Credit and Economic Recovery: Demystifying Phoenix Miracles*

Michael Biggs   Thomas Mayer   Andreas Pick

March 15, 2010

Abstract

This paper offers a solution to the puzzle that economic activity recovers after a financial crisis without a rebound in credit. These credit-less recoveries, known as "Phoenix Miracles", question the importance of credit. We argue that these recoveries appear credit-less because GDP is compared to the stock of credit. We show in a theoretical model that recoveries in GDP coincide with recoveries in the flow of credit and this can occur even as the stock of credit declines. Data from emerging and developed economies confirm this finding.

JEL Classification Numbers: F30, G01

Keywords: Credit, economic recovery, financial crises

*We would like to thank Markus Brunnermeier, Menzie Chinn, Michael Dooley, Gabriele Galati, Daniel Gros, Dwight Jaffee, Rudy Loo-Kung, Pierre Lafourcade, Agnieszka Markiewicz, Christopher Morris, Holger Strulik, Peter Tinsley, Harald Uhlig, Joris de Wind, and seminar participants at DNB and UC Davis for helpful comments. We are grateful to Guillermo Calvo for sharing his data with us. The views expressed are the authors' and do not necessarily reflect those of Deutsche Bank.

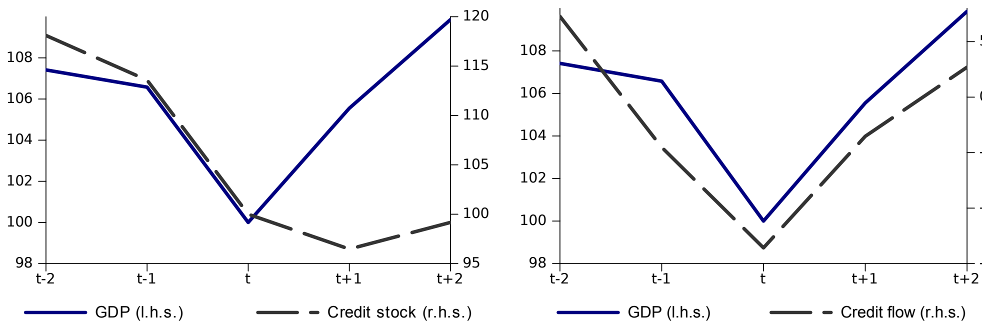
1 Introduction

It has become almost a stylized fact that after financial crises, economic activity recovers without a rebound in credit (see for example International Monetary Fund (2009)). This phenomenon, termed a "credit-less recovery" or "Phoenix Miracle", was first highlighted by Calvo, Izquierdo and Talvi (2006a, 2006b) in the context of emerging market economies, but is also a feature of business cycles in industrial countries (Claessens, Kose and Terrones 2008). Perhaps the most striking example of this is the U.S. experience after the Great Depression. A credit squeeze is thought to have been an important cause of the Great Depression (Bernanke 1983) and both GDP and credit declined sharply from 1931 to 1933. However, even though credit growth remained negative in 1934 and 1935, U.S. real GDP growth rebounded to 9% and 11% respectively. This raises the question: given that the decline in credit during financial crises is so closely related to the decline in economic activity, how does the economy recover without a rebound in credit?

In this paper, we argue that these recoveries appear credit-less because developments in the stock of credit are compared to developments in the flow of economic activity. To the extent that spending is credit financed, GDP will be a function of new borrowing, or the *flow* of credit. In each of these "credit-less recoveries" the rebound in domestic demand is highly correlated with the rebound in the flow of credit, even if it is poorly correlated with developments in its stock.

To illustrate this point, consider the graphs in Figure 1. The left graph replicates (without smoothing) that of Calvo et al. (2006b) and plots GDP against the stock of credit for an average of 22 episodes of systemic sudden stops in emerging markets. The divergence of GDP and credit after the trough of the crises lead Calvo et al. (2006a, 2006b) to call these episodes credit-less recoveries. In contrast, the right panel plots GDP against the flow of credit. It is easily seen

Figure 1: Credit and economic recovery around systemic sudden stop crises in emerging markets



Note: The left panel shows the average of GDP and the average credit stock across 22 episodes of systemic sudden stops. The right panel shows the average GDP and the average credit flow across the same 22 episodes. The charts are based on the data of Calvo, Izquierdo and Talvi (2006a). t denotes the trough of the respective systemic sudden stop episode.

that the recovery in the flow of GDP coincides with the recovery in the flow of credit.

