W_d contains the cost of deposits and other borrowing, and W_p is the vector of prices for labor and facilities. W_k is the cost of equity capital. In the short-run, one can treat equity as quasi-fixed and minimize costs conditional on the level of equity K to formulate a cash-flow cost function.

$$C(Q, W_p, W_d, K, R, E) = min_{X_p, X_d}(W_p' X_p + W_d' X_d)$$

such that $T(Q, X, K, R, E) = 0$ and $K = K^0$. Using a Cobb-Douglas functional form (following the learning by doing literature and for ease of interpretation), the extended bank cost function is then:

$$C_i = e^{\alpha} \cdot Q_i^{\beta_q} \cdot \prod_g W_{g,i}^{\gamma_g} \cdot K_i^{\beta_k} \cdot R_i^{\beta_r} \cdot E_i$$

with $E_i = F_i^{\beta_F}$. Taking logs to attain the estimation equation:

$$lnC_i = \alpha + \beta_q lnQ_i + \sum_g \gamma_g lnW_{g,i} + \beta_k lnK_i + \beta_r lnR_i + lnE_i + \epsilon_i \qquad (3.1)$$

This is the key estimation equation. The coefficient of interest is β_F, the elasticity of cost with respect to firm-specific experience. A negative coefficient estimate would

suggest evidence of learning by doing.[18]

3.3 Testing for learning by doing

Table 3.1: Variable definitions

C	Cost: the sum of reported salaries and benefits paid, rents, interest expenses, and bank funding costs.
Q	Output (*Earning Assets*): the total value of loans and other earning assets on the bank's balance sheet.
W_1	Price of labor: the sum of salaries and benefits paid, divided by number of employees.
W_2	Price for physical capital: average dollar value of premises and fixed assets.
W_3	Price for deposits: total interest paid on deposits divided by amount of deposits.
W_4	Price for other borrowed funds: total interest paid on other borrowed funds divided by amount of other borrowed funds.
K	Quantity of financial capital (*Equity*): sum of shareholders' equity, loan loss reserves, and subordinated debt
R	Asset quality measure (*Risk*): proxied by average total volume of non-performing and non-accruing loans (30 days or more past due) plus gross charge offs.[1] Although this is an *ex post* measure of asset quality, it nevertheless provides a metric of the risk associated with the banks assets.
E	Experience: firm-specific experience F_i proxied by *Age* of bank, from the date the charter was granted.

1. Gross charge offs are the amount the bank has written off for a given non-performing asset before accounting for any recovery value. Some banks aggressively take charge offs in order to move non-performing assets off their balance sheet, other banks have large non-performing loan pools but are not writing them off as quickly. Thus, combining these numbers gives a fuller picture of a bank's balance sheet quality.

[18]Note that increasing returns to scale is allowable in this set up, although these scale efficiencies would not vary with size. Scale is not the primary focus of this paper, but this model does explicitly allow for distinct scale efficiencies and learning efficiencies. An estimate of $\beta_q < 1$ would represent scale cost efficiencies.

3.3.1 Data

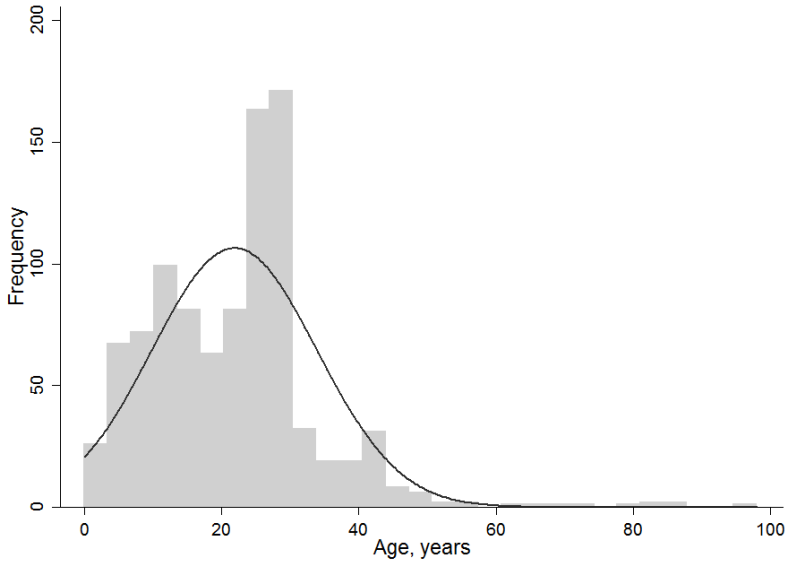
This research focuses on the US because of the relatively high quality and public availability of US bank data. For US bank data, I use the comprehensive and detailed data publicly available from the Federal Reserve Bank of Chicago: the FRY-9C database comprising domestic bank holding companies, reported on a consolidated basis. I use the top most organizational level, because this data represents the entire organizations' operational status, and can thus capture efficiency gains made through the choice of organizational structure, operational methods managed from headquarters, as well as lower down the organizational structure. If banks are typically managed top down, with reporting along business and geographic lines, and incentivized to minimize regulatory compliance costs, there are multiple areas where learning from experience could yield efficiency gains. A narrower approach would use branch level or product level data however this would focus only on learning about the particular geography or product business, and the hypothesis of this paper is more broad. For example a firm may choose to centralize the management of a certain product line, then the bulk of the costs for this product would accrue at headquarters and efficiency gains would be less likely to be observed in the branch level data. The 2010 sample comprises 952 corporations and top-tier holding companies[19] with total assets ranging from around USD85million to USD$2,268,347$million

I observe firm age in this dataset. The Age variable is continuous and calculated from the time the bank received its charter. Experience in the manufacturing setting has been proxied by both cumulative output and age. For banks, distinguishing between cumulative output and current output is non-trivial. Consequently, modeling effects from cumulative output—a common measure of experience—poses issues. If

[19]The sample excludes limited partnerships and other limited liability structures, trusts and mutuals.

banking cumulative output is defined as earning assets, this is also a measure of size, which could then conflate experience and scale effects. Thus in my analysis of the US sample, I use Age of the bank as the proxy for firm-specific experience. The sample includes very young inexperienced banks as well as older firms. Age ranges from a few months old to almost 100 years old. Looking at the age distribution, 90 percent had their charter for 33 years or less and the average bank age was just under 22 years. Of the sample of 952 banks, 156 were 10 years or younger, 237 were between 10 and 20 years old, and a bulk of 410 were between 20 and 30 years old. As can be seen in Figure 3.1 on page 84, the distribution includes several observations in the far right tail. A negative coefficient on the Age variable (costs are decreasing in experience) would support the hypothesis of learning by doing in banking. (See Table 3.1 for a summary of variable definitions.) Summary statistics for the 2010 cross-section of bank holding companies are listed in Table 3.6 in the appendix.

Figure 3.1: Distribution of Age variable for 2010 cross-section



Looking more closely at the characteristics of the banks in my dataset, Table 3.2 on page 86 lists average size by output (earning assets), and compares loans to total

earning assets for banks subgrouped by age deciles. The largest bank by earning assets is in the oldest decile, however the first and third age deciles have the next highest maxima for Earning Assets. In all subgroups, the loan to earning assets ratio maximum does not go below 90percent. However the subgroup minimum varies from 9percent for the oldest decile, to 44percent in the 5th decile. This suggests heterogeneity in the banks' asset composition is not associated with age.

For the full sample, the median loans to earning assets ratio is 72pct of earning assets, similar to the simple bank production framework emphasized above where bank output is credit. For some banks, other assets such as trading assets and short-term, liquid securities account for a higher proportion of total earning assets. The type of output mix may introduce different learning and cost dynamics. As a robustness check, the 18 banks tagged as systemically important and stress tested by the Federal Reserve in March 2013 were excluded. The results were similar, although the coefficient estimates suggested a *greater* effect on cost from the experience variable.[20]

For the size distribution, the 90th percentile for Earning Assets was just under USD6bn. Not all old banks were large and not all large banks very old. For the full sample, the correlation between age and size, measured as Earning Assets, was 0.24. (For Age and size scatter plot, please see Figure 3.2 on page 87.) Breaking that down by age quartiles, correlation between age and size was strongest for the oldest banks (over 27.9 years of age)and negligible for the others.[21]

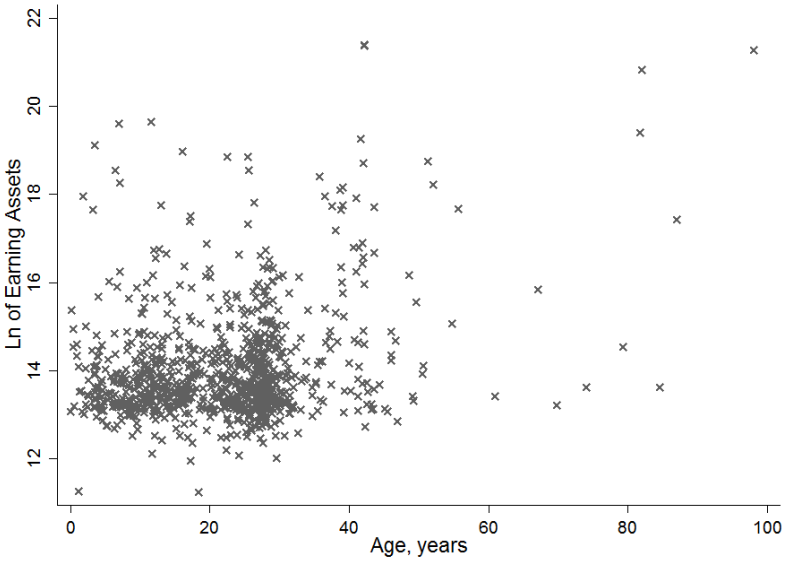
[20]See Figure 3.7 for the plots of average marginal effects using the estimates from the reduced sample.

[21]Correlation between age and size was -0.01 for banks up to about 12.5 years of age, 0.01 for banks $12.5 - 23$ years old, -0.02 for $23 - 28$ years old, and 0.35 for banks older than 28 years.

Table 3.2: Asset allocation, Age deciles vs. Full sample

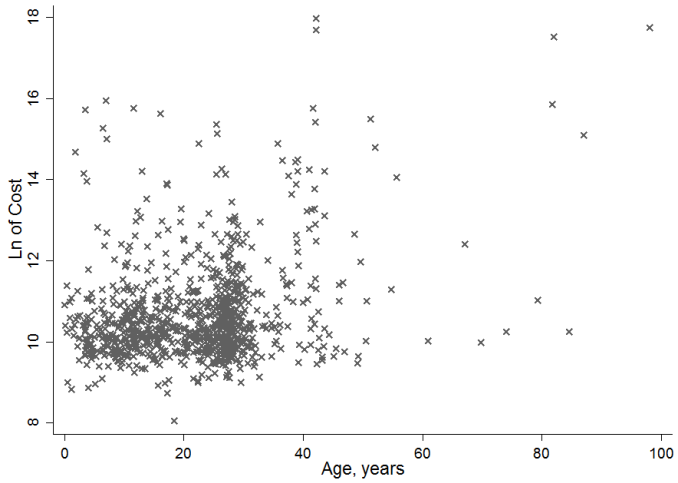
Decile	Age	Earning Assets	Total Loans	Other Earning Assets	Loans/ Earning Assets
1 Min	0	77,461	56,363	21,098	0.16
Max	7	324,090,148	141,917,020	182,173,120	0.95
Median	4	760,130	567,116	217,188	0.73
2	7	273,250	233,922	23,480	0.40
	11	11,232,587	6,100,855	6,089,345	0.96
	9	742,316	550,995	206,443	0.76
3	11	181,575	117,208	17,530	0.14
	14	342,702,000	47,795,000	294,907,008	0.96
	13	834,751	624,860	258,611	0.74
4	14	75,718	47,807	27,911	0.31
	19	172,905,059	126,550,123	46,354,936	0.94
	16	819,092	615,936	210,152	0.75
5	19	195,620	142,769	27,466	0.44
	23	153,111,842	66,642,348	86,469,496	0.90
	21	950,244	616,791	265,455	0.73
6	23	174,416	143,714	27,748	0.41
	26	154,603,840	119,475,313	35,128,528	0.91
	25	823,431	578,902	239,628	0.71
7	26	257,984	132,843	34,621	0.09
	27	54,528,256	27,542,879	26,985,376	0.93
	27	813,510	621,628	248,122	0.72
8	27	231,155	141,160	16,778	0.26
	29	18,502,899	13,576,961	4,925,938	0.96
	28	922,968	643,701	293,613	0.69
9	29	163,256	111,411	19,278	0.25
	34	12,385,437	8,922,221	5,432,985	0.96
	30	965,239	660,620	266,297	0.72
10	34	335,645	183,627	46,573	0.09
	98	1,943,209,050	993,149,151	1,185,099,008	0.90
	42	2,287,370	1,690,346	700,280	0.69
Full Sample	0	75,718	47,807	16,778	0.09
	98	1,943,209,050	993,149,151	1,185,099,008	0.96
	23	875,378	622,459	258,179	0.72

Figure 3.2: Age and Size for 2010 cross-section



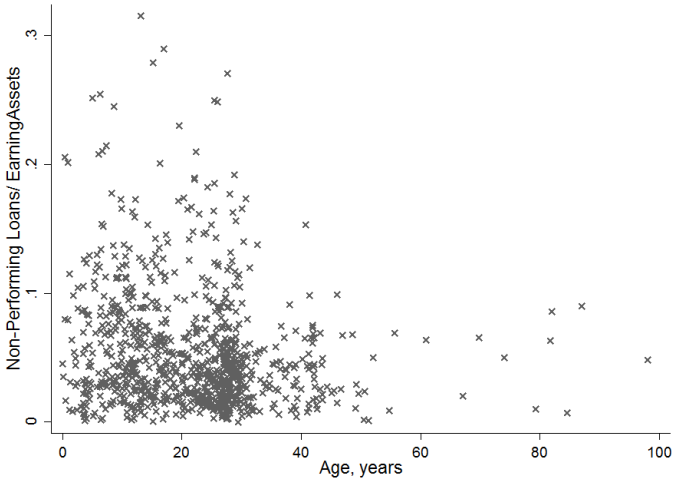
Plotting the data for the 2010 cross-section, no clear pattern emerges between costs and age. (See Figure 3.3).

Figure 3.3: Age and Cost for 2010 cross-section



Focusing in on *screening* efficiency, the proportion of non-performing assets to total earning assets seems to be lower for more experienced banks (See Figure 3.4). This provides support for a hypothesis that learning leads to better screening, fewer defaults by borrowers, and thus lower non-performing loan ratios for experienced banks.

