# Growth, Recessions and Banking Crises*

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Abstract

We examine the relationship of banking crises with economic growth and recessions. Our data cover 21 economies from around the world, most from 1870 to 2009 with the rest starting in 1901 or earlier. The data include capital investment and human capital formation. We have two major findings. First, we find very large heterogeneity in growth of Gross Domestic Product (GDP) and capital investment after banking crises. Most strikingly, twenty-five percent of counties experience no decrease real GDP per capita in the year of the crisis or the following two years. Some countries see an increase in long run growth after a crisis while others see a fall with no clear overall pattern. Second, we find clear evidence consistent with Zarnowitz's Law. The cross country data show that if there is a contraction in economic activity after a banking crisis, larger decreases in real GDP per capita are followed by faster subsequent growth of real GDP per capita.

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Are banking crises related to economic growth? The existing literature on banking crises and real Gross Domestic Product (GDP) focuses on the relationship between banking crises and recessions and the ensuing recoveries. As does much of the related literature on banking crises, we focus on banking crises and leave aside currency crises, sovereign-debt crises and so-called inflation crises. Besides examining a temporary negative effect of banking crises on economic growth through recessions, we examine the relationship between an economy's economic growth over longer periods and the occurrence of banking crises. A positive relationship between long-run growth and banking crises is not as far-fetched as it might seem at first glance. In a relatively straightforward theoretical paper, Rancière, Tornell and Westerman (2008) show that long-run growth and banking crises can be positively related. There is a large literature showing a positive relationship between financial development and economic growth. An economy that is financially repressed is unlikely to have a banking crisis and is likely to have lower growth than it would otherwise. Rancière, Tornell and Westerman illuminate this observation by a model in which credit growth finances economic growth but is subject to downside risk. Banking crises are the realization of that downside risk, but their data indicate negative skewness if credit growth is positively associated with economic growth. With this exception, the literature on banking crises generally focuses on recessions and sometimes recoveries related to the crises.

Bordo, Eichengreen, KIingebiel and Martina-Peria (2001) examine data on twenty-three countries from the nineteenth century until today to determine whether banking and currency crises were worse in the 1980s and 1990s than in earlier periods. They conclude that banking and currency crises had become more frequent although they were not more severe than in

earlier periods. Reinhart and Rogoff (2009a) examine the effects of selected banking crises for which they have housing prices. The crises include: what they call "the big five", Spain 1977, Norway 1987, Finland, 1991, Sweden, 1991, and Japan, 1992; plus the 1997–1998 Asian crisis reflected in Hong Kong, Indonesia, Korea, Malaysia, the Philippines, and Thailand; and crises in Colombia in 1998, Argentina in 2001 and two earlier historical crises in Norway in 1899 and the United States in 1929. They find that banking crises are associated with substantial recessions which lower real Gross Domestic Product (GDP) per capita for about 1.9 years on average with lingering effects on unemployment for 4.8 years on average.

Claessens et al. (2009) examine the relationship between credit and housing prices with crises using data from 21 OECD countries from 1960-2007. They provide detailed evidence on the association between "certain types of financial market difficulties" (Claessens et al. 2009, p. 657) and the behavior of the economy. They find evidence which suggests that larger falls in housing prices are associated with more severe recessions. They conclude that some of their evidence is consistent with difficulties in credit markets affecting housing prices and thereby other parts of the economy.

Bordo and Haubrich (2010) examine U.S. data since 1873 and find that fluctuations in financial variables are related to the severity of recessions. Claessens, Kose and Terrones (2012) examine cross-country data for 44 countries from 1960 to 2010 and find similar results. Bordo and Haubrich (2012) follow up their earlier paper by examining the strength of recoveries with banking crises and find that deeper recessions associated with banking crises are associated with faster recoveries. Schularick and Taylor (2012) and Jordà, Schularick and Taylor (2012)

examine 14 economies, all of which are developed by the end of the twentieth century, for the effect of credit – in particular bank loans – on recessions and recoveries.

Some recent literature examines the severity of the recession and the strength of the recovery associated with a banking crisis using data from the United States. Dwyer and Lothian (2011, 2012) also examine recessions and recoveries in the United States based on dating by the National Bureau of Economic Research (NBER) and Cagan's (1965) characterization of recessions. They find that recessions with larger decreases in Gross National Product (GNP) are followed by recoveries with faster increases in real GNP. The pattern is evident for recessions associated with banking crises as well as recessions not associated with a banking crisis. The two outliers from this general result are the 1930s and the recent recession.

Our data for 21 countries span the globe, including Australia in Australasia, with data for as many as 140 years and never less than 109 years. In the next section, we discuss why we think these data are informative. We have balanced data for each country with data on Gross Domestic Product (GDP), capital formation and human capital, making it possible to look at the effects of banking crises on not only GDP but also on the growth of physical capital and Total Factor Productivity (TFP). We have dating by others on banking crises which we can bring to bear to examine the relationship between economic growth, capital formation and TFP growth before and after a banking crisis. As we have discovered, the relationship is not as simple as it might seem based on a prior from U.S. experience. In particular, we find very large heterogeneity in growth of Gross Domestic Product (GDP) and capital investment after banking crises. Most strikingly, twenty-five percent of counties experience no decrease real GDP per capita in the year of the crisis or the following two years. On the other hand, one empirical

regularity for the US economy - Zarnowitz's Law- is supported by cross country data. We find clear evidence that if there is a contraction in economic activity after a banking crisis, larger decreases in real GDP per capita are followed by faster subsequent growth of real GDP per capita.

## DATA

There are three other data sets on financial crises using long run data. Reinhart and Rogoff (2009b) cover virtually all countries from 1800 with limited data in many cases. There are two other data sets which focus on a smaller group of economies with data that can support detailed analysis. Bordo et al. (2001) have data on 23 countries. Schularick and Taylor (2012) include 14 countries.

### Country Coverage

Our data on 21 countries include Argentina, Australia, Brazil, Canada, Chile, Colombia, Denmark, Finland, France, Germany, Italy, Japan, Mexico, Netherlands, Norway, Spain, Sweden, Taiwan, the United Kingdom, the United States, and Venezuela. Bordo et al. (2001) include 23 economies including 5 which we do not include: Belgium, Greece, Portugal, Switzerland and New Zealand. On the other hand, we have data on Columbia, Mexico, Taiwan and Venezuela. Schularick and Taylor (2012) examine 14 economies which are developed by the end of the Twentieth Century. All of their economies are in our data set save Switzerland.

**Variables**

The most obvious distinguishing feature of our data from the others is our set of real variables. In addition to the usual income per capita, we have investment, the capital stock and human capital. This allows us to measure Total Factor Productivity (TFP). Schularick and Taylor (2012) include investment but no other variables associated with National Income and Product Accounting.

We are limited in our data collection by the need to collect data on physical capital formation. We were unable to find data on capital formation for Belgium, Greece, Portugal, Switzerland and New Zealand. This explains why these countries are in the Bordo et al (2001) but not in ours. Schularick and Taylor (2012) use the same sources, for the most part, as we do. There is one exception. We were unable to uncover annual data on investment for Switzerland before World War I, and we do not include it in our data set.

**Rationale**

Why use long run data? Data for a single economy such as the United States provide relatively few observations to allow us to generalize with respect to the effects of rare events such as banking crises. What is the advantage of our long run study with a relatively small number of countries as opposed to a much larger sample of countries after 1970? Results after 1970 may be dominated by poor developing countries with low capital mobility and large distortions and much different institutional settings than in developed countries. The results from such countries may tell us little about the questions that interest us. The counter-argument of course is that conditions in the late nineteenth century and early twentieth

century may tell us relatively little about the effects of events today. We interpret this problem to mean that care drawing generalizations for current events is warranted, but it is not an insurmountable problem.

Schularick and Taylor (2012) take this argument a bit further to suggest that it is best to focus only on currently developed countries.

> [O]ur sample consists of long-run data for 14 developed countries, in contrast to the focus of much of the recent literature on the experience of developing countries where financial crises are often linked to currency instability or sovereign debt problems. A pure developed-country sample is also arguably less affected by the institutional weaknesses and credibility questions that emerging markets tend to face. (Schularick and Taylor 2012).

Taken literally, this implies that all countries which are developing today or earlier should be excluded. In our data, this would suggest deleting Latin America countries that are not currently developed. Yet some of the countries in Schularick and Taylor's (2012) data set might better be considered as emerging economies for most of the years after 1870. This is certainly the case for Italy and Japan. In terms of income per capita, Argentina was more developed than Japan or Italy for much of the period covered by our data. Bordo *et al*. show one way of dealing with this issue, which is by classifying countries as industrial or emerging with a country's classification allowed to change over time.

As do others, we exclude World Wars I and II from our data. We do not delete the data for all countries though, only those that are combatants for part of the war or are invaded. This makes it possible for us to examine Latin American countries and the financial difficulties created for those countries by the wars. If we were examining the causes of banking crises, this would require some care but we are not, and there is no known reason to assume the effects are different for World Wars I and II than other wars, which are quite common as a matter of

fact. For all countries, we use the same dates for the wars even if the country's direct involvement is for a shorter period. We delete data from 1914 to 1919 for World War I and we delete data for 1939 to 1949 for World War II. For example, data for the United States are deleted for all these years even though the United States was not formally involved in either war for this entire period. We delete years at the ends of both wars to remove the wars' aftermaths associated with occupations, territorial changes and forced migrations of people. The countries involved in both World Wars I and II are Australia, Canada, Finland, France, Germany, Italy, Japan, Taiwan as a colony of Japan, the United Kingdom, and the United States. The countries involved only in World War II are Denmark, the Netherlands and Norway.