An important implication, which is evident in the right graph of Figure 1, is that for economic activity to rebound after a financial crisis, it is not necessary for credit growth to turn positive but only for the flow of credit to increase. We call the change in the flow of credit the "credit impulse". The fact that the credit impulse can turn positive even as the stock of credit falls means that domestic demand can recover even as the economy delevers.

It should be noted that the distinction between the flow and the stock of credit is overly simplistic, and our arguments should not be understood to say that the stock of credit is not important for output. In our model it is related to the capital stock, which in turn determines the level of potential GDP in the economy. However, as we will show, focusing purely on the stock of credit misses the developments in the flow of credit that are more important for understanding large fluctuations in GDP.

A substantial theoretical literature has emphasized the importance of financial frictions for the macroeconomy, and has demonstrated how these frictions can cause small temporary shocks to generate large, persistent fluctuations in output (Bernanke 1983, Bernanke and Blinder 1988, Bernanke and Gertler 1989, Greenwald and Stiglitz 1993, Kiyotaki and Moore 1997). These papers tend to focus either on business cycles or the credit channel of monetary policy transmission, and they place less emphasis on the relationship between specific credit aggregates.

There is also a substantial empirical literature that focuses on whether bank loan supply has real effects. However, many of these papers (including Bernanke (1983) and Peek, Rosengren and Tootell (2003)) use proxies for loan supply that do not correspond specifically to either credit stocks or credit flows. Papers that employ an instrumental variables approach, such as Driscoll (2004), generally develop instruments for growth in the stock of credit. The impact on output is often found to be insignificant. While the purpose of our paper is not to investigate the direction of causality between credit and output, our results suggest that developing instruments for the flow rather than the stock of credit might provide a fertile avenue for further research.

Section 2 provides the intuition for our argument in a simple framework, and Section 3 uses the model of Monacelli (2009) to show that our arguments hold within the framework of a standard macroeconomic model. This demonstrates that the divergence between GDP and the stock of credit after a crisis does not run counter to the conclusions of standard models of credit and the business cycle, but rather that it is an overlooked implication of these models. Thereafter, we test the empirical validity of our theoretical findings more widely. In Section 4, we revisit the "Phoenix Miracles" in industrial countries and in the Great Depression, and show that in each case the post-crisis recovery in GDP or domestic demand coincided with a rebound in the flow of credit. In Section 5, we analyze the post-war experience in the U.S. and find that after downturns economic growth is more closely related to the credit impulse than credit growth.

2 The relationship between credit and economic growth

In this Section, we model the relationship between the flow of credit and economic activity and demonstrate that the flow of credit and GDP can increase even while the stock of credit is falling. This result can be achieved within the context of a standard macroeconomic model, as we show in Section 3. However, these models have in general not focused on the distinction between the stock and the flow of credit. Here we provide a simple framework that enables us to follow credit through the economy and to state the main results analytically.

The model consist of two sectors. Households produce investment goods which they sell to firms. They save some of the proceeds with banks, and use the remainder to finance consumption. Firms borrow from the banks to purchase these investment goods, which they use to produce consumer goods. These goods are sold to the consumer, and the revenues from these sales are used to meet the firms' debt servicing costs and to pay down debt.

Credit is introduced with the assumption that firms have to borrow from banks to finance their investment. Like Bernanke and Gertler (1989) and Greenwald and Stiglitz (1993) we abstract from other sources of finance for simplicity and as our focus is on credit. While investment financed by other means than credit could weaken the correlation between private demand and any measure of credit, the issue whether the stock or the flow of credit are more closely correlated with private demand remains unaffected.

It is also assumed in the model that credit is used to finance investment only. We make this assumption for expositional simplicity. In Section 3 we show that the result carries over to a model where credit is used to finance spending on both investment and consumption.

Consider a two good economy that produces non-durable consumer goods, $Y_{c,t}$, and durable intermediate goods, $Y_{d,t}$,which are used in the production process of the consumer good. The income of the economy is therefore $Y_t = Y_{c,t}+Y_{d,t}$.