Figure 3.4: Age and Non-Performing Loan ratio for 2010 cross-section



3.3.2 Estimation of uncorrected model

Turning to the econometric analysis, equation 3.1, the uncorrected econometric model, was estimated using the 2010 cross-section of banks.[22]

For the full sample, in the log-log form, the results do not suggest any cost efficiency gains from experience. The estimated coefficient on experience (Age) is significant and positive, 0.030. Based on results from DeYoung and Hasan (1998) suggesting younger banks have significantly more to gain from experience, I estimated the model using two sub-samples, the first for banks under 9 years of age, and the second for established banks over 9 years of age. Nine years was the length of time DeYoung and Hasan (1998) found it took younger banks to match established banks' profitability. Estimation results are reported in Table 3.4, columns 2 and 3. The coefficient estimate was negative and significant for the young bank subsample, -0.112, suggesting newer banks may be learning by doing. Results from regressions by age deciles are reported in Table 3.3. The marginal effect of experience for the youngest decile (91 banks under 7 years of age), was -0.144 and significant at the 10pct level.

Based on the sub-sample results, I revised the model, adding powers of $lnAge$ to the estimation equation.[23] Including $(lnAge)^2$ and $(lnAge)^3$, the full sample now yields the results in column (5) of Table 3.4.

Investigating scale and experience, interaction terms between age group and size were not significant. However using the continuous Age variable and adding an interaction term between size (Earning Assets) and experience (Age) suggests the slope does differ with firm scale. Column (6) of Table 3.4 on page 91, reports the coefficient estimates when scale and experience are allowed to interact. The interaction term

[22] I chose 2010 because during 2009, reporting was adjusting to volatile conditions and a high degree of uncertainty.

[23] It could be the case that 'forgetting' occurs (as in Benkard (2000)), or older banks balance sheet risks affect cost in a way that is not captured by the data.

Table 3.3: Regression by Age deciles, Dependent variable: Ln of Cost

	1	2	3	4	5	6	7	8	9	10
Earning Assets	0.941***	0.932***	0.938***	0.950***	0.827***	0.942***	0.660***	0.957***	0.970***	0.924***
	(0.14)	(0.06)	(0.03)	(0.05)	(0.06)	(0.09)	(0.09)	(0.07)	(0.08)	(0.08)
Price of Labor	0.384*	0.011	-0.017	0.123	0.196*	-0.008	0.437***	0.224*	0.012	0.345***
	(0.17)	(0.07)	(0.07)	(0.09)	(0.10)	(0.13)	(0.11)	(0.09)	(0.11)	(0.09)
Price of Physical Capital	0.040	-0.022	0.033	0.052	0.123**	0.051	-0.047	0.114***	0.033	0.043
	(0.07)	(0.02)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)	(0.03)	(0.04)	(0.04)
Deposit interest rate	0.314***	0.139**	0.044	0.347***	0.301***	-0.014	0.244***	0.362***	0.068	0.172***
	(0.07)	(0.05)	(0.04)	(0.06)	(0.07)	(0.07)	(0.07)	(0.04)	(0.06)	(0.04)
Other Borrowed Funds interest rate	0.100	0.013	0.022	0.013	-0.011	0.043	0.099**	0.058**	0.025	0.075**
	(0.05)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
Equity	0.090	-0.010	-0.066**	-0.041	0.085	-0.070	0.253***	0.030	-0.054	0.024
	(0.10)	(0.04)	(0.02)	(0.03)	(0.04)	(0.08)	(0.07)	(0.05)	(0.06)	(0.08)
Risk	-0.053	0.023	0.069**	0.056*	0.033	0.072*	0.033	-0.011	0.042	0.027
	(0.05)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
Age	-0.144*	0.161	0.047	0.236	0.101	0.877	0.475	1.158	-0.576	0.152
	(0.07)	(0.13)	(0.22)	(0.33)	(0.31)	(0.80)	(1.53)	(1.04)	(0.42)	(0.09)
Constant	-2.688**	-2.352***	-2.225**	-2.290*	-1.908	-5.120	-3.942	-5.752	-0.406	-3.797***
	(0.89)	(0.51)	(0.67)	(1.11)	(1.08)	(2.59)	(5.12)	(3.41)	(1.56)	(0.52)
N	91	92	92	91	89	90	89	89	89	93
R^2	0.92	0.96	0.98	0.97	0.97	0.96	0.95	0.98	0.97	0.99

Significance levels: $*$: 10% $**$: 5% $***$: 1%. Standard errors in parentheses.

Table 3.4: OLS estimation results, Dependent variable: Ln of Cost

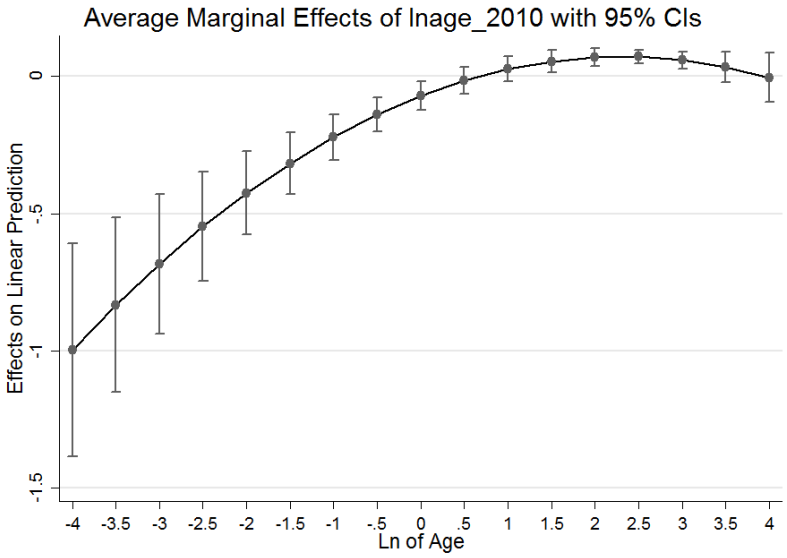
	Full sample (1)	Age<9 (2)	Age≥9 (3)	Full sample (4)	Full sample (5)	Full sample (6)
Earning Assets	0.908***	0.924***	0.919***	0.910***	0.908***	0.841***
	(0.023)	(0.101)	(0.020)	(0.022)	(0.022)	(0.030)
Price of Labor	0.227***	0.395**	0.171***	0.254***	0.266***	0.262***
	(0.033)	(0.126)	(0.032)	(0.033)	(0.033)	(0.033)
Price of Physical Capital	0.034*	0.004	0.033**	0.035**	0.034**	0.031*
	(0.013)	(0.045)	(0.013)	(0.013)	(0.013)	(0.013)
Deposit interest rate	0.197***	0.305***	0.178***	0.215***	0.214***	0.213***
	(0.018)	(0.060)	(0.018)	(0.018)	(0.018)	(0.018)
Other Borrowed Funds interest rate	0.044***	0.089*	0.037***	0.050***	0.049***	0.048***
	(0.009)	(0.042)	(0.008)	(0.009)	(0.009)	(0.008)
Equity	0.033*	0.080	-0.001	0.027	0.032*	0.032*
	(0.016)	(0.071)	(0.015)	(0.016)	(0.016)	(0.016)
Risk	0.024*	-0.042	0.047***	0.024*	0.024*	0.022*
	(0.010)	(0.038)	(0.009)	(0.009)	(0.009)	(0.009)
Age	0.030**	-0.112*	0.072***	-0.103***	-0.088***	-0.384***
	(0.010)	(0.051)	(0.017)	(0.026)	(0.026)	(0.093)
Age^2				0.032***	0.062***	0.062***
				(0.006)	(0.011)	(0.011)
Age^3					-0.008**	-0.009***
					(0.002)	(0.002)
Interaction Age with Earning Assets						0.022***
						(0.007)
Constant	-2.667***	-2.660***	-2.677***	-2.535***	-2.708***	-1.770***
	(0.165)	(0.675)	(0.152)	(0.164)	(0.171)	(0.331)
Observations	905	133	772	905	905	905
Adjusted R^2	0.967	0.916	0.977	0.968	0.969	0.969

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

is significant.[24] Figure 3.5 plots average marginal effects at representative values of $lnAge$.

The Adjusted R-squared statistic for the full sample and sub-sample models were above 90 percent, and F-tests rejected the hypothesis that the covariates had no effect on the dependent variable. The estimated coefficient on output (Earning Assets) remained significant, positive and of a similar magnitude for all the various models, and input price coefficient estimates satisfied theoretical regularity.[25]

Figure 3.5: Marginal effects using OLS estimates, column (6)



[24]Calculating marginal effects using the coefficient estimates from either the specification with (Column (6)) or without (Column (5)) the interaction term suggest the beneficial effect of age on cost disappears after about 2 years. Without an interaction term the effect of age wanes around 2.4 years ([1.42,4.17]), with a size and age interaction in the model the effect wanes around 2 years ([1.22,3.60]).

[25]Input price coefficients γ_j, were not restricted to sum to 1. An F-test comparing constrained to unconstrained supported the unconstrained specification. The Risk metric was statistically insignificant in the young subsample but was significant for older banks.

3.3.3 Estimation correcting for endogeneity and selection

The initial analysis suggests experience is linked to lower production costs. However the role of endogeneity and survivorship biases in the estimates need to be addressed. Simultaneity issues arise in production and cost function estimation because of correlation between the bank's choice variables (output in this case) and unobserved efficiency shocks anticipated by managers. Managers simultaneously observe input prices and choose output and could respond to lower input prices by raising output, with an ambiguous effect on cost. (Appendix Table 3.7 reports regression results estimating the effect of input prices on output (Earning Assets). The estimated coefficients on all input prices except physical capital are significant.) However assuming it is in fact these unobserved efficiency shocks that drive output decisions provides a rationale for controlling for the endogenous component of output.

With regards to bias introduced by sample dependence, during 2008-2010, 182 US banks failed according to FDIC data.[26] We therefore cannot observe the relation between cost and experience for those that exited. If we conjecture that bank failure is a function of cost, my sample would be truncated by the dependent variable at some high-cost threshold above which the bank has gone bankrupt. As such higher cost younger banks are excluded from the analysis, and a "flatter", weaker estimated effect would result. Also, it is possible that the surviving banks are more cost efficient for some other reason than experience and thus the estimates are biased. For example, because older and larger firms may be less likely to exit at a given cost threshold than smaller and younger firms, the age coefficient could be underestimated.[27]

To formally address these biases a two-step correction method is applied. In the

[26]See the FDIC Failed Bank list. http://www.fdic.gov/bank/individual/failed/banklist.html.

[27]In the Appendix, Figure 3.8 plots age and size and Figure 3.9 plots age and cost, comparing surviving banks to those that exited.

first stage, the probability of selection—the bank continuing to operate and thus observed in the sample—is estimated for each bank, and in the second stage these probabilities are used as instruments in the estimation of the cost function itself. The logic in brief is that by assuming an unobserved (to the econometrician) efficiency factor influences both selection and output choice, the estimate of the probability of the bank continuing provides an instrument for the unobserved efficiency factor. Therefore its inclusion in the cost equation controls for both selection and endogeneity biases.[28]

To concretize this approach rewrite the cost function with the error term ϵ_{it} as a combination of two terms. Assume the first represents an anticipated cost efficiency innovation known to the banks but unknown to the econometrician ω_{it}. The second term one can think of as an unanticipated efficiency shock, ν_{it}, the true error. Adding a time subscript, we have the following expression:

$$lnC_{it} = \alpha + \beta_q lnQ_{it} + \sum_g \gamma_g lnW_{g,it} + \beta_k lnK_{it} + \beta_r lnR_{it} + lnE_{it} + \omega_{it} + +\nu_{it} \quad (3.2)$$

Using the assumption that the probability of bank selection is influenced by ω_{it}, which banks observe, we can write a selection equation where $D = 1$ if the bank continues, and $D = 0$ if the bank exits[29]:

$$D(\omega_{it}, \mathbf{H}_{it}) = 1 \text{ if } V(\omega_{it}, \mathbf{H}_{it}) < \theta$$

Surviving till period t thus depends on observed cost efficiency ω_{it} to some degree, along with a vector of other factors H.[30] And conditional on not exiting, greater

[28]This approach draws heavily on Heckman (1979) and Olley and Pakes (1996).

[29]I do not explicitly look at the role of regulators in this process. It is enough to assume that bank efficiency influences the continuation versus exiting outcome.

[30]For example, in many industries, including finance, larger firms (greater Q) are less likely to fail

efficiency, ω_{it} (rather than lower C_{it}) would cause higher output. Thus including ω_{it} in the cost function controls for endogeneity bias.[31]

To implement the above estimation approach, the probability of selection P is estimated for each bank using a Probit model. In the second stage these probabilities are used in the estimation of the cost function itself. For identification, at least one factor influencing continuation (in H and included in the Probit selection model), should be excluded from the cost equation. For this exclusion restriction I use regional bankruptcies and the average regional unemployment rate.[32] It is unlikely that higher firm failure rates would have a direct impact on a bank's cost, however this would increase the likelihood of bank failure because of the direct negative effect of increased bankruptcies on loan repayment and asset values. High unemployment rates could inhibit credit creation, worsen default rates, and signal future bankruptcies. For the selection equation, I would expect to see a negative coefficient estimate for unemployment and bankruptcies. The estimated Probit equation (See Appendix Table 3.8 on page 102 for the Probit model estimation results.) does show both unemployment and bankruptcies are statistically significant.[33] However the sign of the coefficient on regional unemployment is positive. It could be the case that high and persistent unemployment may reduce future bank labor costs via the dampening effect on wage expectations. The Probit model was estimated using $t-1 = 2007$ to ensure a large enough number of exited banks. Consequently, the probability of selection into the 2010 sample was predicted using 2007 data. This lag may have resulted in the wage expectation channel dominating the demand shock channel. Nevertheless, for

for a given realized efficiency level, than smaller firms.

[31] As noted in Heckman (1979), the selection bias correction will be successful even with a relatively weak probit model, in other words a full model of bank bankruptcy is not necessary.

[32] The US data is grouped into 12 regions based on the Federal Reserve system districts. See Benkard (2000) for examples of other demand shock proxies used in production function estimation.

[33] Although for the selection equation the estimated coefficient on bankruptcies was 0.000, using regional unemployment alone resulted in the variable being statistically insignificant.

the purposes of the correction method, the key outcome of the first step is a viable estimated function of ω_{it}, even with low explanatory power. Obtaining the inverse Mills ratio $f(\omega_{it}, \mathbf{H}_{it})$ / $F(\omega_{it}, \mathbf{H}_{it})$, using the Probit selection model step provides this function. This then becomes the instrument for ω_{it} in the corrected model.