**GROWTH, CONTRACTIONS AND BANKING CRISES**

Figure 1 shows the levels of real GDP for the 21 countries. The data for some countries start after 1870, so comparisons of final levels and implied growth rates cannot be made directly for all countries. In addition, the figure shows real GDP not adjusted for purchasing power differences across economies. All of the series are plotted as index numbers with a base of 100. Nevertheless, the substantial variation in the growth of countries over time is clear in the graph. Colombia is perhaps the country with real GDP represented most clearly by a simple straight line. The United States is close in terms of constant growth except perhaps for higher growth in the late nineteenth century and lower growth in the 1930s. The disruption associated with World War II is evident for both Japan and Germany, although Germany's decrease in real GDP is partly due to the separation of Germany into East and West Germany after World War II. The unification of Germany in 1990s creates hardly a ripple in real GDP, presumably reflecting

low productivity in East Germany and difficulties associated with integrating East and West Germany.[1]

Figure 2 shows the growth rates of real GDP for each of the countries. The growth rates for some countries are substantially more variable than for others. For example, the growth rates for Argentina are substantially more variable than for Italy, both in the early 1900s and in recent years. While it is possible this difference is an artifact of the data's construction, we know of no reason to think so. The growth rates for some countries, for example Australia, Chile and the United States, are more variable in earlier years than in later years, which may be an artifact of the data's construction or may reflect differences in these economies over time. Not all countries have more variable growth in earlier years though; for example Norway has a relatively low variability of its growth rate in the nineteenth century and early twentieth century. It is possible, of course, that this is a different artifact of the data's construction.

Figure 3 shows the level of real GDP per capita. Real GDP per capita is the measure of economic activity most commonly used in prior studies of banking crises.[2] Other than the scale which has a lower range because population growth is positive for all these countries, this figure is comparable to Figure 1. The figure shows a better representation of the increase in the well-being of people over time in these countries because population growth varies substantially across countries. The low growth of Argentina is evident in this figure. While Taiwan's real GDP did not fall substantially due to World War II, its GDP per capita did. This

[1] We examined other boundary changes in the data and found they are small relative to the variance from other sources in the data. Given disparities in dating the effects of the boundary changes on real GDP and population, we decided not to attempt to adjust the data for boundary changes that are not associated with World Wars I and II and deleted from the data by deleting those years for combatants.

[2] Neither measure receives overwhelming support from an examination of consistency of contraction's dates based on real GDP or real GDP per capita with the NBER's dating of contractions in the United States, France, Germany and Great Britain from 1870 to the 1930s.

difference is associated with the influx of two million Chinese after the revolution on the mainland. In the rest of the paper, we will examine real GDP per capita rather than real GDP, as do other papers on banking crises. We do this even though aggregate real GDP is the more standard measure of economy-wide contractions and it is obvious that real GDP per capita can decrease when real GDP increases.

**Banking Crises**

There are various ways of determining banking crises. A recent definition used in creating a data set is the one provided by Laeven and Valencia (2010, p. 6),

> "[S]ignificant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and bank liquidations)"
> "[S]ignificant banking policy intervention measures in response to significant losses in the banking system"

These dates are available only for 1970 on. For earlier years, we use Bordo, et al, (2001, p.55) in which they define a banking crisis thus:

> "For an episode to qualify as a banking crisis, we must observe financial distress resulting in the erosion of most or all of aggregate banking system capital."

We use these data when they are available, which is for most of the years for most of the countries. When they are not available, we use Reinhart and Rogoff's dates, which are based on the definition:

> "[B]ank runs that lead to the closure, merging, or takeover by the public sector of one of more financial institutions" … "If there are no runs, the closure, merging, takeover, or large-scale government assistance of an important financial institution (or group of institutions) that marks the start of a string of

> similar outcomes for other financial institutions" (Reinhart and Rogoff 2009b, p. 10).

All of these definitions are sufficiently imprecise that they suggest some amount of judgment was used in determining whether or not there is a banking crisis.

Figure 4 shows real GDP per capita with vertical lines for banking crises. There is substantial variation in banking crises across countries. For example, several countries have only two banking crises and Italy has the most with eight. It is not the case that so-called developed countries have fewer banking crises and developing countries have more. Australia, Canada, Colombia, Mexico and Venezuela have two crises. Italy has eight crises; Argentina and Brazil have seven; the United States has six crises. In all, there are 86 crises in our data, which is not many considering there are 2523 country-year pairs on the level of real GDP per capita in the data.[3] This is about 3.4 percent of the observations, which means that a crisis occurs on average about once every 29 years.

**BANKING CRISES, CONTRACTIONS AND EXPANSIONS**

Are banking crises always associated with contractions in the economy? Surprisingly enough at least to us at first glance, the answer is "no". In fact, the start of a banking crisis often is not associated with a contraction in real GDP. Table 1 shows the relative frequency of contractions in real GDP per capita and the onset of banking crises. Over half the banking crises are not associated with decreases in real GDP per capita in the year in which they start. This may partly reflect the averaging implicit in annual data. Table 1 also shows the relative

[3] The picture could be different if there were data on GDP for all the countries before 1900 but it would not be. From 1870 up to the data becoming available, Argentina had one crisis, and Brazil and Chile had two crises. Colombia, Japan, Mexico, Taiwan and Venezuela had none.

frequency of banking crises and contractions in real GDP per capita in the year the crisis started and the following year and for an additional year as well. About three quarters of the banking crises are associated with a decrease in real GDP per capita in the year a banking crisis starts or the following year. Adding another year of possible contraction in real GDP per capita increases the proportion of banking crises associated with a contraction in real GDP per capita, but the increase is small and contractions in real GDP per capita in that year or the succeeding two years are fairly common. From Table One, over half the years in our data set not associated with banking crises have contractions in real GDP per capita in that year or the succeeding two years.

Banking crises generally are associated with decreases in real GDP per capita, but far from always. While the typical response no doubt is of interest, the fact that a quarter of banking crises are not associated with a decrease in real GDP per capita in the same year or the next or so seems remarkable to us.[4] It is quite different than most of the U.S. experience. Yet the recent financial crisis for the US is dated as starting in 2007 and the decline in the economy in the United States was not really evident in real GDP until 2009, the second year after the start of the financial crisis.

There are various conclusions that can be drawn from this analysis. The most appealing to us is that the dates of the starts of banking crises are at best indicative and it is better to treat an associated decrease in real GDP per capita in the proximity of the start of the banking crisis as being associated with it.

[4] This is similar to the fraction mentioned in passing by Bordo et al. (2001, p. 60).

How serious are these banking crises? Table 2 provides summary statistics on this question. Table 2 shows the mean changes in real GDP per capita for five years before and five years after the start of banking crises. As is emphasized in the literature, average real GDP per capita decreases in the year of a banking crisis and the year afterwards, followed by subsequent increases. Reassuringly, the averages across all banking crises reflect these results found by others. Nonetheless, the means by country show substantial variability across countries. The means for the United States are substantially negative, substantially more so than the means for most of the other countries. On the other hand, across countries, 12 of 21 mean changes in the year of a crisis are positive and 8 or the 21 mean changes in the following year are positive.

The means in Table 2 are changes in the logarithms of real GDP per capita (in percentage terms), so it is possible to add the changes across the two years to get the total change. For 6 of the 21 countries, the mean change over the two years is positive. While some of these sums are quite small, the mean change for Taiwan is 5.8 percentage points per year.

The average growth rate of real GDP per capita for all years for which we have data shows that banking crises, even when growth is positive at the start of a banking crisis, are not among the best years for these countries. For all but three countries, the year in which a banking crisis starts is a year in which the economy grows at less than the economy's average growth rate.[5] The average difference between growth at the start of a banking crisis and all years is a substantial -2.5 percentage points per year and the largest deviation is for Norway, for which the start of a banking crisis is associated with a growth rate of real GDP per capita -8.3 percentage points less than Norway's average growth rate. Averaging across the first and

[5] The 3 countries are Canada, Spain and Taiwan.

second year at the start of a crisis, the mean difference is -2.58 percentage points per year. Even averaging across these two years, we find that Taiwan has a positive growth rate of real GDP per capita on average at the start of a banking crisis and for the succeeding year. In other words, Taiwan had a banking crisis when it was growing faster than on average from 1901 to 2009.

Table 3 presents summary statistics for contractions and subsequent recoveries associated with banking crises for all countries and by country. Tables 1 and 2 suggest that the dates at which banking crises are determined to have started are not particularly well aligned with any ensuing contraction if there is one. To find any contraction associated with a banking crisis, we consider contractions that start at the same time as the banking crisis and in the following two years as being associated with the banking crisis. We include the entire length of that contraction as being associated with the banking crisis. Table 1 suggests there is little to be gained by going beyond two years after the start of the banking crisis and it is quite possible that unrelated recessions will be included, which would conflate contractions associated with banking crises and more typical contractions.