The consumer good is produced by firms with production function

$$Y_{c,t} = AK_t, \tag{1}$$

where A is a constant and K_t represents the aggregate stock of intermediate goods that firms have acquired. The intermediate good depreciates at rate δ, so that

$$K_t = (1-\delta)K_{t-1} + Y_{d,t}. \tag{2}$$

The market for consumer products is competitive and firms make no profits from which to buy the investment goods, instead they need to borrow funds from banks. At each period the firms therefore borrow an amount equal to $Y_{d,t}$. The firms' profit maximization subject to (1) and (2) yields the interest rate

$$r = A - \delta. \tag{3}$$

After paying interest rK_t, firms are left with income δK_t, which they use to repay a part of the accumulated stock of credit. Assuming that all investment has been financed via borrowing, the firms' credit dynamics are therefore

$$D_t = (1-\delta)D_{t-1} + Y_{d,t}. \tag{4}$$

The intermediate good is produced with the production function $Y_{d,t} = f(N_t)$, where N_t is labor supplied by households. We assume that the supply of labor and, therefore, of the investment good is infinitely elastic at price of one, and the quantity produced depends purely on demand. This assumption simplifies the exposition but is not essential—an upward sloping supply curve of labor would yield the same result. The only requirement is that an increase in demand gives rise to an increase in production. Bernanke and Gertler (1989) derive a similar supply curve for investment funds that is perfectly elastic with respect to the interest rate by assuming that output can be stored as inventory that yields a gross return.

Households own no capital that can be used as collateral and therefore cannot borrow. At the beginning of the period households work to produce the intermediate good and save the proceeds, equal to $Y_{d,t}$. At the end of the period they pay for their consumption, $C_t = Y_{c,t} = AK_t$ with the interest income, rD_t, and withdrawals of size δD_t. Therefore, the stock of consumers' savings evaluated at the beginning of each period develops in line with (4).

We can now combine consumption and investment to obtain GDP. First, under the assumption that all investment has been financed by borrowing, we have from (1) and (3) that consumption can be expressed in terms of credit, $Y_{c,t} = AK_t = AD_t = (\delta + r)D_t$. Second, it follows from (4) that $Y_{d,t} = \Delta D_t + \delta D_{t-1}$. Therefore,

$$\begin{aligned} Y_t &= (\delta + r)D_t + \Delta D_t + \delta D_{t-1} \\ &= (1 - \delta)\Delta D_t + (2\delta + r)D_t, \end{aligned} \tag{5}$$

which shows that GDP is a function of the stock of credit, D_t, and of the flow of credit, ΔD_t. For reasonable levels of δ and r the coefficient of the flow of credit is substantially larger than that of the stock of credit.

Rearranging (5) to obtain the growth rate of GDP, y_t, we have

$$y_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}} = (1 - \delta)\frac{\Delta D_t - \Delta D_{t-1}}{Y_{t-1}} + (2\delta + r)\frac{\Delta D_t}{D_{t-1}}\frac{D_{t-1}}{Y_{t-1}}, \tag{6}$$

which suggests that GDP growth is a function of both the change in the flow of credit, $\Delta D_t - \Delta D_{t-1}$, relative to GDP, which we call the "credit impulse", and the growth of the stock of credit weighted by the size of credit relative to GDP. If credit changes at a stable rate ($\Delta D_t = \Delta D_{t-1}$), the credit impulse will be zero and GDP growth is related to credit growth. If credit growth is volatile, and given that $1-\delta > (2\delta + r)$ for reasonable levels of δ and r, growth is mainly related to the credit impulse.

It is also evident from (6) how credit-less recoveries or "Phoenix Miracles" occur. Assume that a crisis in year $t-1$ causes a contraction in credit. Both $\Delta D_t - \Delta D_{t-1}$ and ΔD_t, and y_t turn negative. However, if in year t the pace of delevering slows, then ΔD_t is still negative but $\Delta D_t - \Delta D_{t-1}$ turns positive. From (6) it follows that if $0 > \Delta D_t > (1-\delta)/(1+\delta+r)\Delta D_{t-1}$, then GDP growth is positive even while credit growth is negative.