Table 3.5 reports estimation results for the initial model and the corrected model. In Column 2, the first corrected model specification shows the estimates when only the inverse Mills ratio (P) is included. Following the logic of Olley and Pakes (1996), the second specification also includes P^2 and P^3. The estimated average marginal effect[34] of age does differ from the initial results. Using the uncorrected model, the overall average marginal effect was 0.047 with a 95pct confidence interval of $[0.017, 0.077]$. Using the model in column (3) of Table 3.5, the overall average marginal effect (the average of marginal effects at representative values of $lnAge$) was 0.030 with a 95pct confidence interval of $[-0.006, 0.066]$. Plotting marginal effects at different representative values of $lnAge$ illustrates how the overall average marginal effect hides the beneficial effects of age on cost for younger banks. (See Figure 3.6.)

The corrected model implies the marginal effect of age on cost remains beneficial until around 10 years of age, rather than the 2 years implied by the benchmark OLS estimation. (See Figure 3.6 comparing the plots of the corrected and uncorrected estimation models.) More specifically, after correcting for biases, the estimated marginal effect of age on cost is decreasing and turns to zero at 10.6 years of age.[35] The upper bound of the 95th percentile confidence interval around the estimated effect of age, turns positive at 7.8 years of age. And the lower bound of the confidence interval turns positive around 15 years of age. In comparison, for the uncorrected model, the range is 1.2 to 3.6 years.

[34]Because all of the variables used are in log form, marginal effects are proportional, and one can think of them as elasticities. I will refer to marginal effects throughout the paper.

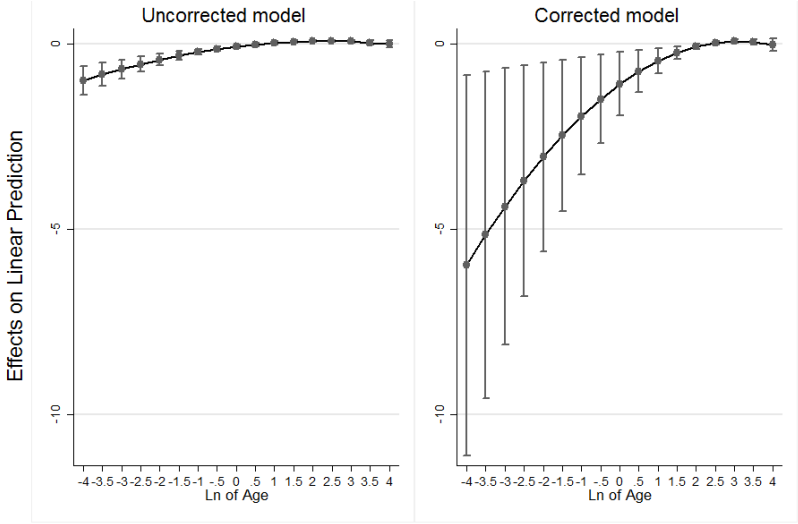
[35]The derivative of $lnVariabeCost$ with respect to $lnAge$ becomes 0 at $lnAge = 2.36$ in Figure 3.6.

Table 3.5: OLS vs. Corrected estimation results,
Dependent Variable: Ln of Cost

	OLS	**P only**	**Powers of P**
	(1)	(2)	(3)
Earning Assets	0.841***	0.891***	0.880***
	(0.030)	(0.038)	(0.039)
Price of Labor	0.262***	0.327***	0.323***
	(0.033)	(0.044)	(0.045)
Price of Physical Capital	0.031***	0.030*	0.033**
	(0.013)	(0.015)	(0.015)
Deposit interest rate	0.213***	0.198***	0.201***
	(0.018)	(0.022)	(0.022)
Other Borrowed Funds interest rate	0.048***	0.032***	0.032***
	(0.009)	(0.009)	(0.009)
Equity	0.033**	0.002	0.006
	(0.016)	(0.020)	(0.021)
Risk	0.022**	0.040***	0.041***
	(0.009)	(0.011)	(0.011)
Age	-0.384***	-1.130**	-1.207**
	(0.093)	(0.492)	(0.497)
Age^2	0.061***	0.354**	0.372**
	(0.012)	(0.159)	(0.160)
Age^3	-0.009***	-0.038**	-0.040**
	(0.002)	(0.019)	(0.019)
Interaction	0.022***	0.007	0.008
Age with Earning Assets	(0.007)	(0.009)	(0.009)
Constant	-1.770***	-1.573**	-1.406**
	(0.331)	(0.656)	(0.675)
N	905	726	726
R^2	0.97	0.97	0.97
$F_{(11,893)}$	2560		
$F_{(12,713)}$		2247	
$F_{(14,711)}$			1925

Significance levels: $*$: 10% $**$: 5% $***$: 1%. Standard errors in parentheses.

Figure 3.6: Marginal effects comparison: uncorrected (1) vs. corrected (3)



3.4 Conclusion

Empirical evidence suggests experience is associated with cost efficiency gains in banking. Using a learning by doing cost function model, the estimated average marginal effects of experience remained beneficial for banks up to around 1.2 to 2 years of age. However, correcting for selection and endogeneity biases, experience effects remain beneficial for banks up to around 10.5 years of age. The results from the corrected estimation model yielded larger coefficients on age, although with larger standard errors associated with these estimates. Nevertheless the coefficients remained statistically significant at the 5 percent level. Computing average marginal effects, the gains from experience are most intense for the youngest banks. For example, on average, a 10 percent increase in experience for a bank of around 1 year of age is associated with a 10.9 percent decline in cost; for a 5 year old bank, an additional 6 months of experience is associated with a 2 percent cost decline. The results from this paper complements the evidence in DeYoung and Hasan (1998) that start up banks in the 1990s on average took nine years to become as profitable as an established bank, with

more than half of the gains made during the first three years of operation.

Further research is needed to generalize these results and to analyze the degree of knowledge spillovers in the banking sector. Historical data in the US that coincided with branching regulatory changes or industry innovation could be used to explore whether knowledge spread between banks in different states, or metropolitan areas, or between branches within a state. Additional single country case studies of countries with banking systems dissimilar to the US, such as Canada, could clarify whether industry structure or some omitted attribute is driving the US result. Internationally, using a multi-country dataset would gauge whether firm-specific experience effects are evident in other countries, and whether spillovers occur at the country and global level.

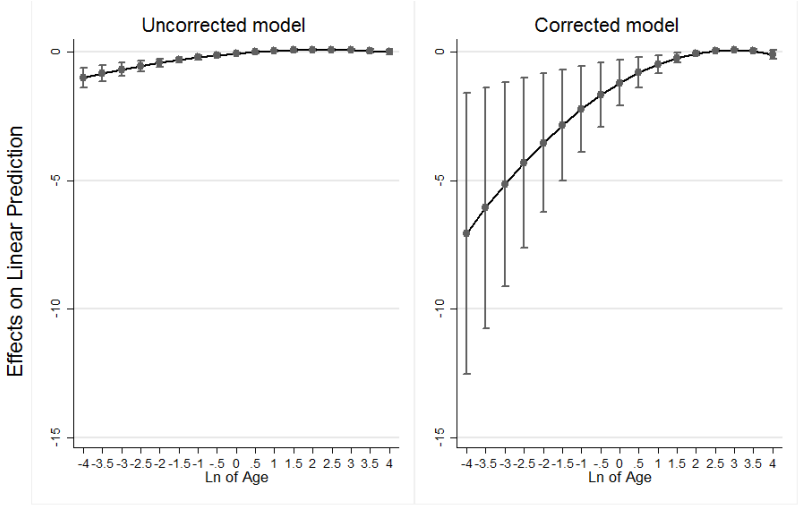
Table 3.6: Summary statistics

Variable (USD, 000s)	Mean	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Cost	385,282	3,135	20,589	30,887	60,624	64,223,637
Earning assets (output)	12,479,761	75,718	582,045	875,378	1,798,673	1,943,209,050
W_1 (labor)	69.17	19.39	55.37	63.29	75.62	383.53
W_2 (physical capital)	0.320	0.038	0.159	0.217	0.325	3.965
W_3 (deposits)	0.012	0.000	0.008	0.012	0.015	0.036
W_4 (other borrowed funds)	0.114	0.000	0.022	0.036	0.049	50.136
Equity	1,825,257	-23,736	60,678	95,238	209,337	317,195,588
Risk	693,039	0	17,940	38,052	99,288	127,511,443
Age, years	21.85	0.04	12.54	22.96	27.91	98.00
Total assets	14,035,930	85,121	629,057	944,064	1,945,596	2,268,347,377

3.5 Appendix

3.5.1 Age and size

Figure 3.7: Marginal effects excluding 18 systemically important banks



3.5.2 Endogeneity and selection

Table 3.7: Effect of input prices on output,
Dependent variable: Ln of Earning Assets

Variable	**Coefficient**	**(Std. Err.)**
Price of Labor	1.028***	(0.158)
Price of Physical Capital	0.116	(0.066)
Deposit interest rate	-0.788***	(0.081)
Other Borrowed Funds interest rate	-0.163***	(0.042)
Constant	5.820***	(0.747)
Observations		909
Adjusted R^2		0.215

Significance levels : * : 10% ** : 5% *** : 1%

Table 3.8: Probit model,
Dependent variable: selection

Variable	**Coefficient**	**(Std. Err.)**
Earning Assets	0.044	(0.173)
Price of Labor	-1.098***	(0.246)
Price of Physical Capital	-0.112	(0.095)
Deposit interest rate	-0.661***	(0.240)
Other Borrowed Funds interest rate	-0.108	(0.072)
Equity	0.325*	(0.153)
Risk	-0.207***	(0.062)
Age	0.100	(0.070)
Regional Bankruptcies	0.000***	(0.000)
Regional Unemployment	0.250**	(0.118)
Constant	0.301	(1.373)
Observations		873
Pseudo R^2		0.124

Significance levels : * : 10% ** : 5% *** : 1%

Figure 3.8: Age and Size for selected vs. nonselected

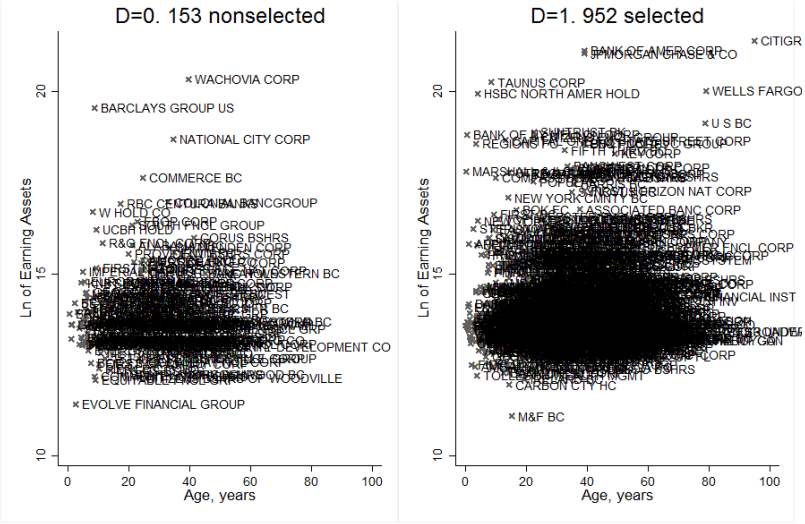
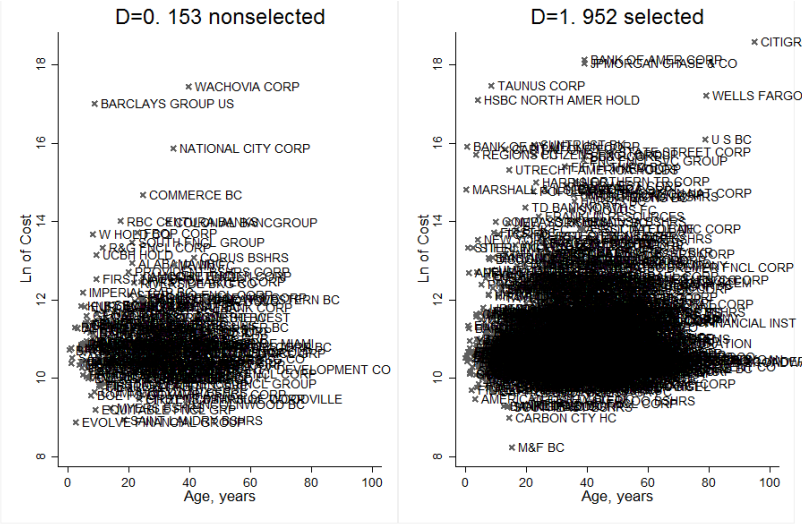


Figure 3.9: Age and Cost for selected vs. nonselected



3.5.3 Functional form: Translog specification

Much of the research on learning by doing uses industrial or manufacturing production specifications with Cobb-Douglas functional forms, as I have used in the body of this paper. However, more flexible functional forms have been used to analyze banking production and as a robustness check the translog functional form is used in the analysis that follows. Consider a second-order translog approximation of the cost function:

$$lnC = \alpha_0 + \sum_i \alpha_i lnZ_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} lnZ_i lnZ_j$$

where Z is the vector of cost inputs, in my model $Z = (Q, W_p, W_d, K, R, E)$. Invoking Shephard's lemma and duality theory, demand for input j is equivalent to the partial derivative of the cost function with respect to the price of that variable input. Factor "share" equations are derived where input j accounts for share S_j of costs, and of course the shares add to one, $\sum_j S_j = 1$.[36]

$$\frac{\partial lnC}{\partial lnw_j} = S_j = \alpha_j + \sum_i \beta_{ij} lnZ_i$$

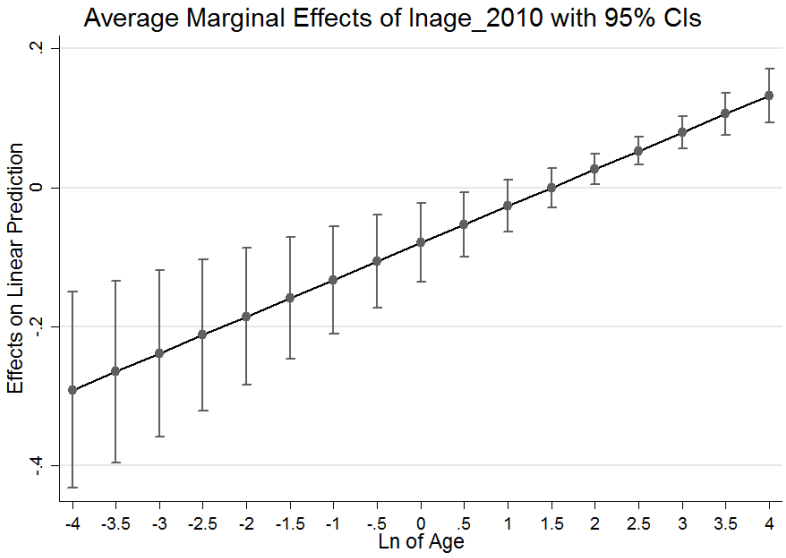
Estimating the model requires a systems approach because of the multiple equations: the cost function, and four share equations— for W_1 (labor), W_2 (physical capital), W_3 (deposits), W_4 (other borrowed funds). One can plausibly assume error terms are not correlated across banks, however correlation between the system equation errors is nonzero. Thus the estimator needs to allow for this. I used a Seemingly Unrelated Regression estimator. The parameters in the share equations are subsets of those in the cost equation. Thus estimating the system of equations can generate more efficient estimates, with some restrictions. The "adding up" constraint on the share

[36]For example, Bossone and Lee (2004), Hughes and Mester (1998), Hunter and Timme (1986) used a similar approach.

equations can be used, and one share equation dropped.[37] I dropped the physical capital share equation. And, symmetry restrictions were imposed on the cross-partial derivatives, $\beta_{ij} = \beta_{ji}$. In Table 3.9, two different specifications are reported, one with only symmetry restrictions, the other with the restriction that $\sum_i \beta_{ij} = 0$. In both, the coefficient on age is the correct sign (negative) and statistically significant.