We present statistics for two different measures of contractions and recoveries. Not all banking crises associated with recessions are followed by one contraction and a subsequent increase in real GDP per capita to its prior level. Sometimes real GDP per capita has a contraction associated with the banking crisis, then rises for a time, then falls, then rises again and eventually real GDP per capita returns to its prior level.[6] This suggests two alternative ways

[6] Indeed, Venezuela's level of real GDP per capita was less in 2009 than its level of real GDP per capita in 1977 before the banking crisis of 1978 and its level of real GDP per capita was less in 2009 than in 1993 before the

of looking at the contraction and the return to the prior level of real GDP per capita. One way is to simply use the initial contraction, which may be best if that contraction is the only one related to the banking crisis directly or indirectly. An alternative way is to measure the contraction from the peak level of real GDP per capita to its minimum and then its first return to a level above the initial peak. We analyze contractions both ways and data for both analyses are included in Table 3.[7] The statistics in Table 3 exclude banking crises that are not associated with a higher level of real GDP per capita before our data end.[8]

Almost 25 percent of the banking crises do not have contractions associated with them. That said, the contractions which do occur are large on average, with real GDP per capita decreasing at a -7.7 percentage points in the average contraction when there is one. The contractions largest in magnitude are for Venezuela, although the United States is close behind.[9] The average annual increases in real GDP per capita after a contraction vary substantially, from 1.3 percent per year for France to 11.6 percent per year for the Netherlands.

A couple of things emerge from this discussion. First, the dating of banking crises is not sufficiently precise to allow one to draw inferences about the effects on economies by looking

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banking crisis of 1994. It is a matter of substantial doubt that the lower level of real GDP per capita in 2009 is due to a banking crisis over 20 years before.

[7] An increase in real GDP per capita to its prior level is neither necessary nor sufficient for the economy to have completed recovery from the banking crisis in any sense other than real GDP per capita equaling or first exceeding its prior level. Nonetheless, it is a useful general measure of the contraction and recovery.

[8] While it might be desirable to estimate parameters associated with this duration issue, this would require a model of banking crises and their subsequent duration, which is well beyond the simple analysis of this section. Other than Venezuela, the main implication is that we drop data associated with the financial crisis of 2007 and 2008. We also drop France in 1930 which had not reached the 1929 level of real GDP per capita by the start of World War II in 1939. This probably is the main observation which would benefit from being included in a full-blown likelihood function for all the data. But our simple statistical summary of the connection between the size of contractions and the rate of subsequent recoveries should not be taken as more than a summary of the data, not a maximum likelihood or Bayesian analysis of the relationship.

[9] Some countries have smaller decreases in real GDP per capita measured to the minimum rather than the first trough. This occurs because the definition based on the minimum includes only contractions and recoveries that reach a recovery with data available. The first trough can be dated sometimes when the minimum cannot. This is more easily seen for Venezuela which had not recovered its initial level of real GDP per capita by 2009.

at averages. This would not be entirely surprising based on the fact that the data are annual averages. In addition, we have also seen that the year of the start of banking crises does not necessarily correspond to the beginning of the effects on the overall economy. Second, there is dramatic variance in the effects of banking crises. Some countries experience no contraction with a banking crisis, such as Taiwan, and other such as the United States see substantial decreases in real GDP per capita when real GDP per capita falls.

**RECOVERIES AFTER BANKING CRISES**

We also can use these data to examine whether or not the recessions that do occur after banking crises are followed by weak and prolonged recoveries, a point in contention recently (Reinhart and Rogoff 2009a; Reinhart and Rogoff 2009b; Reinhart and Rogoff 2012. 2012, Dwyer and Lothian 2011; Dwyer and Lothian 2012; Bordo and Huabrich 2012).

We study recovery using data from all recessions following banking crises in our data. Sometimes such an analysis is conditioned on severe contractions. It almost goes without saying that it is not possible to generalize any results conditioning on severe contractions to contractions associated with banking crises in general. This point, which has been overlooked by some, can be seen in various ways. The algebra is straightforward. For example, suppose that an analysis of consumption conditions on consumption disasters and examines only consumption disasters. Given this conditioning, it clearly is not possible to make statements about consumption in other circumstances. Similarly, conditioning on severe banking crises, which inevitably means conditioning on substantial recessions and large falls in asset prices correlated with substantial recessions, makes it impossible to generalize to recessions in

general. Similarly, conditioning on severe banking crises associated with protracted recoveries means that it is not possible to say anything about banking crises in general.

Using annual data to study this issue is not ideal. Clearly quarterly data would be more informative about the contractions associated with banking crises. As Moore and Zarnowitz (1986, p. 749) point out,

> Annual records alone are a poor guide to dating, since they obscure some mild and short business cycles. Phases of twelve months or less that overlap two calendar years (mostly contractions) have been frequent, particularly in the United States since the 1870s. Independent annual dating can miss the short business cycles and combine two or even three of them into one, while producing only a rough one-to-one correspondence with the longer cycles in the monthly chronology. There is ample statistical evidence that this is a serious measurement problem (Burns and Mitchell 1946, chap. 6, esp. 262).

That said, it is interesting – and it turns out informative – to see how the severity of contractions associated with banking crises is associated with the subsequent strength of recoveries. This generalization, often called Zarnowitz's Law (1992) is reflected in Friedman's plucking model (1993). If bigger decreases in real GDP per capita are associated with slower recoveries, this is inconsistent with both Zarnowitz's Law and Friedman's plucking model. Obviously, the banking crises with no recession – a decrease in real GDP per capita in years zero, one or two – are ignored. We are examining the strength of the recovery conditional on a prior contraction if there was one.

There are different ways to examine the speed of a recovery. One way to examine a recovery is the standard one in the macroeconomic literature – a fixed period after the end of the contraction. An alternative suggested by Reinhart and Rogoff (2009b, 2012) is growth from the trough to the prior peak level of real GDP per capita. We use this alternative measure.

Figure 5 shows the relationship between the size of contractions and the rate of increase in subsequent recoveries of real GDP per capita based on the first trough and the minimum of real GDP per capita. There is substantial variability in the relationship. That said, there is a negative relationship between decreases in real GDP per capita in contractions and the rate of expansion. This means that larger contractions are associated with faster recoveries. The correlation of the size of contractions with the rate of subsequent recoveries is -0.25 for contraction based on the trough and -0.40 for the contractions based on the minimum.

Figure 5 includes two regression lines. Because the contraction precedes the expansion temporally, it is not obviously incorrect to regress the rate of expansion on the size of the contraction. On the other hand, effects of expectations of the speed of the recovery make any assumption of exogeneity in the regression dubious. The regressions can be interpreted as predictive but not causal. We also present the regression line excluding a constant. Many of the contractions are small, and no contraction should be associated with no expansion, which suggests leaving out the constant term. A positive constant term implies a positive rate of recovery when there is nothing from which to recover. Eliminating the constant term increases the slope of the line.

Table 4 presents the regression results. It also presents regression results excluding the one apparent outlier in Figure 5 for the contraction and expansion based on the minimum. This apparent outlier is the Netherlands in 1914, which has a speed of recovery of over 20 percent per year. Table 4 summarizes the data on speed of recovery of real GDP per capita and the size of the prior contraction in terms of regressions of the speed of recovery on the size of the prior contraction. We interpret these regressions as providing support for larger contractions being

followed by faster recoveries in general. As a purely predictive matter, a larger contraction would lead one to predict a faster recovery. These regressions are inconsistent with all but relatively small positive coefficients on the size of contractions. The regressions using minimum real GDP per capita as the measure of how far income falls are uniformly inconsistent with the proposition that larger decreases in real GDP per capita are followed by slower recoveries.

### GROWTH BEFORE AND AFTER A CRISIS

The literature on growth and financial development finds that an improvement in financial intermediation raises growth. [10] Levine (2006) summarizes these findings as follows:[11]

"A growing body of empirical analyses, including firm-level studies, industry-level studies, individual country-studies, time-series studies, panel-investigations, and broad cross-country comparisons, demonstrate a strong positive link between the functioning of the financial system and long-run economic growth… even when controlling for potential simultaneity bias."

A banking crisis is by definition a negative shock to financial intermediation. Given the important role played by banks in the financial system, it seems natural to suppose that the disruptions in the financial sector associated with a systemic banking crisis will be reflected in lower growth over the medium and perhaps the longer run.[12]

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[10] The traditional view is that the creation of a banking system helps to allocate resources to higher value uses. Banks also allow for better risk diversification as well as providing useful information to financial markets. The expansion of the banking system should therefore lead to higher levels of capital per worker and improved factor productivity see Levine (1997).

[11] The empirical findings are buttressed by models from the theoretical literature on finance and growth where improvements in the financial sector can raise long run growth rates. Early papers in this literature include Greenwood and Jovanovic (1990), Bencivenga and Smith (1991) and King and Levine (1993)

[12] There are other reasons to expect a banking crisis to depress growth. Reinhart and Rogoff (2009b) find that banking crises are associated with a very large increase in government debt. To the extent that this leads to an increase in tax rates we would expect some negative effects on growth.

To examine the effects of a crisis on growth we consider changes in capital stock per worker, human capital and total factor productivity. First, however, we introduce some notation. Assume that output at time t, Y(t), is produced by an aggregate production function of the form:

(1) $Y(t) = A(t)F(K(t),H(t))$

where K(t), H(t) and A(t) are indices of the physical capital stock, human capital and total factor productivity. Assuming perfect competition and that social marginal product equals private marginal product, we can write changes in output per worker as

(2) $y = a + \alpha k + (1-\alpha)h$

where $\alpha$ is the share of income from capital in output and lower case letters represent rates of change.

We described our data on GDP and investment above. The extra variable in equation (1) is human capital. Here we rely on the index of human capital from Baier, Dwyer and Tamura (2006) updated to 2009. Their measure of human capital combines years of schooling and experience to construct a measure of human capital for the labor force.