Note that we do not suggest a causal direction from either credit to economic growth or vice versa. In many states of the world developments in domestic demand are likely to drive developments in credit, whereas during a credit crunch the causality could be reversed. Our aim here is not to prove causality, but to demonstrate that the close link between credit and domestic demand holds even during the recovery stage after financial crises.

3 Credit and economic recovery in a DSGE model

We now demonstrate that the above result, that after a financial crisis the flow of credit rebounds in tandem with GDP even if the stock of credit falls, is also a conclusion of standard macroeconomic models, and that this implication seems to have merely been overlooked. We use the model of Monacelli (2009) as an example. Here, we provide only a brief, non-technical summary of the model, with a more technical description in Appendix A. For a more detailed discussion of this model see Sterk (forthcoming). We then investigate the behavior of GDP, the stock and the flow of credit after a negative monetary policy shock.

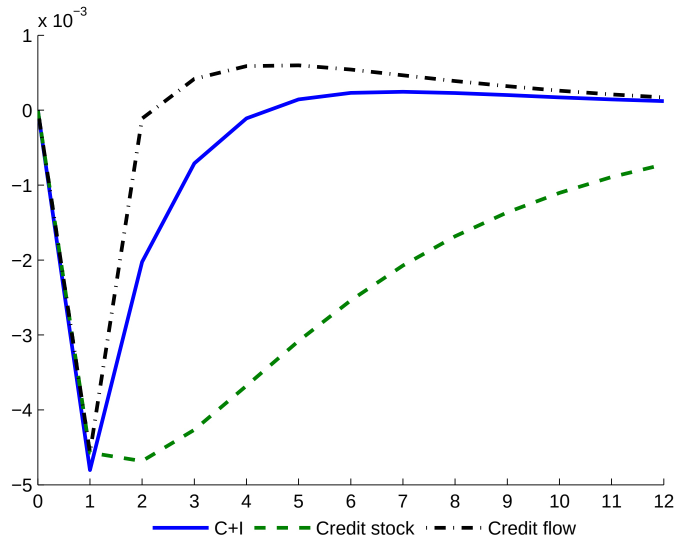
The model features two types of households that differ only in their discount factors. This introduces credit into this model: impatient households with lower discount factor borrow from the more patient households with higher discount factors. Both household types maximize utility, which is determined by consumption of durable and non-durable goods and labor, subject to a budget constraint and a collateral constraint. The latter limits borrowing of the impatient household.

Final goods are produced from intermediate goods in competitive markets. Intermediate goods are produced from labor by producers with some price-setting power due to product differentiation. Markets clear and monetary policy reacts to the inflation rate in the economy. The model is then solved numerically using parameters calibrating it to quarterly data. The parameter values are reported in Appendix A.

Figure 2 plots the impulse response functions of GDP, the flow of credit and the stock of credit to a negative monetary policy shock. After the negative shock GDP increases and returns to the steady state level. The stock of credit, however, continues to fall for another period before increasing and slowly converging to it's long run level. This continued decline in the stock of credit after GDP has started to recover is consistent with the behavior of the stock of credit that has been observed in the data (Calvo et al. 2006a). This divergence appears naturally even though there is no change in the role of credit in the model and the recovery is therefore not credit-less.

Furthermore, the rebound in the flow of GDP is matched by a rebound in the flow of credit. The two flow variables increase in parallel but, because the flow of credit remains initially negative even though it is rising, the stock variable continues to fall. The divergence between GDP and the stock of credit after the crisis is not a "Phoenix Miracle", but rather the logical if overlooked implication of standard macroeconomic models of credit and the business cycle.

Figure 2: Impulse response functions of GDP, the flow and the stock of credit in the model of Monacelli (2009)