Average marginal effects (AMEs) at representative values are calculated using the Translog model with symmetry imposed, and plotted in Figure 3.10. The effect is negative, decreasing and evident up to banks of around 5 years of age. (The derivative turns to 0 at 4.57 years.) The upper bound of a 95pct confidence interval around the AME turns to 0 at 2 years, the lower bound at just under 7 years. (Note that the Translog estimation does not specifically address the biases involved in estimating cost functions. Full Translog estimation results used to calculate AMEs and available on request; interaction term coefficients not reported in the table.)

Figure 3.10: Marginal effects using Translog estimates



[37]Since the share equations add to one, they are not linearly independent.

Table 3.9: Translog functional form,
Dependent variable: Ln of Cost

	Symmetry only	Symmetry and betas sum to 0
	(1)	(2)
Earning Assets	1.867***	1.865***
	(0.23)	(0.23)
Price of Labor	-1.939***	-2.071***
	(0.45)	(0.42)
Price of Physical Capital	0.115	0.106
	(0.20)	(0.20)
Deposit interest rate	1.588***	1.546***
	(0.24)	(0.23)
Other Borrowed Funds interest rate	-0.025	-0.042
	(0.13)	(0.13)
Equity	-0.960***	-0.965***
	(0.20)	(0.20)
Risk	0.101	0.105
	(0.13)	(0.13)
Age	-0.430**	-0.462***
	(0.13)	(0.13)
Constant	4.825***	5.039***
	(1.21)	(1.18)

Significance levels: $*$: 10% $**$: 5% $***$: 1%. Standard errors in parentheses.

Chapter 4

Testing for experience effects and spillovers in an international sample of banks

An important macroeconomic question involves identifying the determinants of a functional and efficient financial sector. Pasali (2013) reviews the literature and factors such as institutional quality, per capita income and openness have been suggested as contributors to financial sector development. However these factors are external to the banking firm. The learning in banking hypothesis I proposed in Chapter 3 focuses on a mechanism internal to the firm whereby bank efficiency improves with experience. Using a sample of US banks, I found empirical evidence that for younger banks, experience was associated with lower bank production costs. This chapter extends the work in Chapter 3 using an international sample of bank balance sheet data to test for empirical evidence of learning by doing.

In addition, this chapter explores knowledge spillovers among banks. Does the experience of the domestic banking sector as a whole improve individual bank's effi-

ciency, for example via imitation, or via intentional knowledge transfers among banks? Do innovations in another part of the world travel? International imitation might be more challenging, however clients might demand what they have experienced elsewhere, or bank managers might observe directly practices in other parts of the world and implement these at home.

The possibility of knowledge spillovers or productivity externalities arise to the extent that firms' own innovations can only partially be protected from other firms. An individual bank may develop changes to its processes and procedures for its own gain, but these practices may be adopted by and increase the efficiency of other banks. In Glaeser et al. (1992), the authors characterize two broad types of knowledge spillovers: within industries and between industries. This paper is explicitly about within industry spillovers.

The empirical analysis tests for the presence of positive spillovers defined as an increase in the cost efficiency of individual banks as a consequence of knowledge spillovers. Potential channels are similar to those discussed in the arms length trade and FDI spillover literature[1], for example imitation, labor mobility, customer and supplier linkages. The approach taken in Coe et al. (2008) uses a measure of the stock of knowledge and the proximity to that knowledge to gauge the presence of knowledge spillovers. Motivated by theoretical models that include product varieties and quality ladders, the trade literature has used the stock of knowledge acquired through and measured by R&D expenditure. In banking there is no R&D expenditure as such posing a challenge to directly measuring knowledge spillovers in banking. This paper focuses on knowledge gained from experience and measured by age of the firm or accumulated production experience, similar to Irwin and Klenow (1994).

[1]See Gorg and Greenaway (2004) and Saggi (2002) for surveys of theorized spillover channels and empirical studies.

This paper relates to several strands of research. Contemporary debate on banking efficiency and financial deepening weighs the costs and benefits of the globalization and growth of the banking sector. At the national level, Philippon (2012) and Cecchetti and Kharroubi (2012) argue that the financial sector pulls resources away from other productive sectors as it grows too large. In terms of bank efficiency, the proposed research relates to the discussion of the role of hard and soft information in banking (Alexandre and Smondel (2010), Stein (2002)). Abstracting from firm structure, the learning curve may entail banks learning how to transform soft into hard information or to use both to reduce costs. Knowledge spillovers may involve hardened (easily transmittable) information or soft information via social (individual-to-individual) learning. Identifying national or global learning-by-doing spillover channels contributes to assessments of banking liberalization policies and relates to the global banking literature (Ghironi and Stebunovs (2010), Goldberg (2010), Russ and de Blas (2010)). International positive knowledge spillovers supports the hypothesis that financial development is facilitated by financial openness. Finally, this research relates to the financial development and growth literature (For a review see Levine (2005)). Evidence of a learning curve in banking would identify a micro-founded driver of financial development. Establishing that on average bank cost efficiency gains dissipate as experience accumulates complements the non-linearity view of the positive finance and growth relation, i.e. financial deepening is beneficial but the relation is not linear, and the positive effect disappears as countries grow. (See Barajas et al. (2013), Cecchetti and Kharroubi (2012), Deidda and Fattouh (2002), Rioja and Valev (2004)).

4.1 Methodology

To assess firm-specific experience effects, first a learning curve model is estimated, a parsimonious first pass at testing for learning in banking that follows the learning curve literature. A negative elasticity of current unit costs to cumulative output defines a learning curve. The rest of the analysis in this paper uses results from estimating a bank-specific cost function augmented to include experience proxies and knowledge spillover measures.[2] The hypothesis is firm-specific or sector-wide experience via spillovers improves bank cost efficiency, ie greater experience is associated with lower costs.

4.1.1 Experience measures

Firm's own experience

Two proxies for a firm-specific experience are typically used in the empirical learning by doing studies: firm age and cumulative output of the firm as of the prior period. Both of these proxies allow for general experience effects including improvements due to employees learning on the job, or investment in technology that embodies firm learning. Age is most straightforward to measure for any type of firm, and allows for learning to occur even with limited production activity.

In contrast to firm age, defining production output Q_t, and corresponding input costs, poses a challenge to applying learning by doing to services industries, and in particular to financial intermediaries. A clean distinction between current output and cumulative output is needed if cumulative output is to be used as an experience proxy.

[2]This paper uses cost efficiency rather than profitability because revenue reporting can be influenced by variables as varied as industry structure, tax regimes and regulatory environments, whereas costs are more likely to be accurate representations of a bank's cost of operating.

Table 4.1 lists bank output definitions based on asset positions.[3] Another approach would be to use income earned to measure current bank output. For example a bank's interest income proxies for amount of financial intermediation services produced. The income measure has the advantage of being a reported flow variable. One can think of the timing of credit creation: the delivery of credit may occur over the course of many years, although the contract is originated at one point in time. The bank is likely to be earning revenue from that asset and incurring costs (and gaining experience) managing that asset for an extended period. From this perspective, we could think of a bank's production of financial services as proportional to the stock of new as well as existing bank assets $Q_t = \delta EA_t$, where EA is total loans and other earning assets.[4] With this definition of output, cumulative output Q_t^c could be measured as the sum of every year's earning assets. We could narrow the output definition to focus on credit intermediation. Then current output could be measured by the *change* in earning assets from the prior year, a flow measure derived from the stock measure. Cumulative output then could be the sum of the changes in earning assets, which nets out to be mathematically equivalent to EA_t.[5] Alternatively, a "gross flows" measure of cumulative output would be the sum of the absolute values of the flows. In other words production experience at a bank could be accrued from managing both an increase and decrease in the asset side of the balance sheet. A database advantage of using the "net" measure is that data on current earning assets, EA_t, is readily available. In contrast, the "gross flows" cumulative measure requires data for the

[3] A conceptual drawback to using broad asset measures as a proxy for experience is that assets for financial intermediaries are also measures of scale. For this reason Age is my preferred experience proxy.

[4] Earning assets comprise Interest bearing balances, securities, fed funds sold, repos purchased, loans, leases net of unearned income and items in the trading accounts.

[5] This is because stocks will net out in the summation. To see this, take a bank with 3 years of activity, so that $EA_{t-3} = 0$. Summing the flows: $(EA_{i,t} - EA_{i,t-1}) + (EA_{i,t-1} - EA_{i,t-2}) + (EA_{i,t-2} - EAi, t-3) = EA_{i,t}$, cumulative output as of period t.

lifetime of the bank if we would like a measure from the start of the bank's existence.

Table 4.1: Bank output measures

Q_t **Current output**	**Cumulative output** Q^c_{t-1}
Asset based:	
current earning assets EA_t	summed up over lifetime of bank $\sum_0^{t-1} EA_s$
change in earning assets (net flows), or new loan issuance $EA_t - EA_{t-1}$	summed up over lifetime of the bank $\sum_0^{t-1}(EA_s - EA_{s-1}) = EA_{t-1}$
absolute value of change in earning assets (gross flows) $\|(EA_t - EA_{t-1})\|$	summed up over lifetime of the bank $\sum_0^{t-1} \|(EA_s - EA_{s-1})\|$
Income based:	
Interest income	summed up over lifetime of the bank
Interest and fee income	summed up over lifetime of the bank

Knowledge spillovers

To analyze knowledge spillovers among domestic banks, we need to measure the experience of the domestic banking sector, excluding that of the individual bank. We can construct measures for national sector activity using the data from the sample.[6] The experience measure used for the individual banks can be aggregated across the sample and parsed into the group of banks in the bank's own country excluding the bank itself. Using the same approach for international spillovers is not optimal in that the global experience variable will be weakly identified (because it is a linear transformation of the domestic banking sector experience variable). In addition, it would not incorporate any adjustments for proximity to the foreign stock of knowledge. Instead, I will take the approach described in Keller (2004) as an association study. The empirics test whether a particular foreign activity leads to a particular domestic technology outcome. In this study on banking, the domestic technology outcome is

[6]Similar to the approach taken in Irwin and Klenow (1994).

lower bank production costs, the foreign activity is trade in foreign financial products and services, or participation in global financial markets. If higher levels of global interaction are associated with higher banking efficiency, this could be interpreted as a positive knowledge spillover from the foreign banking sector.[7]

4.1.2 Learning curve model

The following learning curve model is comparable to earlier empirical studies of learning curves in various industries.[8] The key hypothesized relationship is between unit costs and production experience, captured as cumulative output.[9]

$$c_t = c_1 n_t^{\alpha}$$

where

- c_t is current unit cost,
- c_1 is first period unit cost,
- n_t is firm's own cumulative output at time t,
- α is elasticity of current unit cost to cumulative output,

Taking logs the equation to be estimated is

$$lnc_t = lnc_1 + \alpha lnn_t + u_t \tag{4.1}$$

[7]This mechanism would be distinct from higher capital flows increasing the domestic supply of capital and thus reducing the 'price' of financial capital. The bank cost function explicitly controls for the price of borrowed funds.

[8]For example Irwin and Klenow (1994) estimate this for the semiconductor industry.

[9]See Berndt (1996) Chapter 3 for more detail. The underlying production function is in Cobb Douglas form, $y = AX_1^{a1}X_2^{a2}X_3^{a3}$, and A is assumed to include the effects of learning and defined as a function of experience measured as cumulative production.

The equation includes u_t, an i.i.d. stochastic disturbance term. Evidence of learning would be represented by $\alpha < 0$, a negative elasticity of current unit cost to experience proxied as cumulative output.[10]

4.1.3 Cost efficiency

To examine knowledge spillovers, the cost function must be extended to include additional terms representing national and global experience.[11] The hypothesis is greater levels of experience are associated with lower bank production costs.

$$lnC_i = \alpha + \beta_q lnQ_i + \sum_g \gamma_g lnW_{g,i} + \beta_k lnK_i + \beta_r lnR_i + lnE_i + \epsilon_i \qquad (4.2)$$

with

$$E_i = F_i^{\beta_F} \text{ or } E_i = F_i^{\beta_F} D_i^{\beta_D} \text{ or } E_i = F_i^{\beta_F} G_h^{\beta_G}$$

Firm-specific experience, F_i can be proxied by *firm cumulative output* as of an earlier period $Q^c_{i,t-1}$ (see Table 4.1); or *Age* of bank, from the date the charter was granted. Domestic sector-wide experience, D_i can be proxied by domestic cumulative output (sum of loans and other earning assets of all domestic banks) excluding the firm's own, $(Q^c_{D,t-1} - Q^c_{i,t-1})$, one period earlier; or collective Age or years of experience of the domestic banking sector excluding the firm's own. Global experience, G_h, is more difficult to measure. I proxy foreign experience by international capital flows. This is a country level variable and thus an indirect measure of a particular bank's international experience. Future work could use more direct measures such as bank

[10] A learning rate can be computed using the formula $1 - 2^{\alpha}$, the rate at which costs fall with each doubling of cumulative output.