To determine what happens to growth after a banking crisis, we examine the change in the growth rates in our variables of interest (Y, K, H and A) relative to growth rates in the domestic and world economy before and after the crisis. We construct indices of GDP, the capital stock and human capital for the world economy using the fourteen economies with data from 1870 to date. They are Australia, Canada, Denmark, Finland, France, Germany, Italy,

Japan, Netherlands, Norway, Spain, Sweden, the United Kingdom, and the United States.[13] As explained in the Data Appendix, these countries account for a large share of world GDP. To obtain world GDP and the world capital stock, we aggregate the GDP and capital stock estimates for our economies with purchasing power parities from Maddison (2007). The resulting indices of GDP and the capital stock are in 1990 world prices. We construct the human capital aggregate by weighting the domestic measures of human capital by each countries share in the world labor force. Finally, we assume that the share of physical capital , $\alpha$ in equation (2), is 0.35

We examine the association between growth and a banking crisis in three ways. First, we look the difference in growth rates for output per worker, physical and human capital per worker before and after the crisis begins for the domestic economy. Second, we examine the difference in growth rates for the domestic economy relative to the world economy after the crisis. The third measure gives the change in domestic growth rates before and after the crisis relative to the change in world growth rates before and after the crisis. The second and third measures compare domestic growth rates with world growth rates. The approach can be seen as a simple application of the difference in difference approach where the world economy is the control group.

We look at growth rates over spans of ten and twenty years. Moving to longer spans greatly reduces the number of observations but can be better suited to long-term comparisons. Or twenty years may be too long. The data will tell the story. We begin with results measured over ten years after the start of the crisis. There are 57 comparisons.

[13] Over the one hundred and forty years covered by our estimates, world output and capital per worker increase by twelve and twenty five times respectively while human capital trebles.

Table 5 gives the average mean differences in growth rates in output per worker, the capital stock per worker and human capital using the three measures for a ten-year window. Below the difference in means we give the standard deviation of the difference in parenthesis. We also give the fraction of economies where the outcome is positive.

The first column of results in Table 5 compares annual growth rates of output and inputs ten years before and ten years after the crisis begins averaged across all banking crises. As expected, the growth in output per worker tends to be lower after a crisis. The differences, however, are small. For output per worker, the decline in the growth rate is only -0.04 percentage points per year. The standard deviation of the differences for output per worker is 2.08 percentage points per year. The growth of output per worker actually increases after the crisis in 54 percent of the cases. On average, the capital stock and human capital grow slower after the crisis. Again, we see a huge variation in outcomes for these variables as the standard deviations are large.

The second column gives the difference in the growth rates in the domestic economy over the ten years after a crisis begins relative to the growth rate in the world economy. The third column looks at the average difference in the domestic growth rates before and after the crisis begins relative to the average difference in the world growth rate. This is a comparison of the change in the domestic growth rate to the change in the world growth rate. The results using both measures are broadly similar to the first measure and they provide little indication that growth falls much on average after a banking crisis.

Table 6 repeats the calculations in Table 5 but with a data span of twenty years before and after the crisis begins. As we move to longer time horizons the number of observations

falls. We have 57 cases for the ten year comparison but we are down to 47 cases with twenty years. The fall occurs because of overlaps with world wars, because some crises occur less than twenty years before our data begins or ends and because more than one crisis can occur within the event window.

The effects on growth are larger over a twenty year-horizon. This is most notable using the first measure where we compare the domestic growth rates for twenty years before and after the crisis begins. The annual growth rate of output per worker is one third of a percent lower while the growth of capital per worker is reduced by almost three quarters of a percent. The effects are large enough to be interesting. To put the estimates in perspective, world GDP per worker expands at an average rate of 1.77 over the period 1870-2009 while capital per worker increases at an average rate of 2.3 percent. The standard deviations also are large though. The standard deviation for capital per worker is almost four times the difference in the means. The comparisons in columns two and three show smaller effects.

If one thought that banking crises have little effect on growth before seeing these data, these data would provide little reason to change that prior. On the other hand, if one has a prior informed by U.S. data, the data suggest that the effects of a banking crisis need not be so dire. There is dramatic diversity of outcomes in the aftermath of a crisis.

Figure 6 shows the distribution of the differences in growth rates for output and capital stock per worker compared to world growth rates for two decades after a crisis. This is the second measure in Table 6. Note the wide variety of outcomes. There are large falls in growth for some economies relative to the world but there are increases in growth rates for others. Consider capital per worker. From Table 6, capital per worker grows more slowly as compared

to the world for 57 percent of the cases. Yet we cannot say with any degree of confidence by how much capital per worker declines given the wide variety of experience. More generally, Figure 6 reinforces the argument that the means of the distributions do not provide much information about the effects of banking crises.

## CONCLUSION

We have two principle findings. Our first major result is the substantial diversity in the effects of banking crises. This finding seems to have been missed by previous work. Most strikingly, we show that twenty-five percent of counties experience no decrease in the growth of real GDP per capita in the year of the crisis or the following two years. In addition, we find some countries see an increase in long run growth while others see a fall with no clear overall pattern. Our second major result is that the cross country evidence is consistent with Zarnowitz's Law. If an economy contracts after a banking crisis, a larger fall in real GDP per capita is associated with recovery at a faster rate.

Our findings may partly reflect the fact that an indicator variable for a banking crisis is not terribly informative and numerical measures of the severity of a banking crisis such as those for currency crises would be nice to have. While they would be nice to have, this is far from a simple undertaking given the lack of comparability of data across countries.

One other explanation of our findings that banking crises are associated with diverse outcomes is policy. Banking crises may sometime have little or no effect on the economy because government policies to deal with the crisis minimize the effect on the economy. Some policies, such as deposit insurance and bailouts, can result in crises having relatively short lived

effects on economic growth and financial intermediation even though they have ill effects in other ways including the probability of a banking crisis in the first place (Demirgüç-Kunt and Detragiache 2002; Baier, Chance and Dwyer 2012). If the policies adopted facilitate recovery then the negative effects on growth of a crisis may also be short lived. Indeed, growth could actually increase if the policies enacted after the crisis improve the efficiency of the financial system. Of course, the policy response can also worsen the crisis and subsequent changes can reduce efficiency and growth.

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Table 1

Frequency of Contractions in Real GDP per Capita and Banking Crises

| | | Banking Crisis Start | |
|---|---|---|---|
| | | Yes | No |
| | | This Year | |
| Contraction in real | Yes | 43 | 643 |
| GDP per capita | No | 48 | 1949 |
| | | This Year or Next | |
| Contraction in real | Yes | 67 | 1038 |
| GDP per capita | No | 24 | 1564 |
| | | This Year or Next Two Years | |
| Contraction in real | Yes | 69 | 1318 |
| GDP per capita | No | 22 | 1284 |

The columns show whether a year has a banking crisis start or not. The rows show whether or not a contraction starts. In the set of two rows, the row values indicate whether or not there is a decrease in real GDP per capita in any given year. In the second set of rows, the indicator for each year is whether or not there is a decrease in real GDP per capita this year or next year. In the third set of rows, there indicator for each year is whether there is a decrease in real GDP per capita this year, next year or the following year. The table then presents the cross-classification of the rows and columns for each year for each country.

Table 2
Means Growth Rates of Real GDP per Capita Around Banking Crises
Five Years Before Crisis and and Five Years After
Percent per year

| Country | Average all years | l5 | l4 | l3 | l2 | l1 | 0 | f1 | f2 | f3 | f4 | f5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aggregate | 2.08 | 1.60 | 1.82 | 1.47 | 3.10 | 1.45 | -0.34 | -1.04 | 1.80 | 2.20 | 2.16 | 2.58 |
| Argentina | 1.37 | 0.44 | 0.59 | 1.96 | -0.59 | -0.02 | -4.81 | -3.16 | 2.20 | 3.18 | 3.56 | 0.94 |
| Australia | 1.21 | -1.04 | 4.24 | -2.67 | 4.22 | -6.53 | -2.99 | -0.32 | -4.31 | 3.99 | -1.97 | 7.91 |
| Brazil | 2.40 | 3.80 | 1.93 | 2.44 | 2.04 | 2.62 | 0.39 | -0.56 | -0.10 | 1.66 | 2.29 | 4.80 |
| Canada | 1.97 | 2.87 | 2.74 | 0.84 | -5.07 | 3.42 | 3.78 | 2.30 | 5.85 | 2.10 | 5.16 | 4.98 |
| Chile | 1.69 | 4.55 | -1.20 | 1.58 | 7.32 | -0.22 | 0.10 | -4.29 | 2.26 | 8.14 | 2.46 | -2.91 |
| Colombia | 1.88 | 2.47 | 4.91 | 3.10 | 0.99 | 0.81 | -1.23 | -3.32 | 1.17 | 0.72 | 2.19 | 3.05 |
| Denmark | 1.92 | 2.23 | 0.70 | 1.79 | 4.20 | 2.17 | 0.75 | -0.36 | 3.30 | -0.40 | -0.34 | 4.61 |
| Finland | 2.47 | 3.01 | 5.06 | 4.47 | 2.69 | -1.94 | -1.15 | 0.33 | 2.04 | 5.11 | 3.47 | 3.22 |
| France | 2.06 | 0.84 | 0.64 | -0.97 | 3.20 | 2.05 | 1.38 | -1.05 | -0.30 | 0.46 | 2.80 | 2.41 |
| Germany | 2.38 | 0.31 | 5.27 | 0.18 | 0.96 | -1.73 | -4.43 | -3.31 | 9.51 | 6.78 | 5.71 | 6.11 |
| Italy | 2.04 | 0.81 | 0.26 | 0.44 | 1.33 | 1.56 | 0.03 | -0.73 | 3.14 | 0.45 | 1.48 | 1.41 |
| Japan | 3.16 | -0.08 | -0.55 | 4.60 | 2.29 | -0.65 | 2.69 | 0.25 | 0.22 | 3.88 | -0.92 | -0.79 |
| Mexico | 1.57 | 2.39 | 1.62 | 3.63 | 3.27 | 4.16 | -0.99 | 0.21 | -0.84 | 2.33 | 1.35 | -0.46 |
| Netherlands | 1.46 | 0.79 | -2.28 | -2.26 | 7.97 | -0.08 | 0.11 | 0.50 | 1.80 | -2.85 | 0.85 | 9.51 |
| Norway | 2.22 | 1.15 | -1.37 | 1.53 | 9.39 | 4.94 | -6.06 | 4.10 | 1.66 | 1.35 | 4.28 | 3.45 |
| Spain | 2.02 | 3.44 | 4.79 | 2.77 | 1.32 | 2.32 | 3.14 | -0.11 | 2.04 | 2.69 | 0.57 | 2.77 |
| Sweden | 2.20 | 1.13 | 3.96 | 1.73 | 3.08 | 3.11 | 1.82 | -2.71 | 1.78 | 2.88 | 2.96 | 2.30 |
| Taiwan | 4.31 | 7.33 | 5.99 | 5.65 | 5.10 | 4.25 | 5.81 | 5.77 | 4.55 | 6.15 | 4.37 | 5.30 |
| United Kingdom | 1.60 | 0.58 | 1.56 | 2.18 | 2.65 | 4.47 | 0.14 | -0.81 | -2.00 | 0.69 | 4.80 | 2.51 |
| United States | 1.81 | 0.66 | 4.88 | -1.43 | 3.63 | 2.86 | -2.35 | -5.67 | 3.69 | -1.25 | 2.48 | 4.13 |
| Venezuela | 2.58 | -4.33 | 3.23 | 4.82 | 4.43 | 0.38 | -3.20 | 0.11 | -3.47 | 0.70 | -1.85 | -8.26 |