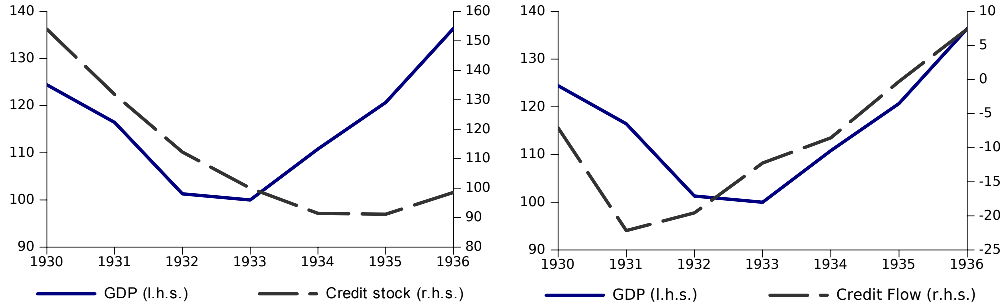
4 Phoenix Miracles reconsidered

The phenomenon of the "credit-less recovery" was first highlighted by Calvo et al. (2006a, 2006b). They investigate the behavior of a number of macroeconomic variables around episodes of systemic sudden stops in emerging markets. Their main observation was that after these sudden stop episodes, GDP recovered without any recovery in credit, a phenomenon they called a "Phoenix Miracle".

Using their data we investigate the relationship between the stock and flow of credit and GDP for the same 22 episodes of systemic sudden stops. Details of the data used are given in Appendix B. As Figure 1 in the Introduction already showed, the rebound in GDP after these systemic sudden stops coincided with an increase in the flow of credit, even as the stock of credit remained largely unchanged.

Calvo et al. (2006a, 2006b) suggested that the U.S. Great Depression in the

Figure 3: Credit and economic recovery in the U.S. Great Depression



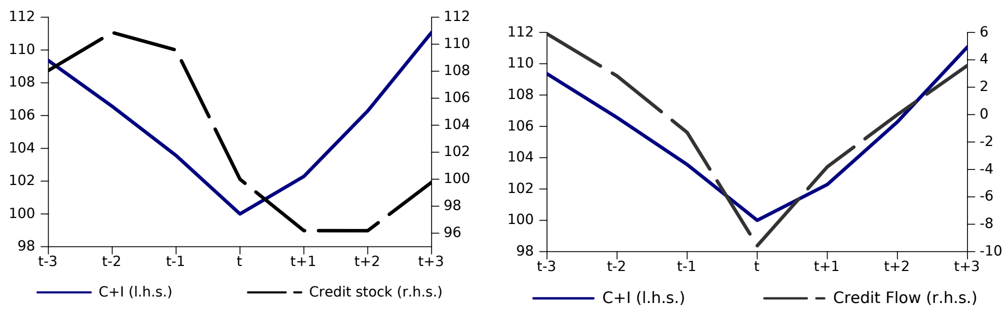
Note: The left panel shows U.S. GDP (volume) and U.S. credit stock (volume) from 1930 to 1936. The right panel shows U.S. GDP (volume) and the U.S. credit flow for the same period. The charts are based on the data of Calvo et al. (2006a).

1930s could also be catalogued as a Phoenix Miracle. To support this claim Calvo et al. plot U.S. GDP (with 1933 = 100) against the level of credit, which we reproduce as the left panel of Figure 3. The apparent lack of any recovery in credit confirmed their conclusions that the recovery from the Great Depression was achieved without any impetus from the credit market.

The right panel of Figure 3 plots the level of GDP against credit flows. It is evident from the right panel that the flow of credit began to recover even before the level of GDP started to recover, even if the stock of credit continued to decline.

Claessens et al. (2008) argue the phenomenon of a credit-less recovery is not limited to emerging economies, but is also a feature of business cycles in industrial countries. To examine this claim, we investigate the role of credit for economic activity in the "big five" banking crises in developed economies as identified by Reinhart and Rogoff (2008). These are the crises in the Nordic countries in the early 1990s, the banking crises in Spain in the late 1970s to early 1980s and the financial crisis in Japan since the early 1990s. Descriptions of these crises can be

Figure 4: Credit and economic recovery around banking crises in developed markets



Note: The graph on the left shows the average level of C+I and average credit stock. The graph on the right shows the average level of C+I and the average credit flow. The averages are calculated over five financial crises in Finland, Japan, Norway, Spain and Sweden, where the level at the trough of the crisis is set to 100.

found in Basel Committee on Banking Supervision (2004).

The impact of credit should be felt most directly on private demand, and consequently we compare developments in the stock and the flow of credit to private consumption and investment. As in the papers by Calvo et al. (2006a, 2006b) and Claessens et al. (2008), we construct average volume indices, which are each centered around the year of the respective crisis.