[11] Refer to Chapter 2 for more detail on the bank cost function specification with only firm-specific experience.

lending data from the Bank of International Settlements.[12]

The coefficients of interest are

- β_F, the elasticity of variable cost with respect to firm-specific experience,
- β_D, the spillover effect on bank i's cost of within-country sector-wide experience, and
- β_G, the spillover effect from international banking experience.

Negative coefficient estimates would suggest evidence of learning by doing and/or knowledge spillovers within or between countries.[13]

4.2 Data

The international bank sample is drawn from the OSIRIS international database of publicly listed companies. Table 4.12 in the appendix lists the 88 countries in the bank sample. Bank variables are drawn from balance sheet and income statements. However OSIRIS does not seperately report deposit interest expenses and other borrowed funds interest expenses. Consequently I use one variable for total interest expense (W_6). Summary statistics for the 2012 cross-section are listed in Table 4.2. Total Assets range from 17.3 million to 201 trillion US dollars, Earning Assets range from 15 million to 174 trillion US dollars. The ratio of Net loans to Total Assets

[12] My approach is testing for an effect from the magnitude of international experience. Claessens et al. (2011) also look at the effects of foreign banking on domestic banking, however they analyze the impact of a change in the foreign bank presence on the ground in the domestic financial sector. They find that foreign bank entry is associated with greater efficiency in the domestic banking system. The authors argue two mechanisms may be the cause: domestic banks may be able "'to reduce costs as they assimilate any superior banking techniques and practices from the foreign banks"', and competition may force domestic banks to pursue greater cost efficiency.

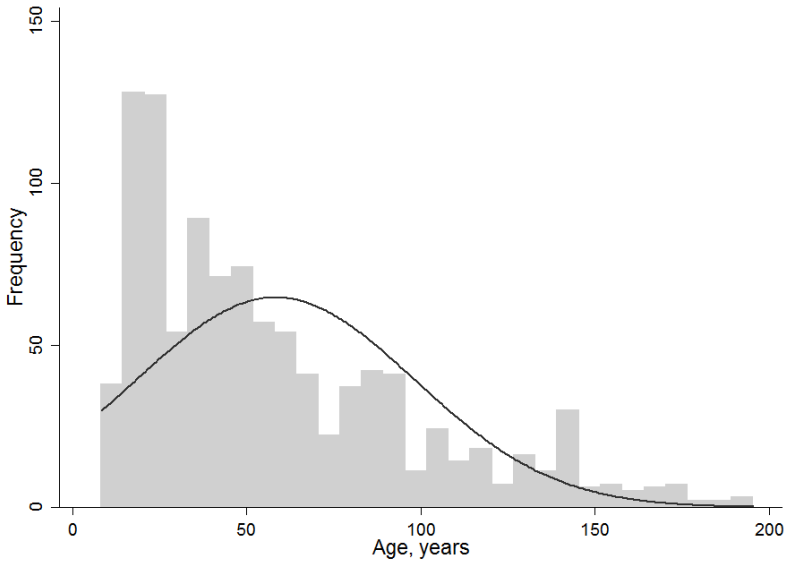
[13] Note that increasing returns to scale is allowable in this set up, although these scale efficiencies would not vary with size. Scale is not the primary focus of this paper, but this model does explicitly allow for distinct scale efficiencies and learning efficiencies. An estimate of $\beta_q < 1$ would represent scale cost efficiencies.

sample average is 58pct, with 75pct of the banks having net loans of more than 51pct of total assets.[14]

Table 4.2: Summary statistics for 2012

Variable	Mean	Std. Dev.	Min.	Max.	N
Cost (USD 000s)	125,741,106	952,169,445	5,569	13,350,281,216	689
Earning assets (USD 000s)	1,740,086,749	12,715,402,460	15,000	174,557,249,536	689
W_1 (labor)	3,362	19,043	0.515	243,039	689
W_2 (physical capital)	4.07	30.23	0.04	732.13	689
W_6 (funding)	0.03	0.04	0	0.96	689
Equity (USD 000s)	223,675,817	1,807,767,399	11,200	24,858,755,072	689
Risk (NPLs, USD 000s)	42,178,076	268,666,443	0	2,925,315,072	607
Age, years	65.96	56.84	8.36	540.49	681
Total Assets (USD 000s)	1,979,234,447	14,601,157,093	17,300	201,000,000,000	689
Net Loans/Total Assets	57.89	16.66	0	90.97	689

Figure 4.1: Distribution of Age variable for 2012 cross-section



In the sample, 681 banks have the age of incorporation data. The Age variable is widely distributed (see Figure 4.1), the mean age is 66 years, with a minimum 8.4 years. While the OSIRIS dataset does provide an international sample of banks, the

[14]For more detail on bank characteristics, Table 4.10 and 4.11 in the appendix lists variables related to size, risk appetite and business model for age quintiles and deciles respectively.

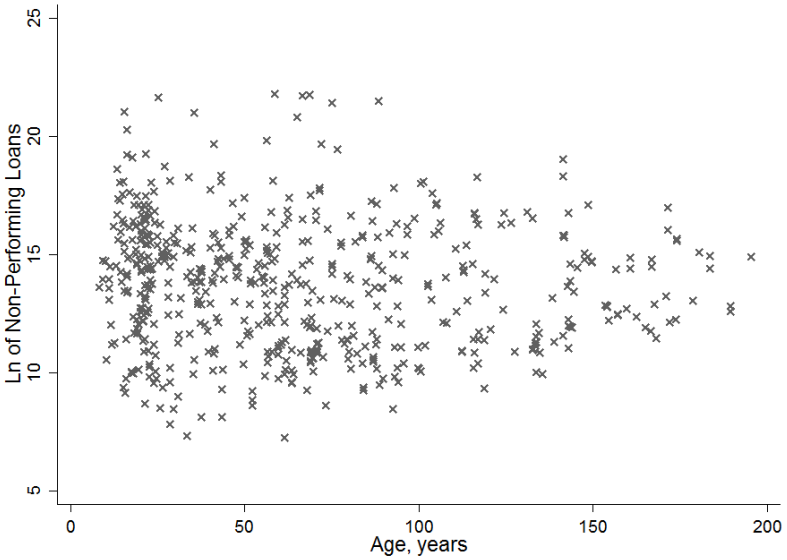
sample does not include young *de novo* banks, consequently it may be hard to discern evidence of learning given the results in Chapter 3 and DeYoung (2001). In addition, the Age distribution in the international sample has significantly more old banks. For the US sample used in Chapter 3, the maximum Age was 98 years, the median 23. The OSIRIS sample has banks as old as 540 years of age, the median 54. For the plots I use the sample of banks under 200 years of age. Figure 4.2 plots Age against a measure of size (Earning Assets) with no clear relation between the two suggesting Age is not simply a proxy for size.

Figure 4.2: Age and Size for 2012 cross-section

Looking at Figure 4.3, no obvious relationship exists between Age and bank costs. One moniker of better bank performance is lower rates of default by its customers. Figure 4.4 plots age and Non-performing loans as a proportion of the bank's balance sheet.

Figure 4.3: Age and Cost for 2012 cross-section

Figure 4.4: Age and Non-Performing Loans for 2012 cross-section



4.3 Results and analysis

4.3.1 Learning curve

Using equation 4.1, $lnc_t = lnc_1 + \alpha lnn_t + u_t$, Table 4.3 reports estimates using bank output defined as the change in earning assets.[15] Columns 1 and 2 use the restricted model (excluding current output) which assumes constant returns to scale, columns 3 and 4 relax that assumption and include a measure of output y_t. The estimates of α, the elasticity parameter and coefficient of n_t, are negative which supports the thesis of a learning curve in banking. However only one estimate satisfies a 5 pct significance level. Also, estimates vary depending on the choice of bank output measure.[16]

Table 4.3: Bank learning curve model,
Dependent variable: Ln of Current Unit Costs

	(1)	(2)	(3)	(4)
c_1, Ln of Period 1 Unit Cost	0.046	-0.016	0.057	-0.029
	(0.153)	(0.181)	(0.150)	(0.181)
n_t, Ln of Cum Output (2011)	-0.071		-0.109*	
	(0.053)		(0.055)	
n_t, Ln of Cum Output (2007)		-0.096		-0.109
		(0.060)		(0.060)
y_t, Ln of Current output (2012)			0.000*	0.000
			(0.000)	(0.000)
Constant	-1.374	-1.096	-0.731	-0.928
	(0.966)	(1.093)	(0.990)	(1.100)
Observations	108	71	108	71
Adjusted R^2	0.000	0.008	0.037	0.013

Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[15] Unit cost c is derived by dividing the change in variable costs by the change in earning assets. Cumulative output n_t is measured as the net flows of earning assets as of the prior or earlier period: $n_t = Q^c_{t-1} = \sum_0^{t-1}(EA_s - EA_{s-1}) = EA_{t-1}$

[16] Estimation results using the gross flows cumulative output measure (the sum of the absolute values of the changes in earning assets) are reported in the appendix, Table 4.14. The disparity in the estimates may be due to the different data required to calculate the different output measures.

4.3.2 Cost function model

The cost efficiency approach provides a richer set of results. This section discusses the estimation results using equation 3.1, with various specifications and experience proxies.

Focusing on **firm-specific** learning by doing, the coefficient of interest is β_F from the following equation

$$lnC_i = \alpha + \beta_q lnQ_i + \sum_g \gamma_g lnW_{g,i} + \beta_k lnK_i + \beta_r lnR_i + \beta_F lnF_i + \epsilon_i$$

The results using bank *Age* as a proxy for firm experience are imprecise. Table 4.4 shows the computed elasticities using the results from three different specifications based on results from Chapter 2 of the dissertation. [17] The overall average elasticity of cost to experience is not significantly different from zero. However, Figure 4.5 and 4.6 show the model implied average marginal elasticities of firm age on predicted bank cost, at different representative values of $lnAge2012$. The blue bands represent a 95 pct confidence interval, and demonstrate the difficulty in pinning down estimates using this data. Nevertheless, these plots suggest a region where experience (Age) does have the hypothesized effect. Until the age of around 36 years, the estimate of the experience effect on cost is negative.

Table 4.4: Average experience effect, Age proxy

	dy/dx	Std. Err.	t	$P > \|t\|$	95 pct Conf. Int.	
Model (1), linear in lnAge	.0083063	.0281148	0.30	0.768	-.0475935	.064206
Model (2), quadratic:	.0095366	.0279717[a]	0.34	0.734	-.0460787	.0651518
Model (3), cubic:	.006046	.0272097[a]	0.22	0.825	-.0480541	.0601461

Errors clustered by country. Regional dummies for US and Euro 11.
a: Standard error computed using the Delta-method.

[17] See Table 4.15 in the appendix for the full regression results.

Figure 4.5: Effect of Age on cost, using Model (2)

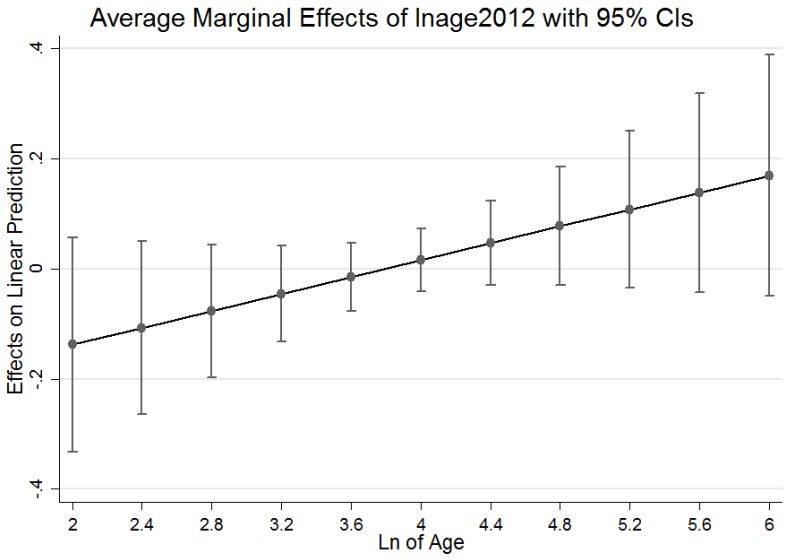
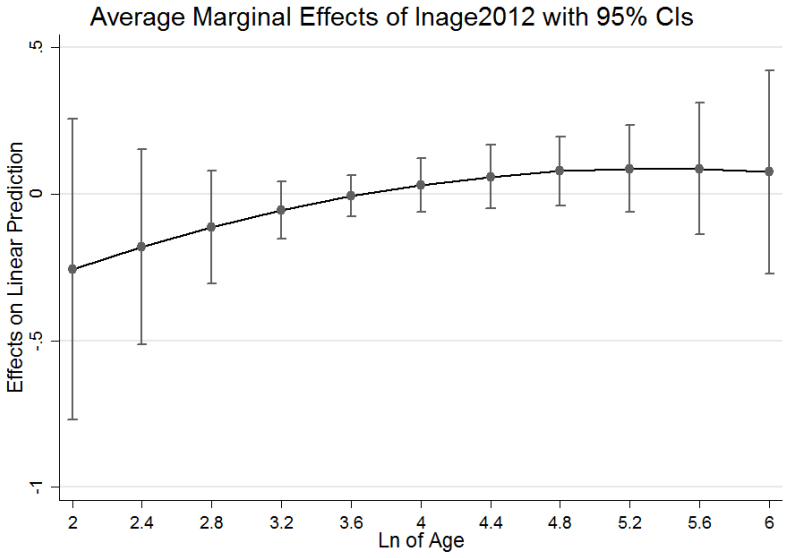


Figure 4.6: Effect of Age on cost, using Model (3)



Further exploring the relationships across the Age distribution, Table 4.5 shows estimates for Age quintiles. The first and second youngest quintiles (bank age from 8 to 22 years) show a negative coefficient on the experience proxy, although they are not statistically significant.[18]

Table 4.5: Regression results for Age quintiles,
Dependent variable: Ln of Cost

Quintile	1	2	3	4	5
2012 lnearning_assets	0.684***	0.716***	0.776***	0.586**	0.691***
	(0.088)	(0.089)	(0.103)	(0.173)	(0.110)
2012 lnw1	0.094**	0.040	0.089**	0.164*	0.054
	(0.033)	(0.036)	(0.029)	(0.062)	(0.033)
2012 lnw2	0.002	-0.053	-0.008	0.102*	0.017
	(0.045)	(0.053)	(0.047)	(0.047)	(0.044)
2012 lnw6	0.573***	0.444***	0.486***	0.372***	0.413***
	(0.058)	(0.091)	(0.055)	(0.060)	(0.054)
2012 lnequity	0.257*	0.229*	0.123	0.255	0.256*
	(0.110)	(0.093)	(0.098)	(0.149)	(0.113)
2012 lnrisk	-0.040	0.000	0.024	0.045	0.002
	(0.055)	(0.039)	(0.038)	(0.056)	(0.043)
2012 lnage	-0.256	-0.329	0.255	0.431	0.074
	(0.182)	(0.234)	(0.308)	(0.255)	(0.087)
USDummy	0.336	0.443*	1.209***	-0.022	0.241*
	(0.209)	(0.168)	(0.124)	(0.178)	(0.109)
Euro11	-0.238*	-0.141	-0.355*	-0.318**	-0.075
	(0.101)	(0.107)	(0.133)	(0.101)	(0.087)
Constant	1.582	1.012	-0.926	-1.442	-0.641
	(0.791)	(0.764)	(1.116)	(1.245)	(0.605)
Observations	114	120	121	126	117
Adjusted R^2	0.985	0.983	0.987	0.993	0.986

Standard errors in parentheses. Errors clustered by country.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[18]In the appendix, Table 4.16 shows results using Age deciles, but only about 50-60 observations comprised each decile. The second youngest decile (ages 18-22 years) has a negative and statistically significant estimate of the coefficient on experience, while the oldest decile (ages from 119 to 540) shows a slight positive coefficient on experience. Many of the younger banks in the second decile are operating in emerging economies and there may be lags in knowledge accumulation and implementation. In contrast, the banks in the oldest decile are all in developed economies. It may be the case that older banks in the developed economies have increased costs from regulatory compliance that overshadow any efficiency gains from learning.