The “Average All Years” is the average growth rate for all years for which we have data. The column “l5” is five years before date zero, “l4” is fours before date zero, …, 0 is the year of the start of a banking crisis, …, and “f5” is five years after date zero .

Table 3
Contractions and Expansions Associated with Banking Crises

| Country | Number of crises | Number of crises with no recession | First Trough | | | | Minimum | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Duration peak to trough | Duration trough to recovery | Total decrease in lrgdp | Annual increase in lrgdp | Duration peak to minimum | Duration minimum to recovery | Total decrease in lrgdp | Annual increase in lrgdp |
| Argentina | 7 | 0 | 2.0 | 5.9 | -12.8 | 5.2 | 3.0 | 4.9 | -14.7 | 4.1 |
| Australia | 2 | 0 | 1.5 | 5.5 | -5.2 | 2.1 | 3.5 | 3.5 | -9.1 | 3.4 |
| Brazil | 5 | 1 | 2.3 | 4.3 | -4.5 | 3.2 | 2.3 | 4.3 | -4.5 | 1.5 |
| Canada | 2 | 1 | 1.0 | 2.0 | -0.1 | 8.0 | 1.0 | 2.0 | -0.1 | 4.0 |
| Chile | 5 | 2 | 2.3 | 4.7 | -15.9 | 11.2 | 2.3 | 4.7 | -15.9 | 5.6 |
| Colombia | 2 | 0 | 2.0 | 4.5 | -4.5 | 1.4 | 2.0 | 4.5 | -4.5 | 1.1 |
| Denmark | 7 | 1 | 1.2 | 3.0 | -3.3 | 3.8 | 1.6 | 2.4 | -4.5 | 4.0 |
| Finland | 4 | 1 | 2.3 | 3.7 | -7.3 | 5.1 | 2.3 | 3.7 | -7.3 | 2.5 |
| France | 6 | 2 | 2.3 | 4.5 | -6.2 | 2.6 | 2.0 | 4.5 | -2.2 | 1.3 |
| Germany | 3 | 0 | 1.3 | 2.5 | -8.2 | 7.1 | 1.5 | 2.5 | -9.9 | 5.3 |
| Italy | 8 | 4 | 1.5 | 4.0 | -5.9 | 5.1 | 2.3 | 3.0 | -5.6 | 3.9 |
| Japan | 4 | 1 | 1.3 | 3.7 | -1.5 | 3.7 | 2.0 | 3.0 | -1.8 | 1.8 |
| Mexico | 2 | 0 | 1.5 | 8.5 | -8.8 | 2.4 | 4.0 | 6.0 | -11.6 | 2.9 |
| Netherlands | 4 | 1 | 1.0 | 3.5 | -3.5 | 1.9 | 3.0 | 1.5 | -10.1 | 11.6 |
| Norway | 3 | 0 | 1.0 | 2.7 | -6.8 | 3.3 | 1.0 | 2.7 | -6.8 | 3.2 |
| Spain | 3 | 2 | 1.0 | | -3.9 | | | | | |
| Sweden | 5 | 1 | 2.0 | 4.3 | -5.9 | 3.2 | 2.0 | 4.3 | -5.9 | 2.2 |
| Taiwan | 3 | 3 | | | | | | | | |
| United Kingdom | 3 | 0 | 2.7 | 3.0 | -4.6 | 4.5 | 3.0 | 3.0 | -3.7 | 1.5 |
| United States | 6 | 1 | 2.2 | 4.0 | -16.5 | 5.6 | 1.5 | 4.0 | -8.5 | 3.6 |
| Venezuela | 2 | 0 | 4.5 | | -16.8 | | | | | |
| Aggregate | 86 | 21 | 1.9 | 4.2 | -7.7 | 4.4 | 2.3 | 3.7 | -7.7 | 3.5 |

The size of contractions is measured by the decrease in the logarithm of real GDP per capita (lrgdp) from the peak before the contraction associated with a banking crisis to 1. the trough value when real GDP per capita first increases ; and 2. the minimum value before real GDP per capita first exceeds the peak value before the contraction.

Table 4
Regressions of the Speed of Recovery on the Depth of the Contraction

| | Constant | Slope Coefficient | | |
|---|---|---|---|---|
| | Standard error | Standard error | $R^2/s_e$ | F/p-value |
| **First trough in real GDP per capita** | | | | |
| With constant | 0.035242 | -0.136589 | 0.06175 | 3.225 |
| | 0.006913 | 0.076059 | 0.0335 | 0.07869 |
| No constant | | -0.42139 | | |
| | | 0.06321 | 0.04103 | |
| **Minimum real GDP per capita before recovery** | | | | |
| With constant | 0.021026 | -0.18018 | 0.1634 | 9.57 |
| | 0.006115 | 0.058244 | 0.02964 | 0.003263 |
| No constant | | -0.32724 | | |
| | | 0.04361 | 0.0327 | |
| **Minimum real GDP per capita before recovery with "outlier" excluded** | | | | |
| With constant | 0.02324 | -0.110082 | 0.1396 | 7.791 |
| | 0.004047 | 0.039438 | 0.01957 | 0.007513 |
| No constant | | -0.27529 | | |
| | | 0.03468 | 0.02516 | |

The table shows regressions of the speed of recovery on the depth of the preceding contraction. All regressions are presented with and without intercepts. Literally, the positive estimated intercepts imply that the recovery in real GDP per capita will occur at the rate estimated by the constant term after no contraction. The size of the contraction is measured in the first two regressions as the decline from the peak to the first trough when real GDP per capita increases. The size of the contraction is measured in the last four regressions as the decline from the peak to the minimum real GDP per capita prior to the subsequent recovery. The speed of recovery is measured as the annual rate of increase of real GDP per capita from the trough or minimum to the subsequent recovered level of real GDP per capita. The last two regressions exclude the Netherlands in 1914 with a speed of recovery over 20 percent per year, an observation far from the others in Figure 5. No $R^2$ is presented when there is no constant term because the $R^2$ does not have the usual interpretation when there is no constant term. Similarly, the F-value is not informative in the usual way and the p-value is not either.