In Figure 4 the average level of private demand is plotted against the stock of credit in the graph on the left and against the flow of credit in the graph on the right. Just as in the case of the sudden systemic stop crises in emerging markets and the Great Depression in the U.S., the left plot shows that private demand recovers while the stock of credit continues to decline. It takes on average two years after the trough of the crisis before credit growth resumes. The plot on the right, however, confirms that the rebound in private demand coincides with the rebound in the flow of credit. Hence, these plots strongly suggest that a rebound in new credit is closely related to economic growth during periods of economic recovery.

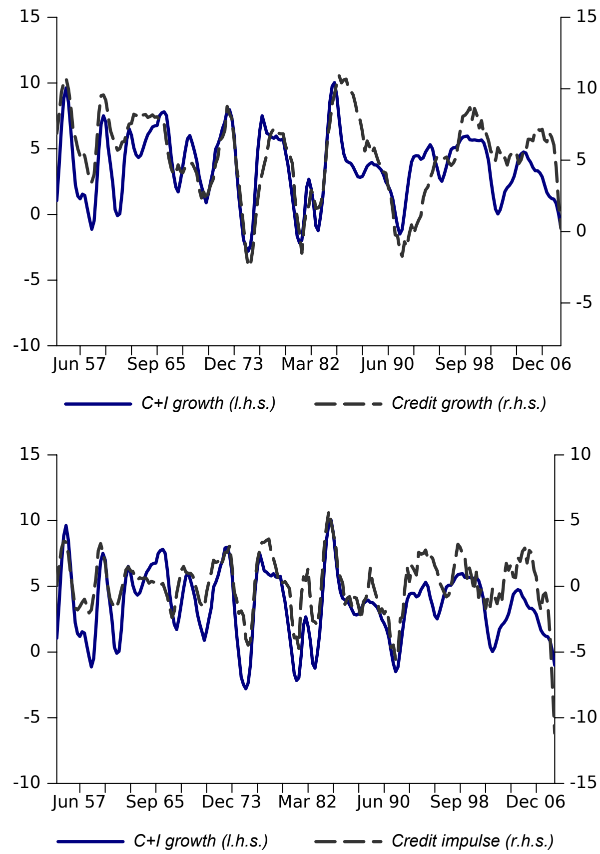
5 Demand and credit growth in the U.S. post-war experience

We now take a closer look at the importance of the credit flows during normal recessions in the U.S. during the period 1954 to 2008. Given that both private demand for goods and services and the level of credit are trending, we use growth rates. In addition, we introduce the concept of the credit impulse, which is the difference in the flow of credit relative to GDP. If the level of private demand is related to the flow of credit, then private demand growth should be related to the credit impulse. We investigate whether it is more closely related to demand growth than credit growth during recoveries from recessions. Details of the data and the precise variable definitions are in Appendix B.

The series are plotted in Figure 5. The first graph plots private demand growth and credit growth and the second graph plots private demand growth and the credit impulse. Both credit series appear to be highly correlated with private demand growth. However, at a number of instances, most notably in the recession in the early 90s, the credit growth series seems to lag the private demand growth series while the credit impulse series moves contemporaneously with it.

In order to investigate this more comprehensively, we estimate a number of simple regressions. Note that we are not attempting to disentangle the causality between credit and GDP with these regressions but that we merely argue that it is the flow of credit rather than the stock of credit that is the relevant measure of credit. Instead of a system of equations we therefore restrict our attention to a reduced form regression. The parameter estimated in this regression is

Figure 5: U.S. demand growth, credit growth and the credit impulse



Note: The graphs show U.S. growth in consumption and investment together with credit growth in the first plot and the credit impulse in the second plot.

a combination of the parameters in a system. As we show in Appendix C, the reduced form parameter will be zero only if no relationship between the economic activity and the respective measure of credit exists. Furthermore, standard t-tests can be applied to test whether a relationship in any direction exists against the alternative that no relationship in either direction exists.

The intuition presented above suggests that both credit growth and credit impulse will be correlated with economic growth but their influence will vary in different periods: when credit growth is stable it will be correlated with economic growth. However, during periods following abrupt changes in credit growth the correlation with economic growth should weaken and the credit impulse should be correlated much more closely with economic growth. We therefore estimate the following equation. First, we regress demand growth on credit growth and credit impulse using all observations:

$$y_t = \beta_0 + \beta_1 d_t + \beta_2 ci_t + \varepsilon_t \tag{7}$$

where y_t is private demand growth, d_t is credit growth, ci_t is the credit impulse, and t, $t = 1, 2, \ldots, T$, denotes time.