Using *bank cumulative output* as the firm-specific experience proxy gives some evidence of learning. Narrowing the definition of financial services output to net flows (the change in earning assets), experience defined as cumulative output is $\sum_0^{t-1}(EA_s - EA_{s-1}) = EA_{t-1}$.[19] Table 4.6 reports the computed overall average elasticities of cost with respect to experience from three different specifications. The point estimate is negative for all three models.[20] Plots of average elasticities at representative values of cumulative output show the effect of firm experience on predicted bank cost for different values of experience, Figure 4.7 and 4.8. These plots suggest there is a region where experience is more strongly associated with lower costs.

Table 4.6: Average experience effect, Cumulative Output proxy

	dy/dx	Std. Err.	t	$P > \|t\|$	95 pct Conf. Int.	
Model (1), linear in Q^c_{t-1}	-.3554133	.1541327	-2.31	0.026	-.6658525	-.0449741
Model (2), quadratic:	-.2776395	.1764422[a]	-1.57	0.123	-.6330123	.0777334
Model (3), cubic:	-.3009764	.1750547[a]	-1.72	0.092	-.6535547	.0516019

Errors clustered by country. a: Standard error computed using the Delta-method.

[19] Using this bank output measure reduces the sample size due to data limitations. Results reported in this section use $t - 1 = 2007$, estimates are available upon request for $t - 1 = 2011$.

[20] Please refer to Table 4.20 in the appendix for full estimation results. Economies of scale are represented in a coefficient estimate of less than 1 on current output.

Figure 4.7: Effect of Cumulative output on cost, using Model (2)

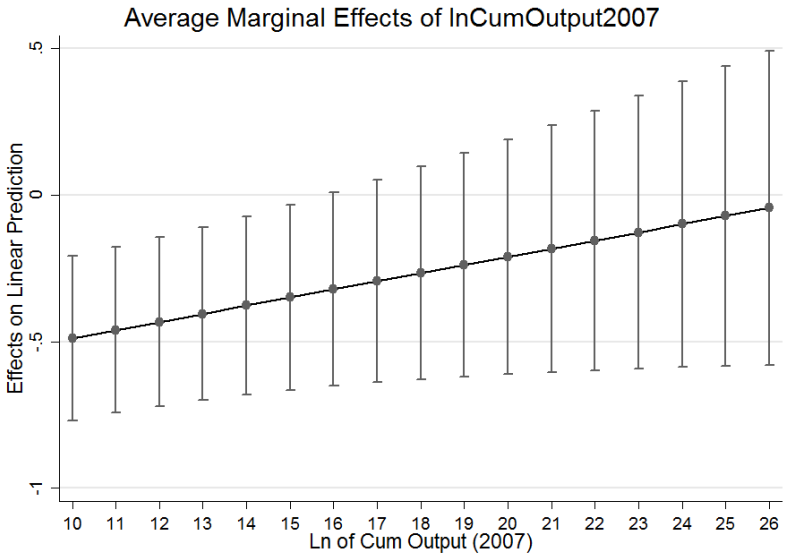
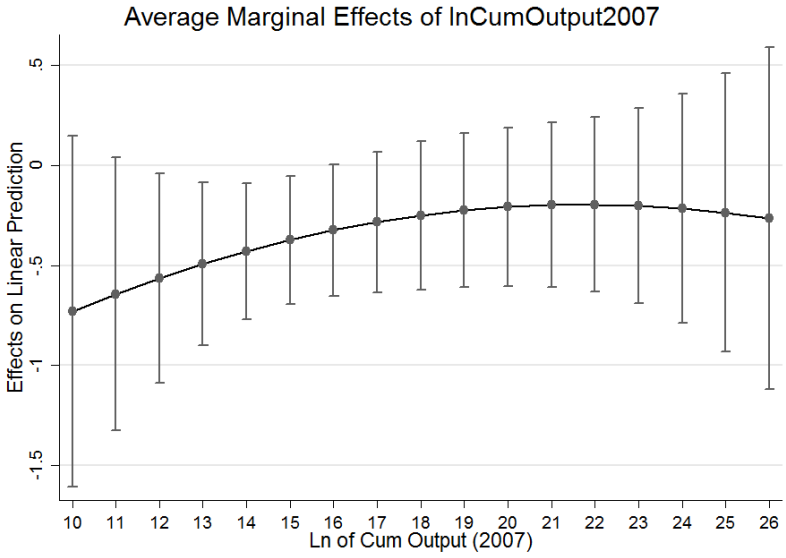


Figure 4.8: Effect of Cumulative output on cost, using Model (3)



Turning to **domestic knowledge spillovers**, the coefficient of interest is β_D from the following equation

$$lnC_i = \alpha + \beta_q lnQ_i + \sum_g \gamma_g lnW_{g,i} + \beta_k lnK_i + \beta_r lnR_i + \beta_F lnF_i + \beta_D lnD_i + \epsilon_i$$

Using bank *Age* as the experience proxy, Table 4.7 reports estimates for coefficients on domestic experience (proxied as the collective age of the domestic banking sector, excluding bank i). The estimate of the coefficients' on the domestic spillover variable is not statistically significant.[21]

[21]Using *bank cumulative output* as the experience proxy, the estimation results (Table 4.22 in the appendix) show little evidence of spillovers and in Model (1) the coefficient estimate is in fact positively signed.

Table 4.7: Domestic spillovers (Age),
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnearning_assets	0.705***	0.703***	0.702***
	(0.055)	(0.053)	(0.053)
2012 lnw1	0.077***	0.078***	0.078***
	(0.019)	(0.019)	(0.019)
2012 lnw2	-0.010	-0.011	-0.010
	(0.029)	(0.029)	(0.029)
2012 lnw6	0.457***	0.456***	0.456***
	(0.043)	(0.044)	(0.044)
2012 lnequity	0.219***	0.221***	0.221***
	(0.057)	(0.055)	(0.055)
2012 lnrisk	0.001	0.000	0.001
	(0.022)	(0.022)	(0.022)
USDummy	0.373***	0.370***	0.372***
	(0.073)	(0.071)	(0.072)
Euro11	-0.190**	-0.210**	-0.210**
	(0.059)	(0.064)	(0.064)
DomesticExclBnkiAge	0.017	0.017	0.016
	(0.023)	(0.023)	(0.022)
2012 lnage	-0.001	-0.308	-0.641
	(0.027)	(0.195)	(0.889)
2012 lnage^2		0.039	0.123
		(0.025)	(0.211)
2012 lnage^3			-0.007
			(0.016)
Constant	0.056	0.650	1.083
	(0.250)	(0.515)	(1.321)
Observations	581	581	581
Adjusted R^2	0.987	0.987	0.987

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For **international knowledge spillovers**, the coefficient of interest is β_G and the estimation equation is

$$lnC_i = \alpha + \beta_q lnQ_i + \sum_g \gamma_g lnW_{g,i} + \beta_k lnK_i + \beta_r lnR_i + \beta_F lnF_i + \beta_G lnG_h + \epsilon_i$$

Using data from Lane and Milesi-Ferretti (2007), gross capital flows proxies for foreign activity. Table 4.8 reports the estimation results from three specifications. The negative coefficient estimate for β_G in all three models may be interpreted to mean greater foreign experience is associated with lower bank production costs.

To question whether the direction of foreign interaction matters, columns 2 and 3 in Table 4.9 report the estimated effect of foreign liabilities and foreign assets respectively. The coefficient on foreign assets is negative and statistically significant, while the estimated effect of foreign liabilities is not.[22] One could interpret this as suggesting that on average domestic banks experience with acquiring foreign assets has a desirable experience effect on cost efficiency.

However gross capital flows is an indirect measure of knowledge flow and may predominantly be capturing a country's level of international financial integration. Also, reverse causality may be an important issue. If a country's banking sector is relatively efficient, domestic agents could more easily choose to access the foreign financial sector. In particular, more efficient banks may have a proclivity towards foreign transactions.[23] These results raise the question, do more efficient banks trade internationally? or does trade make the banks more efficient? Further research is needed.

[22]This result is robust to estimation specifications with old age bank dummies, only a single experience term, or adding experience cubed.

[23]Related to this question, the authors in Niepmann and Kerl (2014) document that for German banks, those with foreign lending on average had lower overhead costs to total assets than those without any foreign claims.

Table 4.8: International spillovers,
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnearning_assets	0.803***	0.799***	0.799***
	(0.052)	(0.051)	(0.051)
2012 lnw1	0.068***	0.068***	0.068***
	(0.017)	(0.017)	(0.017)
2012 lnw2	-0.010	-0.011	-0.011
	(0.027)	(0.027)	(0.027)
2012 lnw6	0.438***	0.439***	0.439***
	(0.059)	(0.059)	(0.060)
2012 lnequity	0.135*	0.141**	0.141**
	(0.052)	(0.051)	(0.050)
2012 lnrisk	0.007	0.005	0.005
	(0.024)	(0.024)	(0.025)
USDummy	0.548***	0.544***	0.545***
	(0.087)	(0.083)	(0.086)
Euro11	-0.076	-0.094	-0.094
	(0.072)	(0.075)	(0.075)
CntryGrossForeign2011	-0.045*	-0.045*	-0.046*
	(0.022)	(0.022)	(0.022)
2012 lnage	0.018	-0.298*	-0.463
	(0.022)	(0.133)	(0.812)
2012 lnage^2		0.040*	0.081
		(0.017)	(0.194)
2012 lnage^3			-0.003
			(0.015)
Constant	0.103	0.720	0.937
	(0.229)	(0.395)	(1.170)
Observations	459	459	459
Adjusted R^2	0.986	0.986	0.986

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.9: International spillovers by direction,
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnearning_assets	0.799***	0.784***	0.811***
	(0.051)	(0.049)	(0.053)
2012 lnw1	0.068***	0.070***	0.068***
	(0.017)	(0.017)	(0.016)
2012 lnw2	-0.011	-0.012	-0.010
	(0.027)	(0.027)	(0.027)
2012 lnw6	0.439***	0.451***	0.427***
	(0.059)	(0.056)	(0.063)
2012 lnequity	0.141**	0.149**	0.134*
	(0.051)	(0.050)	(0.051)
2012 lnrisk	0.005	0.010	0.000
	(0.024)	(0.024)	(0.025)
USDummy	0.544***	0.529***	0.543***
	(0.083)	(0.086)	(0.079)
Euro11	-0.094	-0.110	-0.082
	(0.075)	(0.072)	(0.078)
2012 lnage	-0.298*	-0.295*	-0.303*
	(0.133)	(0.134)	(0.131)
2012 lnage^2	0.040*	0.040*	0.041*
	(0.017)	(0.017)	(0.016)
CntryGrossForeign2011	-0.045*		
	(0.022)		
CntryForeignLiab2011		-0.038	
		(0.021)	
CntryForeignAsts2011			-0.048*
			(0.022)
Constant	0.720	0.700	0.640
	(0.395)	(0.400)	(0.399)
Observations	459	459	459
Adjusted R^2	0.986	0.986	0.987

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4 Conclusion

This paper uses an international sample of bank balance sheet data to test for empirical evidence of learning and knowledge spillovers in banking. The hypothesis is that firm-specific and sector-wide learning, via knowledge spillovers, improves bank cost efficiency. The empirical learning by doing literature has studied spillovers and social learning in several contexts (See Bahk and Gort (1993), Barrios and Strobl (2004), Conley and Udry (2010), Foster and Rosenzweig (1995), Irwin and Klenow (1994)). This paper adds to the empirical learning by doing literature by looking at a new industry and builds on Irwin and Klenow's study which explicitly considered national and global learning-by-doing spillovers.

First a simple learning curve model was estimated. The estimates of the elasticity parameter (the coefficient of cumulative output), are negative which supports the thesis of a learning curve in banking. However only one estimate satisfied a 5 pct significance level, and estimates varied depending on the choice of bank output measure.

Next, the international sample was used to estimate a bank-specific cost function augmented to include experience proxies and knowledge spillover measures. The estimated effects of experience are not precise and vary depending on the experience proxy and econometric model used, potentially due to data limitations. There is evidence that for banks at the younger end of the age distribution, firm-specific experience effects are associated with lower bank production costs. Knowledge spillovers within a country seem absent, and it may be that other domestic banks' activity increases production cost. There is evidence to suggest that international knowledge spillovers occur. In particular, foreign assets had an estimated dampening effect on bank costs. The spillovers results contrast with Branstetter (2001) which found do-

mestic knowledge spillovers (using R&D measures for knowledge) were greater than international spillovers. Finance may be different in that technical diffusion in banking may be driven more by international network effects and proximity to financial hubs.