Table 5

Changes in Growth over one decade before and after a Banking Crisis

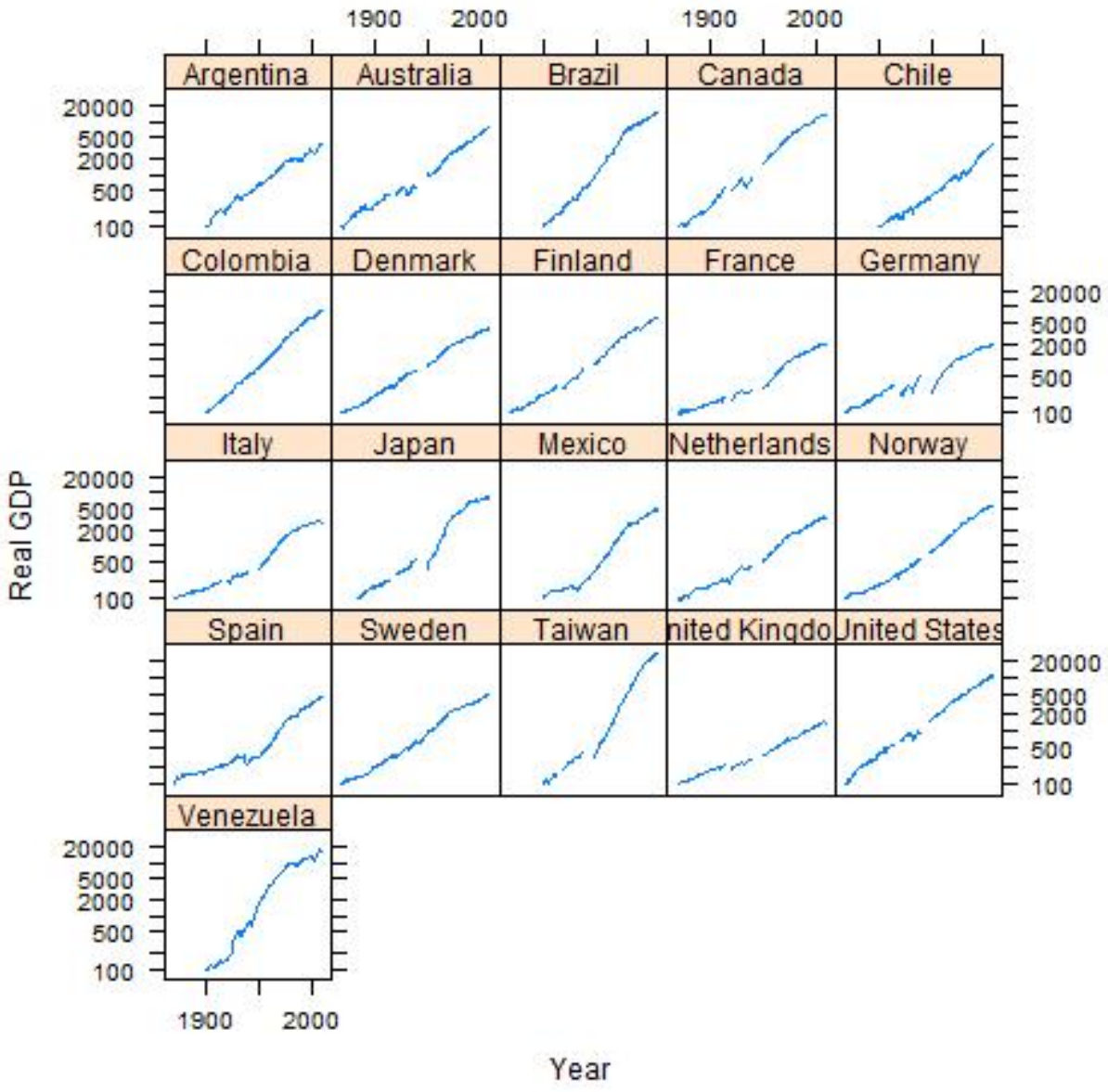
| | Difference in domestic growth before and after banking crises | Difference between domestic and world growth rates after a banking crisis | Change after banking crisis in difference between domestic and world growth rates |
|---|---|---|---|
| Output | -0.04 | -0.08 | -0.11 |
| | (2.08) | (1.71) | (1.89) |
| | 0.54 | 0.52 | 0.51 |
| Physical Capital | -0.07 | -0.27 | -0.31 |
| | (1.86) | (1.69) | (1.52) |
| | 0.42 | 0.40 | 0.40 |
| Human Capital | -0.01 | 0.08 | 0.04 |
| | (0.30) | (0.36) | (0.28) |
| | 0.49 | 0.53 | 0.54 |
| TFP | -0.02 | -0.09 | -0.09 |
| | (1.88) | (1.45) | (1.82) |
| | 0.54 | 0.57 | 0.51 |

Table 6

Changes in Growth over two decades before and after a Banking Crisis

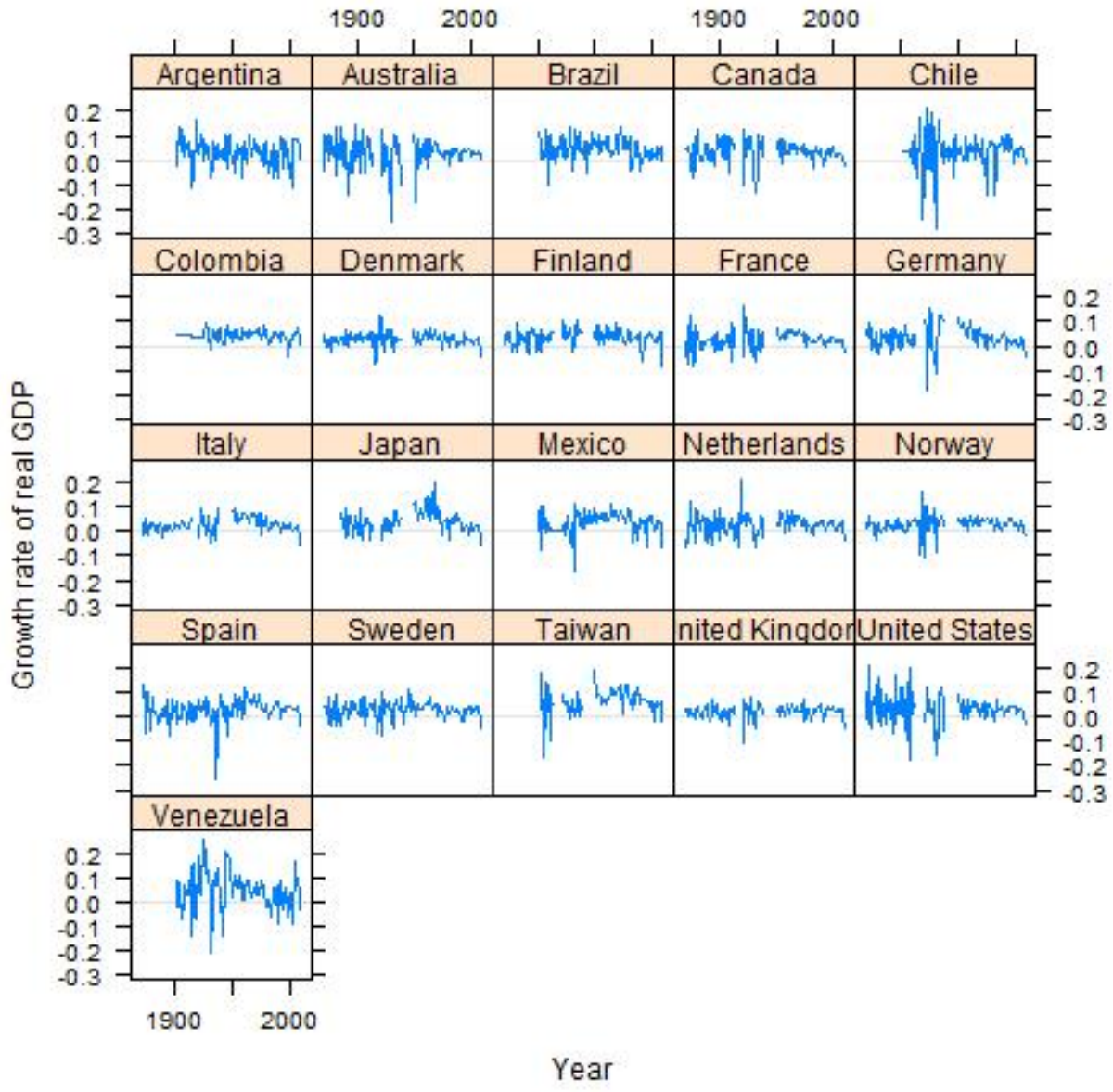
| | Difference in domestic growth before and after banking crises | Difference between domestic and world growth rates after a banking crisis | Change after banking crisis in difference between domestic and world growth rates |
|---|---|---|---|
| Output | -0.34 | -0.19 | -0.18 |
| | (1.50) | (1.21) | (1.39) |
| | 0.45 | 0.49 | 0.47 |
| Physical Capital | -0.70 | -0.19 | -0.12 |
| | (1.67) | (1.53) | (1.66) |
| | 0.34 | 0.43 | 0.47 |
| Human Capital | 0.05 | 0.11 | 0.11 |
| | (0.33) | (0.38) | (0.31) |
| | 0.36 | 0.51 | 0.53 |
| TFP | -0.14 | -0.20 | -0.21 |
| | (1.24) | (0.92) | (1.18) |
| | 0.57 | 0.45 | 0.49 |

Figure 1
Real GDP




World Wars I and II are excluded for combatants. The scales of all graphs are identical. The initial value of real GDP is set to 100 for each country. The vertical scale is a proportional scale, so the slope of the line is the growth rate.