Second, in order to assess whether the credit impulse is more important during recoveries from downturns than credit growth, we estimate (7) for quarters where growth is increasing after having been below 1% in the previous quarter, that is, we select observations where $y_{it} > y_{i,t-1}$ and $y_{i,t-1} < 0.01$. Finally, we estimate (7) for non-recovery periods, that is, where $y_t > 0.01$ and $y_{t-1} > 0.1$. The thresholds were chosen such that enough observations remained when considering recessions. The results appear robust to variations of the threshold. Note that we are interested in the conditional results and correction for sample selection is therefore not necessary.

Table 1 reports the results from the regressions. The first column shows the results of a regression over the entire sample. As expected both variables have significant parameters. The second column shows the regression results for the recovery periods. While there are fewer recovery observations, it is notable that the credit growth parameter becomes insignificant while the credit impulse parameter remains positive and significant. This suggests that even during periods of economic recovery from recessions that were not related to a financial crisis the credit impulse is the more appropriate measure of credit for economic growth. Finally, the results for the non-recovery period are in the third column. They

Table 1: Regression results for U.S. quarterly data

	full sample	recovery	non-recovery
credit growth	0.329	−0.043	0.280
	(4.573)	(0.421)	(4.380)
credit impulse	0.687	0.648	0.702
	(6.131)	(4.713)	(7.132)
T	217	19	173

The table shows the results of OLS regressions with quarterly C+I growth as the l.h.s. variable. The sample contains 217 quarterly observations from 1954Q4 to 2008Q4. Recovery periods are defined as periods of increasing growth following GDP growth of less than 1%. Non-recovery periods are characterized by growth of more than 1% in the current and the previous period. In brackets are absolute t-statistics based on Newey-West HAC standard errors. T denotes the number of observations. All regressions additionally contain an intercept.

suggest that the credit impulse is an important determinant of economic activity also during periods of economic expansion.

The findings from these regressions confirm the intuition presented above that the credit impulse is an important variable at all times but credit growth is relevant only during normal periods. Expressed in terms of levels, this implies that consumption and investment are strongly related to new credit, and this relationship is even more important during recovery periods.

6 Conclusion

This paper shows that a rebound in economic activity is closely related to a rebound in the flow of credit, rather than the stock of credit. The flow of credit can rebound even when the stock continues to decline. Not only does this point hold empirically, but it is also a logical if overlooked implication of standard macroeconomic models of credit.

This result leaves open a number of questions, such as whether it is the supply of credit, the demand for credit or both that is so drastically reduced during a recession and that drives the high correlation during a recovery, and why the supply or demand dries up and then recovers. While we leave these questions for future research, this paper suggests that these are important questions as credit in the form of new credit remains closely related to economic activity during periods of economic recovery.

A The model of Monacelli (2009)

Here we provide a condensed description of the model of Monacelli (2009). We refer readers to the original article and Sterk (forthcoming) for further details.

Firms produce final goods with the production function

$$Y_{jt} = \left(\int_0^1 Y_{jt}(i)^{(\varepsilon_j - 1)/\varepsilon_j} \mathrm{d}i \right)^{(\varepsilon/(\varepsilon_j - 1)}, \quad j = c, d,$$

where Y_{jt} is the quantity of final goods, which are either durable goods, d, or non-durable goods, c, and are produced using intermediate goods, $Y_{jt}(i)$ with elasticity of substitution ε_j. The intermediate goods are produces with labor input only $Y_{jt}(i) = N_{jt}(i)$, where $N_{it}(i)$ is the labor demand for the intermediate good i.