The measure of foreign knowledge used in this paper is indirect. Further research on banking and international knowledge spillovers could use a smaller sample but a more direct measure of foreign experience (such as bilateral bank lending data), and an approach drawing on the empirical trade literature focused on R&D. Coe et al. (2008) summarize past research on R&D spillovers and empirically test whether the trade-weighted stock of foreign R&D is associated with higher domestic productivity. Knowledge is measured by the stock of foreign R&D expenditure, and proximity to that knowledge is measured by the magnitude of trade. Trade channels R&D, embodied in the traded goods and services, from country j to country i. To be precise the authors define the stock of foreign R&D for country i as follows: $S_i^f = \sum_{j \neq i} w_{ij} S_j^d$ where S_j^d is the stock of domestic R&D in all business sectors for country j, $w_{ij} = \frac{M_{ij}}{\sum_{j \neq i} M_{ij}}$, and M_{ij} is country i's imports of goods and services from country j. The knowledge spillovers are hypothesized to affect overall domestic Total Factor Productivity. However, patents in finance are still a new development, and R&D expenditure is not a primary focus. In this study, knowledge is captured in experience not R&D expenditure, and the hypothesis is that knowledge spillovers within banking affect banking sector efficiency. Consequently, S_j^d would be replaced by a measure of the experience of the banking sector in country j. For example, using cumulative output as the experience proxy, S_j^d could equal cumulative banking output of country j. In addition, to define the appropriate trade weights w_{ij}, one would use trade in financial products rather than consumer and capital goods. For example, bilateral bank lending data could be used to construct w_{ij}. Is there anything gained

by borrowing from foreigners (besides the money itself)? Additional questions could be asked, such as whether privatization or liberalization of the banking sector helps or hurts technical diffusion. Are their factors that increase the absorptive capacity of domestic banks? Does knowledge spillovers occur differently in a bank-centric versus capital market oriented financial sector?

4.5 Appendix

4.5.1 OSIRIS 2012 cross-section statistics

Table 4.10: Age quintiles vs. Full sample

Age quintile	Age	Earning Assets	Equity	Risk (NPLs)	Total Assets	$\frac{NetLoans}{TotalAssets}$
1 Min	8	15,000	11,200	0	17,300	0.28
Max	22	46,930,743,296	5,664,624,128	1,391,789,952	56,494,582,000	85.71
Median	18	50,436,250	3,313,800	2,085,000	56,212,050	57.84
2	22	81,600	14,942	1,558	98,700	6.35
	38	48,727,441,408	7,448,584,192	2,512,716,032	55,435,570,000	84.12
	27	35,774,650	3,697,000	1,687,650	40,251,400	61.07
3	38	101,300	28,761	3,402	131,800	3.78
	60	92,603,744,256	12,939,145,216	2,925,315,072	108,000,000,000	90.97
	50	40,171,600	3,568,000	1,171,900	41,112,100	63.82
4	61	232,820	18,581	1,437	259,283	3.61
	91	174,557,249,536	24,858,755,072	2,803,559,936	201,000,000,000	87.87
	73	17,483,400	1,380,300	399,300	20,152,255	60.85
5	92	303,692	18,367	4,803	314,339	0.00
	540	12,229,626,880	861,542,016	183,568,992	12,680,615,000	88.90
	132	29,375,500	2,133,300	602,655	30,748,700	62.52
Total	8	15,000	11,200	0	17,300	0.00
	540	174,557,249,536	24,858,755,072	2,925,315,072	201,000,000,000	90.97
	54	30,327,600	2,424,300	1,040,200	32,765,500	61.19

Table 4.11: Age deciles vs. Full sample

Age decile	Age	Earning Assets	Equity	Risk (NPLs)	Total Assets	$\frac{NetLoans}{TotalAssets}$
1 Min	8	123,729	38,300	0	331,200	0.28
Max	18	46,930,743,296	5,664,624,128	1,391,789,952	56,494,582,000	84.96
Median	15	85,759,904	7,615,400	2,047,000	97,916,400	57.44
2	18	15,000	11,200	5,932	17,300	0.58
	22	7,324,883,968	1,481,654,016	234,000,992	7,892,506,000	85.71
	20	25,594,600	1,832,000	2,334,800	29,572,000	58.74
3	22	167,696	18,958	5,000	183,662	6.35
	28	48,727,441,408	7,448,584,192	2,512,716,032	55,435,570,000	84.12
	23	42,397,000	4,475,900	3,024,000	48,890,600	64.99
4	28	81,600	14,942	1,558	98,700	11.75
	38	22,431,764,480	2,197,382,912	1,338,136,960	24,759,888,000	82.81
	34	15,238,700	1,822,700	1,007,500	17,065,400	57.65
5	38	101,300	46,476	3,402	131,800	3.78
	49	4,995,069,952	713,382,976	354,343,008	5,812,055,000	82.64
	43	56,959,000	4,996,700	1,696,350	58,165,900	60.54
6	49	289,846	28,761	5,690	300,637	11.62
	60	92,603,744,256	12,939,145,216	2,925,315,072	108,000,000,000	90.97
	56	20,668,268	3,101,900	983,300	26,407,536	65.28
7	61	232,820	18,581	1,437	259,283	14.66
	71	155,528,069,120	22,475,767,808	2,803,559,936	180,000,000,000	74.88
	67	9,459,050	1,003,700	163,462	10,446,964	61.30
8	71	343,901	21,550	5,571	356,075	3.61
	91	174,557,249,536	24,858,755,072	2,154,481,920	201,000,000,000	87.87
	84	21,951,700	2,093,530	643,200	26,189,700	60.85
9	92	303,692	18,367	4,803	314,339	1.19
	119	12,229,626,880	861,542,016	87,196,200	12,680,615,000	80.50
	105	20,724,250	1,703,950	903,200	20,509,100	63.85
10	119	1,103,089	40,175	21,200	1,147,991	0.00
	540	3,293,895,936	138,996,000	183,568,992	3,485,181,000	88.90
	145	35,767,300	3,315,000	540,755	39,800,000	61.55
Total	8	15,000	11,200	0	17,300	0.00
	540	174,557,249,536	24,858,755,072	2,925,315,072	201,000,000,000	90.97
	54	30,327,600	2,424,300	1,040,200	32,765,500	61.19

Table 4.12: Country representation

2012 COUNTRY	Frequency	Percent	Cumulative	2012 COUNTRY	Frequency	Percent	Cumulative
Australia	6	0.86	0.86	Republic of Korea	1	0.14	74.03
Austria	9	1.29	2.15	Republic of Moldova	5	0.72	74.75
Bangladesh	7	1.00	3.16	Romania	4	0.57	75.32
Barbados	1	0.14	3.30	Russian Federation	10	1.43	76.76
Belgium	3	0.43	3.73	Saint Kitts and Nevis	1	0.14	76.90
Benin	1	0.14	3.87	Saudi Arabia	6	0.86	77.76
Bermuda	1	0.14	4.02	Serbia	7	1.00	78.77
Bolivia	1	0.14	4.16	Singapore	2	0.29	79.05
Bosnia and Herzegovina	5	0.72	4.88	Slovakia	6	0.86	79.91
Botswana	2	0.29	5.16	Slovenia	4	0.57	80.49
Brazil	1	0.14	5.31	South Africa	4	0.57	81.06
Canada	7	1.00	6.31	Spain	13	1.87	82.93
Chile	1	0.14	6.46	Sri Lanka	10	1.43	84.36
China	19	2.73	9.18	Sweden	5	0.72	85.08
Colombia	6	0.86	10.04	Switzerland	22	3.16	88.24
Croatia	15	2.15	12.20	Taiwan	4	0.57	88.81
Cyprus	5	0.72	12.91	Thailand	1	0.14	88.95
Czech Republic	4	0.57	13.49	Togo	1	0.14	89.10
Denmark	24	3.44	16.93	Turkey	23	3.30	92.40
Egypt	10	1.43	18.36	Uganda	1	0.14	92.54
El Salvador	3	0.43	18.79	Ukraine	1	0.14	92.68
Estonia	2	0.29	19.08	United Arab Emirates	1	0.14	92.83
Finland	4	0.57	19.66	United Kingdom	7	1.00	93.83
France	29	4.16	23.82	United States of America	33	4.73	98.57
Georgia	2	0.29	24.10	Venezuela	2	0.29	98.85
Germany	26	3.73	27.83	Vietnam	4	0.57	99.43
Ghana	2	0.29	28.12	Zambia	4	0.57	100.00
Greece	11	1.58	29.70	Total	697	100.00	
Hong Kong	5	0.72	30.42				
Hungary	3	0.43	30.85				
India	24	3.44	34.29				
Indonesia	13	1.87	36.15				
Ireland	4	0.57	36.73				
Israel	9	1.29	38.02				
Italy	26	3.73	41.75				
Japan	103	14.78	56.53				
Jordan	1	0.14	56.67				
Kazakhstan	2	0.29	56.96				
Kenya	5	0.72	57.68				
Latvia	2	0.29	57.96				
Liechtenstein	1	0.14	58.11				
Lithuania	6	0.86	58.97				
Luxembourg	5	0.72	59.68				
Macedonia (Fyrom)	4	0.57	60.26				
Malaysia	1	0.14	60.40				
Malta	4	0.57	60.98				
Mauritius	3	0.43	61.41				
Montenegro	2	0.29	61.69				
Morocco	3	0.43	62.12				
Nepal	6	0.86	62.98				
Netherlands	3	0.43	63.41				
Nigeria	7	1.00	64.42				
Norway	10	1.43	65.85				
Oman	4	0.57	66.43				
Pakistan	18	2.58	69.01				
Papua New Guinea	1	0.14	69.15				
Paraguay	1	0.14	69.30				
Peru	2	0.29	69.58				
Philippines	11	1.58	71.16				
Poland	14	2.01	73.17				
Portugal	5	0.72	73.89				

4.5.2 Geography

Several strategies were applied to deal with country effects in the Cost function estimation approach. At a minimum errors were clustered by country. Other specifications involved including dummies for the US and for the original Euro 11, or a full set of country dummies. Although including additional dummies helped with precision, no one strategy seemed robust to model types. With a large number of countries, many of the individual country dummies were omitted. When using Age of the bank as a proxy for experience, 31 observations were US, and 99 were Euro11. Table 4.13 shows alternative estimation results for each approach. Results reported in the body of the paper for the Age experience proxy use clustered errors (by country) and the 2 geographic dummies. When using cumulative output as the proxy, about 7 observations were US, and 16 were Euro11. For this model, results reported in the body of the paper use clustered errors (by country).

Table 4.13: Strategies to address country heterogeneity

	beta or dydx	s.e.	t	$P > \|t\|$	95pct Conf. Int.	
Model (1), linear:						
Clustered errors	.0033075	.0280207	0.12	0.906	-.0524051	.0590202
US and Euro dummies	.0083063	.0281148	0.30	0.768	-.0475935	.064206
Country dummies	-.0045818	.030767	-0.15	0.882	-.0657548	.0565912
Model (2), quadratic:						
Clustered errors	-.0981916	.1930868	-0.51	0.612	-.4820999	.2857167
US and Euro dummies	.0095366	.0279717	0.34	0.734	-.0460787	.0651518
Country dummies	-.0041175	.0286847	-0.14	0.886	-.0611503	.0529154
Model (3), cubic:						
Clustered errors	.0026196	.0278676	0.09	0.925	-.0527888	.0580279
US and Euro dummies	.006046	.0272097	0.22	0.825	-.0480541	.0601461
Country dummies	.0030564	.0281951	0.11	0.914	-.053003	.0591157

4.5.3 Learning curve model

Results using the gross flows output measure:

Table 4.14: Bank learning curve model,
Dependent variable: Ln Current Unit Costs

	(1)	(2)
c_1, Ln of Period 1 Unit Cost	0.060	0.160***
	(0.072)	(0.070)
n_t, Ln of Cum Output	0.004	0.456***
	(0.030)	(0.073)
y_t, Ln of Current output		-0.430***
		(0.067)
Constant	-2.738***	-3.888***
	(0.536)	(0.515)
Observations	257	188
Adjusted R^2	-0.005	0.180

Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.5.4 Cost function model

Estimation with Age as experience proxy

Table 4.15: Firm specific experience (Age),
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnearning_assets	0.719***	0.717***	0.715***
	(0.054)	(0.053)	(0.053)
2012 lnw1	0.082***	0.082***	0.082***
	(0.017)	(0.017)	(0.017)
2012 lnw2	-0.005	-0.006	-0.006
	(0.029)	(0.029)	(0.029)
2012 lnw6	0.451***	0.451***	0.452***
	(0.036)	(0.036)	(0.037)
2012 lnequity	0.204***	0.207***	0.207***
	(0.058)	(0.056)	(0.056)
2012 lnrisk	-0.002	-0.003	-0.001
	(0.022)	(0.022)	(0.022)
USDummy	0.381***	0.377***	0.380***
	(0.078)	(0.077)	(0.077)
Euro11	-0.186***	-0.206***	-0.207***
	(0.049)	(0.055)	(0.055)
2012 lnage	0.008	-0.291	-0.788
	(0.028)	(0.196)	(0.974)
2012 lnage^2		0.038	0.163
		(0.025)	(0.236)
2012 lnage^3			-0.010
			(0.018)
Constant	0.099	0.680	1.326
	(0.237)	(0.505)	(1.409)
Observations	598	598	598
Adjusted R^2	0.987	0.987	0.987

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.16: Regression results for Age deciles,
Dependent variable: Ln of Cost

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Earning assets	0.626***	0.766***	0.694***	0.885***	0.505**	0.749***	0.753***	0.502*	0.778***	0.649***
	(0.134)	(0.068)	(0.098)	(0.150)	(0.180)	(0.155)	(0.101)	(0.224)	(0.124)	(0.147)
2012 lnw1	0.117*	0.038	-0.015	0.106	0.092*	0.054	0.119**	0.208*	0.047	0.072
	(0.049)	(0.019)	(0.033)	(0.053)	(0.042)	(0.029)	(0.041)	(0.084)	(0.030)	(0.083)
2012 lnw2	0.001	0.029	-0.139***	0.087	-0.044	0.011	0.076	0.076	0.047	0.019
	(0.057)	(0.040)	(0.036)	(0.051)	(0.043)	(0.111)	(0.047)	(0.044)	(0.056)	(0.055)
2012 lnw6	0.471***	0.650***	0.551***	0.368**	0.634***	0.424***	0.457***	0.343***	0.414***	0.302**
	(0.069)	(0.043)	(0.056)	(0.109)	(0.056)	(0.068)	(0.046)	(0.082)	(0.049)	(0.100)
2012 lnequity	0.302*	0.132	0.296**	0.003	0.425*	0.123	0.021	0.379	0.188	0.399*
	(0.140)	(0.065)	(0.091)	(0.168)	(0.189)	(0.132)	(0.091)	(0.187)	(0.109)	(0.172)
2012 lnrisk	-0.055	0.073*	-0.011	0.025	0.026	0.080	0.127***	-0.014	0.018	-0.110*
	(0.064)	(0.030)	(0.044)	(0.045)	(0.058)	(0.064)	(0.029)	(0.069)	(0.062)	(0.045)
2012 lnage	0.118	-1.895*	-0.269	-0.050	-0.223	0.362	-0.025	1.054	0.000	0.204*
	(0.266)	(0.729)	(0.605)	(0.578)	(0.635)	(0.718)	(0.234)	(0.554)	(0.266)	(0.087)
USDummy	0.000	0.732***	0.451**	0.375	1.345***	0.000	-0.044	-0.129	0.484***	0.057
	(.)	(0.083)	(0.139)	(0.202)	(0.196)	(.)	(0.073)	(0.257)	(0.102)	(0.147)
Euro11	-0.302	-0.124	-0.138	-0.170	-0.382**	-0.151	-0.397	-0.313**	-0.332**	0.343
	(0.168)	(0.134)	(0.104)	(0.232)	(0.136)	(0.282)	(0.205)	(0.109)	(0.109)	(0.214)
Constant	0.739	5.923**	1.010	-0.458	1.591	-1.781	0.574	-4.136	-0.876	-1.927
	(1.005)	(2.090)	(1.990)	(2.005)	(2.359)	(3.068)	(1.049)	(2.747)	(1.282)	(1.069)
Observations	54	60	61	59	59	62	68	58	58	59
Adjusted R^2	0.977	0.995	0.991	0.980	0.983	0.992	0.998	0.989	0.993	0.969