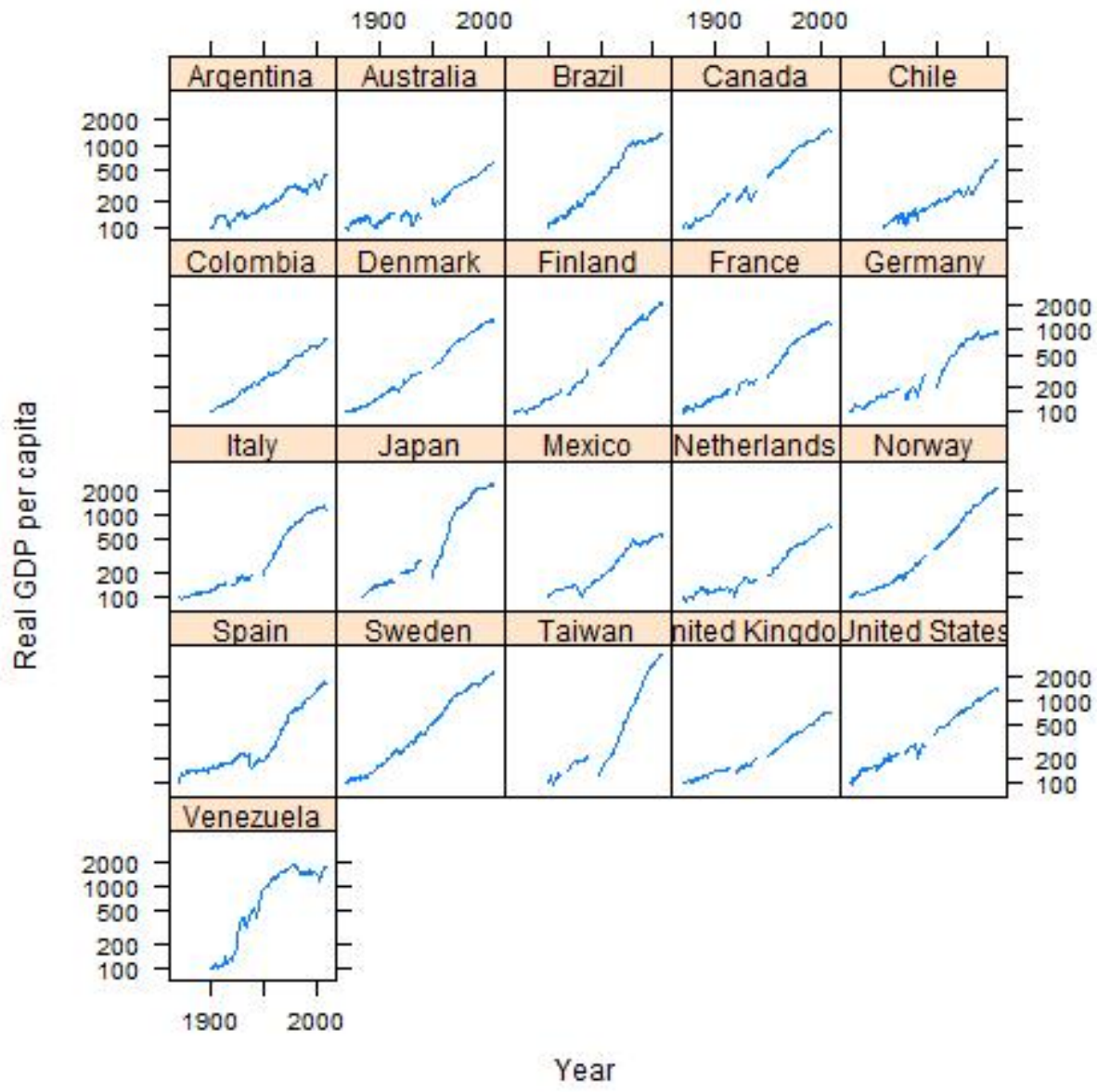
Figure 2
Growth Rate of Real GDP




World Wars I and II are excluded for combatants. The scales of all graphs are identical. The growth rates are annual changes in the logarithms of real GDP.

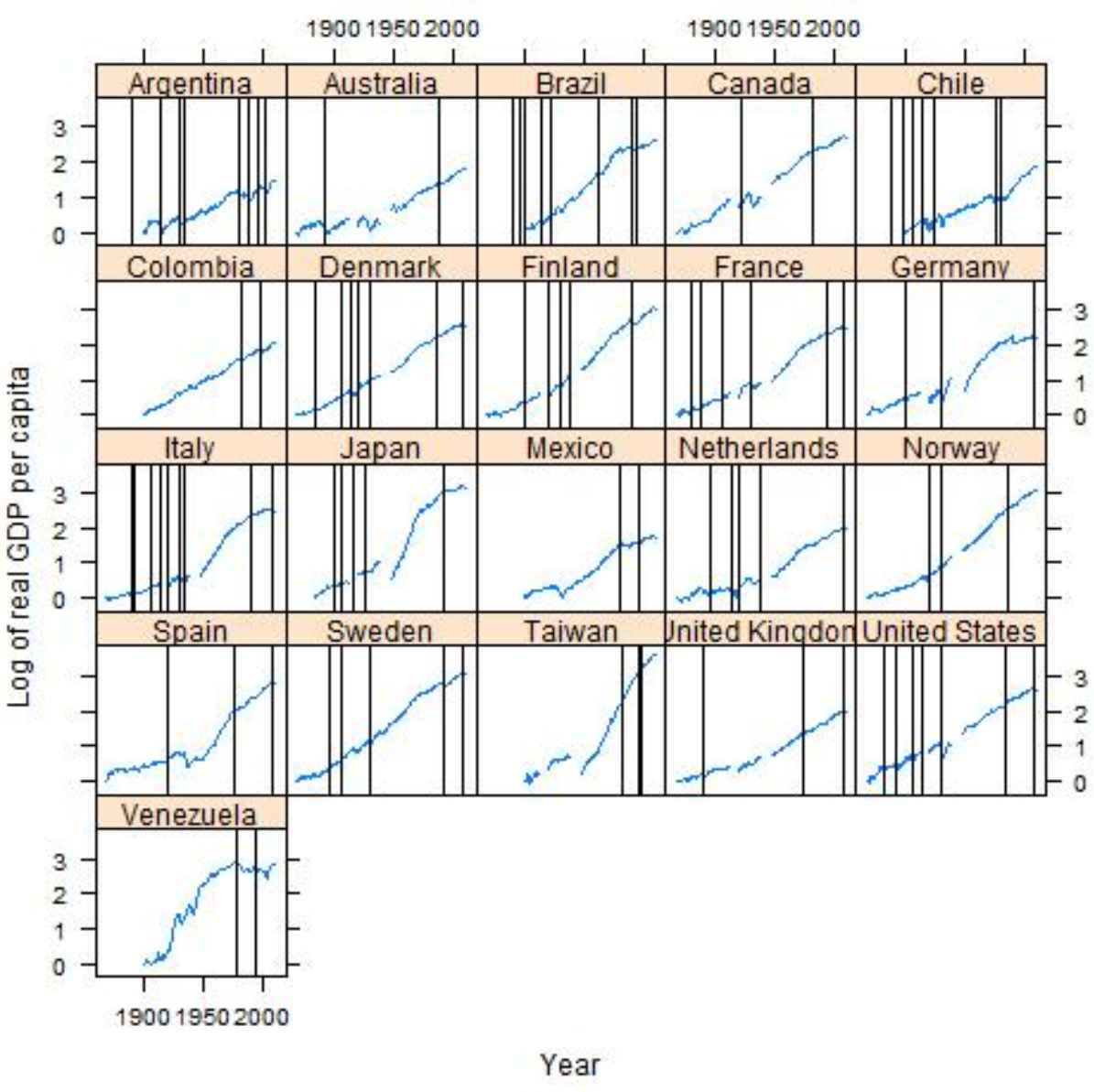
Figure 3

Real GDP per Capita



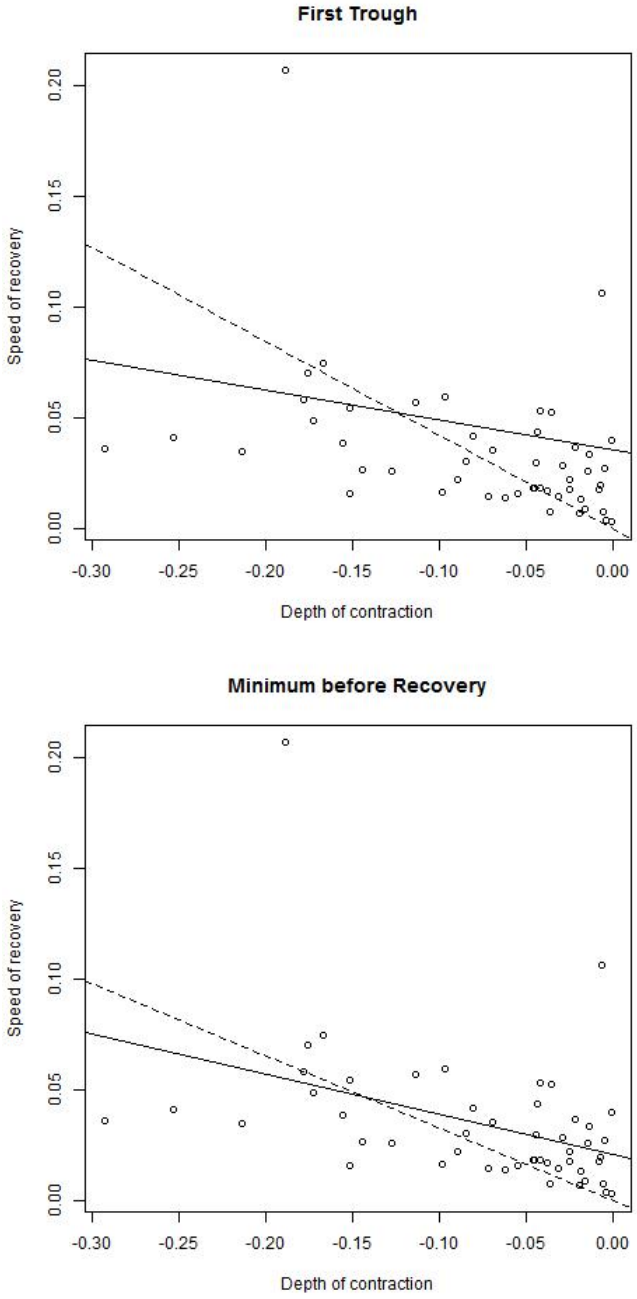

World Wars I and II are excluded for combatants. The scales of all graphs are identical. The initial value of real GDP is set to 100 for each country. The vertical scale is a proportional scale, so the slope of the line is the growth rate.