Standard errors in parentheses. Errors clustered at the country level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.17: Dummy for banks over 100 years old,
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnearning_assets	0.720***	0.717***	0.713***
	(0.054)	(0.054)	(0.053)
2012 lnw1	0.082***	0.083***	0.083***
	(0.017)	(0.018)	(0.018)
2012 lnw2	-0.005	-0.005	-0.005
	(0.029)	(0.029)	(0.029)
2012 lnw6	0.451***	0.451***	0.453***
	(0.036)	(0.036)	(0.036)
2012 lnequity	0.204***	0.205***	0.207***
	(0.058)	(0.057)	(0.056)
2012 lnrisk	-0.002	-0.002	0.000
	(0.022)	(0.022)	(0.022)
OldDummy100	-0.016	-0.091	-0.112
	(0.067)	(0.068)	(0.065)
USDummy	0.382***	0.380***	0.386***
	(0.078)	(0.077)	(0.076)
Euro11	-0.183***	-0.203***	-0.203***
	(0.053)	(0.054)	(0.054)
2012 lnage	0.014	-0.431**	-1.450
	(0.033)	(0.146)	(0.940)
2012 lnage ^{2}		0.060***	0.314
		(0.017)	(0.226)
2012 lnage ^{3}			-0.020
			(0.017)
Constant	0.078	0.895*	2.227
	(0.274)	(0.439)	(1.342)
Observations	598	598	598
Adjusted R^2	0.987	0.987	0.987

Standard errors in parentheses. Errors clustered at the country level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Correction for endogeneity and sample selection

Table 4.18: Two-step regression results, Age proxy

	(1)	(2)	(3)	(4)
2012 lnearning_assets	0.715***	0.773***	0.743***	0.749***
	(0.053)	(0.058)	(0.061)	(0.057)
2012 lnw1	0.082***	0.073***	0.077***	0.082***
	(0.017)	(0.019)	(0.019)	(0.018)
2012 lnw2	-0.006	0.019	0.008	0.004
	(0.029)	(0.032)	(0.032)	(0.030)
2012 lnw6	0.452***	0.422***	0.447***	0.431***
	(0.037)	(0.073)	(0.077)	(0.076)
2012 lnequity	0.207***	0.119*	0.145*	0.135*
	(0.056)	(0.053)	(0.056)	(0.053)
2012 lnrisk	-0.001	0.053	0.047	0.057*
	(0.022)	(0.028)	(0.028)	(0.026)
USDummy	0.380***	0.366***	0.411***	0.414***
	(0.077)	(0.085)	(0.090)	(0.085)
Euro11	-0.207***	-0.218	-0.294*	-0.304*
	(0.055)	(0.136)	(0.144)	(0.136)
2012 lnage	-0.788	1.001	0.124	-0.529
	(0.974)	(1.650)	(1.691)	(1.612)
2012 lnage^2	0.163	-0.252	-0.032	0.143
	(0.236)	(0.392)	(0.405)	(0.384)
2012 lnage^3	-0.010	0.021	0.003	-0.012
	(0.018)	(0.029)	(0.031)	(0.029)
lambda		0.132	-0.838	-3.051***
		(0.278)	(0.525)	(0.853)
lambda^2			0.634	4.234**
			(0.318)	(1.331)
lambda^3				-1.618**
				(0.558)
Constant	1.326	-1.742	-0.013	0.950
	(1.409)	(2.878)	(3.004)	(2.860)
Observations	598	340	340	340
Adjusted R^2	0.987	0.991	0.991	0.991

Standard errors in parentheses. Errors clustered at the country level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.18 reports estimation results using a two-step regression to correct for

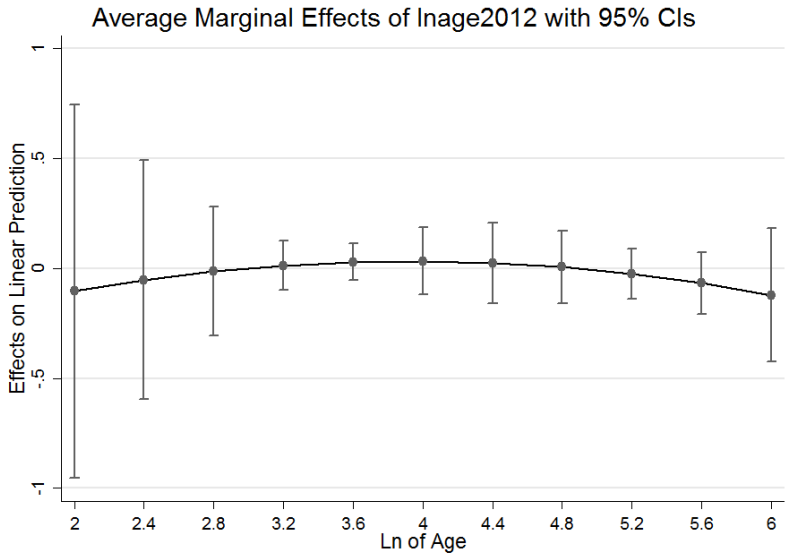
endogeneity and sample selection biases. The estimates are not considerably different from results reported in the text suggesting these issues may not be driving the results in this sample. The sample includes a wide range of bank age, but no banks are younger the 8 years old. Exit issues may be more relevant for younger banks.

Table 4.19: OLS vs. Corrected estimation results, Age proxy

	dy/dx	Std. Err.	t	$P > \|t\|$	95 pct Conf.	Int.
Model (1), cubic:						
lnage2012	.006046	.0272097[a]	0.22	0.825	-.0480541	.0601461
Model (4), Two-stage cubic:						
lnage2012	.0105147	.0298059[a]	0.35	0.725	-.0490664	.0700958

Errors clustered by country. a: Standard error computed using the Delta-method.

Figure 4.9: Effect of Age on cost, using Model (4)



Estimation with Cumulative Output as experience proxy

Because of data limitations the sample consists of 148 banks, only 7 are in the US and 16 in the Euro11. Results reported in Table 4.20 were used for the analysis in the body of the paper, clustered errors by country but did not include regional dummies. Table 4.21 clustered errors by country and also includes two regional dummies. Using this alternative specification, Figure 4.10 and 4.11 plot average marginal elasticities of firm experience on predicted bank costs. The results are similar.

Table 4.20: Firm experience (Cum. Output),
Dependent variable: Ln of Cost

	(1)	(2)	(3)
$\text{EA}_t - EA_{t-1}$	0.286*	0.285*	0.278*
	(0.114)	(0.116)	(0.118)
2012 lnw1	-0.049	-0.038	-0.029
	(0.062)	(0.057)	(0.054)
2012 lnw2	-0.114	-0.147	-0.138
	(0.090)	(0.096)	(0.099)
2012 lnw6	0.709***	0.683***	0.660***
	(0.133)	(0.126)	(0.138)
2012 lnequity	1.162***	1.065***	1.076***
	(0.178)	(0.202)	(0.201)
2012 lnrisk	-0.080	-0.074	-0.063
	(0.078)	(0.074)	(0.077)
lnEA_{t-1}	-0.355*	-0.766***	-2.030
	(0.154)	(0.197)	(2.192)
lnEA^2_{t-1}		0.014	0.084
		(0.007)	(0.122)
lnEA^3_{t-1}			-0.001
			(0.002)
Constant	0.074	4.157	11.294
	(0.767)	(2.216)	(12.283)
Observations	148	148	148
Adjusted R^2	0.926	0.927	0.927

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.21: Firm experience with regional dummies,
Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnFDearning_assets	0.286*	0.285*	0.280*
	(0.113)	(0.116)	(0.118)
2012 lnw1	-0.062	-0.052	-0.045
	(0.067)	(0.063)	(0.061)
2012 lnw2	-0.119	-0.152	-0.146
	(0.088)	(0.092)	(0.096)
2012 lnw6	0.734***	0.719***	0.704***
	(0.180)	(0.173)	(0.184)
2012 lnequity	1.052***	0.969***	0.978***
	(0.214)	(0.230)	(0.229)
2012 lnrisk	-0.065	-0.062	-0.055
	(0.080)	(0.077)	(0.081)
USDummy	0.123	0.199	0.205
	(0.396)	(0.402)	(0.397)
Euro11	-0.567	-0.506	-0.490
	(0.488)	(0.491)	(0.477)
2007 $\ln EA_{t-1}$	-0.252	-0.628*	-1.483
	(0.212)	(0.239)	(1.954)
2007 $\ln EA^2_{t-1}$		0.013	0.060
		(0.007)	(0.109)
2007 $\ln EA^3_{t-1}$			-0.001
			(0.002)
Constant	-0.004	3.735	8.563
	(0.778)	(2.209)	(10.823)
Observations	148	148	148
Adjusted R^2	0.927	0.928	0.928

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 4.10: Effect of Cumulative Output on cost, using Model (2)

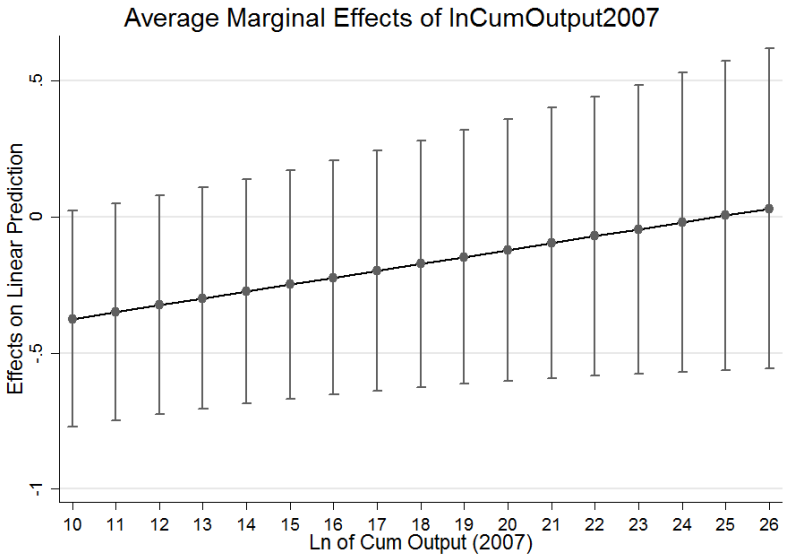


Figure 4.11: Effect of Cumulative Output on cost, using Model (3)

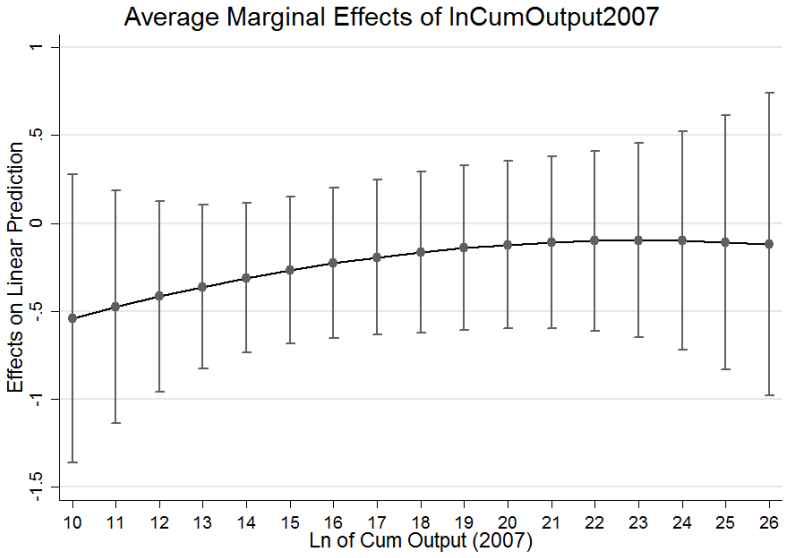


Table 4.22: Domestic spillovers (Cum. Output), Dependent variable: Ln of Cost

	(1)	(2)	(3)
2012 lnFDearning_assets	0.204*	0.196*	0.252*
	(0.092)	(0.094)	(0.106)
2012 lnw1	-0.101	-0.106	-0.134
	(0.072)	(0.070)	(0.078)
2012 lnw2	-0.194	-0.208	-0.262
	(0.107)	(0.111)	(0.135)
2012 lnw6	0.925***	0.926***	0.967***
	(0.231)	(0.234)	(0.251)
2012 lnequity	0.847***	0.771**	0.721**
	(0.182)	(0.218)	(0.245)
2012 lnrisk	-0.123	-0.117	-0.153
	(0.144)	(0.142)	(0.162)
USDummy	0.377	0.484	0.399
	(0.472)	(0.514)	(0.475)
Euro11	-0.640	-0.599	-0.665
	(0.512)	(0.508)	(0.511)
DomesticExclBnkiEA	0.101*	0.089	0.086
	(0.050)	(0.050)	(0.046)
2007 lnEA	0.020	-0.243	4.778
	(0.214)	(0.241)	(4.951)
2007 lnEA^2		0.010	-0.272
		(0.008)	(0.273)
2007 lnEA^3			0.005
			(0.005)
Constant	-0.825	2.141	-26.291
	(1.071)	(2.724)	(26.931)
Observations	208	208	208
Adjusted R^2	0.899	0.899	0.903

Errors clustered by country. Standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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