Figure 4
Real GDP per Capita and Banking Crises



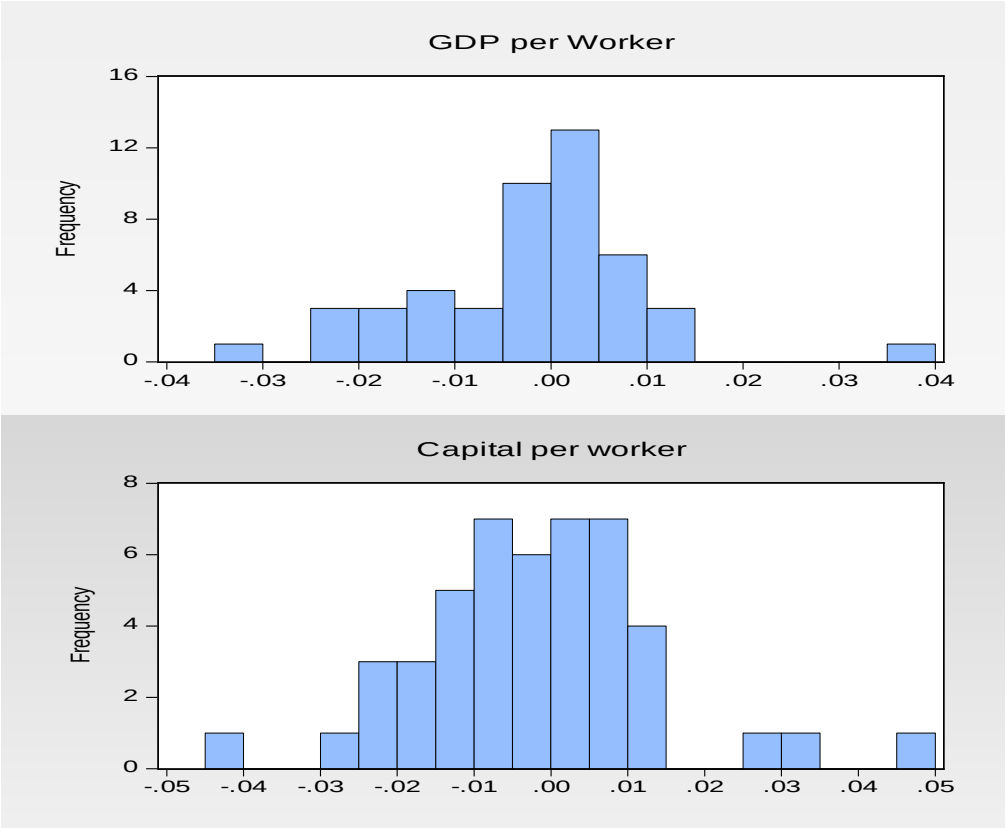

World Wars I and II are excluded for combatants. The scales of all graphs are identical. The initial value of real GDP is set to 100 for each country. The vertical scale is a proportional scale, so the slope of the line is the growth rate. The vertical lines indicate the starts of financial crises.

Figure 5
The Depth of Recessions and the Beginnings of Financial Crises




The graphs show the speed of recovery as a function of the depth of the preceding contraction. The size of the contraction is measured in the first graph as the decline from the peak to the first trough when real GDP per capita increases. The size of the contraction is measured in the second graph as the decline from the peak to the minimum real GDP per capita prior to the subsequent recovery. The speed of recovery is measured as the annual rate of increase of real GDP per capita from the trough or minimum to the subsequent recovered level of real GDP per capita. The solid lines in the graphs are regression lines for regressions of the speed of recovery on the depth of the contraction. The dashed lines are regression lines with no intercept.

Figure 6
Growth rates for output and capital per worker twenty years



## Data Appendix

Our data set contains GDP, Gross Fixed Capital Formation (GFCF), population and the labor force for each economy as well as world measures. This appendix provides a brief description of sources and procedures.

### Capital Stocks:

We calculate the capital stock using the investment data (GFCF) and an initial value of the capital stock. We determine the initial value year of capital for year t as follows where K is the capital stock and I is investment.

$K_t$ = AverageInv/ (N + d)

Where AverageInv is the average investment from for previous ten years. N is the average growth in population and d is the depreciation rate, assumed to be four percent.

We then determine the capital stock for other years with the permanent inventory approach.

$K_{t+1} = (1-d)\ K_t + I_t$

### GDP and Gross Fixed Capital Formation

**1970-2009**

Unless otherwise note, GDP and GFCF are from the UN National Accounts database at:
http://unstats.un.org/unsd/snaama/Introduction.asp
Population: UN National Accounts database and the Penn World Tables.
http://pwt.econ.upenn.edu/
Labor Force: From the Total Economy Data Base of the Conference Board
http://www.conference-board.org/data/economydatabase/

### *1870-1970*

***GDP Source Notes***

***Australia:***

At 1911 prices. From Mitchell (2003a) before 1900. After 1900, Butlin (1977.

***Canada***

At 1986 prices. From 1870 to 1970 from McInnes (2001). We adjust GNP to GDP using Maddison (1992).

***Denmark***

1929 prices. Before 1967, estimates from Mitchell (2003b). After 1967, from Stat Denmark. Mitchell is in factor cost. We transform to market prices using Jones/Obstfeld (1997) NBER data. For 1915 to 1920, we assume investment is fifteen percent of GDP.

***France.***

1905-1913 prices. Source Mitchell (2003b). Data is missing for both World Wars. For 1914 to 1919 We interpolate using volume from Maddison (2007) and CPI data from Lee (1976). For 1939 to 1948, we use Maddison (2007) for volume and the CPI from Lee (1976) for the price level. Pre-1949, investment from Levy-Leboyer and Bourguingon (1990).

**Finland**

GDP data from 1860 to 2005 from Nordic Historical National Accounts data base:
http://old.nhh.no/forskning/nnb/?selected=brows/xls
From 2005-2009: United Nations national accounts database.

**Germany.**

At 1913 prices. Source Mitchell (2003b). GDP for 1914 to 1924 from Maddison (2007). No adjustment for changes in boundaries. Capital formation is in net terms before 1950.

***Italy***

All data from Baffigi (2011).

**Japan**

K. Ohkawa and M. Shinohara (1979). We assume real GFCF for 1945 equals 1944. We chain the pre-and post 1952 series for real GDP using Maddison (2007). For GFCF We assume that the share of investment at constant prices is the same for 1952 as for 1951

***Norway***

At 2000 prices. All data from Grytten (2004).

***Sweden***

From the Swedish Historical National Accounts 1800-2000 data base at
http://www.ekh.lu.se/database/lu-madd/National%20Accounts/default.htm

***Netherlands***

At 1913 prices. Smits et al (2000) to 1913. After 1913, GDP at current market prices and GFCF from Maddison (1992) and Mitchell (2003b).

**Spain**

GDP data from 1850 to 2000 from Leandro Prados de la Escosura, L. (2003). El progreso económico de España, 1850-2000. Madrid:Fundación BBVA. Revised data supplied by the author. 2000-2009 from UN national Accounts.

**Taiwan**

1900-2000 Mizoguchi, Toshiyuki, "Estimates of the Long-run Economic Growth of Taiwan Based on Revised SNA (1901-2000) Statistics", Institute for Economic Research - Hitotsubashi University, Discussion Paper Series, No. 123, October, 2005.
2001-2011: Statistical Yearbook of Taiwan.
http://eng.dgbas.gov.tw/public/Data/011917403371.pdf

***UK***

1913 prices. Compromise estimate. 1870-1947 from Mitchell (1988). Thereafter UK Stats chained estimates.

***USA***

1870 to 1909 from Gallman as given in Rhode (2002) adjusted to GDP using Kendrick (1961) for 1870-1909. 1909-1950 from Kendrick (1961). 1950 to 2004 BEA chained series where GFCF is calculated in the same manner as Kendrick.

**Argentina, Brazil, Chile, Columbia, Mexico and Venezuela**

Sources: 1900 to 1994. Hoffman (2000) Table B3 and D1. 1995-2009. UN. National Income Statistics.

**World GDP and Capital Stocks**

We construct indices of GDP and the capital stock and human capital for the world economy using the fourteen economies with data from 1870 to date. They are Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, the United Kingdom, and the United States. For Japan we interpolate using Maddison (2007) for missing early years. Maddison (2007) does not provide deflators for investment. We assume that the implied price level from Maddison for overall GDP also applies to the investment price level. For most years, our measure of world GDP accounts for between fifty and sixty percent of total world GDP using data from Maddison covering all economies in the world. Our world aggregate includes almost all GDP arising in developed economies over the entire period.

## Population and Labor Force

Unless otherwise specified population comes from Maddison (2007) while the labor force estimates come from the spreadsheets underlying Baier, Dwyer and Tamura (2006).

**Argentina, Brazil, Chile, Columbia, Mexico and Venezuela**

1900 to 2000. Oxford Latin American Economic History Database OXLAD from the following website:
http://oxlad.qeh.ox.ac.uk/

**Finland**

Nordic Historical National Accounts data base:
http://old.nhh.no/forskning/nnb/?selected=brows/xls

**Japan**

Labor force 1885-1997 from Godo, Yoshihisa, 'Estimation of Average Years of Schooling by Levels of Education for Japan and the United States, 1890-1990,' at http://www.cgeh.nl/sites/default/files/Human-capital-hub/data/Godo_data.pdf .
Data are missing from 1940 to 1952 where we assume a labor force participation rate of 0.45. From 1956 onwards, data is from the Total Economy Database (TED)

**World Population and Labor Force**

We construct the human capital aggregate by weighting the domestic measures of the labor force and human capital by each countries share in the world labor force.

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