Households with lower discount factors, called "borrowers", which make up a share ω of the economy, maximize $\mathrm{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U(X_t, N_t) \right]$, where $U(X_t, N_t) = \log(X_t) - \nu N_t^{1+\phi}/(1+\phi)$, and $X_t = \left[(1-\alpha)^{1/\eta} C_t^{(\eta-1)/\eta} + \alpha^{1/\eta} D_t^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)}$ is bundle of consumption goods, consisting of durable goods, D_t, and non-durable goods, C_t, and elasticity of substitution, η. In the calibrations, the weight of durables, α, is set such that the amount of durables in the consumption basket is 0.2. Borrowers optimize subject to

$$\begin{aligned} P_{ct} C_t + P_{dt} I_{dt} + R_{t-1} B_{t-1} &= B_t + W_t N_t, \\ D_t &= (1-\delta) D_{t-1} + I_{dt}, \\ R_t B_t &\leq (1-\chi)(1-\delta) \mathrm{E}_t (D_t P_{d,t+1}), \end{aligned} \tag{8}$$

where P_{dt} is the price of durable goods, P_{ct} that of non-durable goods, I_{dt} the amount of durables purchased, R_t the nominal interest rate, B_t the nominal amount of debt, W_t the nominal wage, δ is the depreciation rate, and χ is the collateral requirement.

Households with higher discount rate, called "savers", maximize an identical utility function but with a higher discount rate, $\gamma > \beta$. They are also not subject to the borrowing constraint (8). They own the firms and receive the profits.

Table 2: Parameter values for simulation of the Monacelli (2009) model

Parameters	β	γ	δ	ε_c	ε_d	η	ξ_π	ω	ρ	χ	ϕ
Values	0.98	0.95	0.01	6	6	1	1.5	0.5	0.5	0.25	1

Goods markets and credit markets clear. Monetary policy is conducted according to the rule

$$\frac{R_t}{R} = \left(\frac{\tilde{\pi}_t}{\tilde{\pi}}\right)^{\xi_\pi} \exp(\varepsilon_t), \quad \exp(\varepsilon_t) = \exp(\varepsilon_{t-1})^\rho u_t,$$

where $\tilde{\pi}_t$ is the composite inflation level, and R and $\tilde{\pi}$ are the steady state level of the interest rate and the inflation rate. The monetary policy shock, ε_t is stationary with $0 < \rho < 1$ and $u_t \sim iid$.

B Data appendix

Data for systemic sudden stops in emerging markets and for the U.S. Great Depression The data were kindly provided to us by Guillermo Calvo. The 22 systemic stops are: Argentina (1982, 2002), Brazil (1983), Chile (1983) Cote d'Ivoire (1984), Ecuador (1999), Indonesia (1998), Malaysia (1998), Mexico (1983, 1995), Morocco (1995), Nigeria (1984), Peru (1983), South Africa (1983), South Korea (1998), Thailand (1998), Turkey (1994, 1999), Uruguay (1984), Venezuela (1983), El Salvador (1982), and Russia (1998), where the year in brackets is the trough of each crisis, and crisis dates have been determined by Calvo et al. (2006a).

For each crisis volume indices of GDP and credit are available. We follow Calvo et al. (2006a) and use the data in levels. For the systemic sudden stop episodes they construct the average GDP level and the average level of credit, both as volume indices with the values at the respective trough of the crisis set to 100. Hence, we compare the level of GDP to the level of credit, D_t, and to the flow of new credit defined as $D_t - D_{t-1}$.

Big five banking crises data Ideally, the credit measures should be based on the broadest possible measure of credit, and should capture only credit extended to the non-financial private sector. Such data are easily available in the countries that produce flow of funds statements (US, Japan, and the UK) but not in most others. For those without flow of funds statements, we use net credit extended by the banking sector to non-financial corporations, households, and non-profit institutions. Furthermore, we measure only credit extended to the private sector and, where possible, plot this against private sector real domestic demand growth.

- **Real consumption, real investment, and nominal GDP**
  Finland: Statistics Finland via Haver Analytics;
  Japan: from Economic Planning Agency National Accounts SNA68;
  Norway: Statistik Sentralbyra;
  Spain: Instituto National de Estatistica;
  Sweden: Statistics Sweden via Haver Analytics.

- **Credit**
  Finland: IMF IFS line 32;
  Japan: Bank of Japan, Economic Statistics Monthly Table "Financial assets and liabilities accounts";
  Norway: Norges Bank and IMF;
  Spain: Banco de Espaa;
  Sweden: Sweden: IMF IFS line 32.

- **GDP deflator**
  For all countries the data are from the IMF IFS line 99.

We construct volume indices for consumption and credit as

$$C_t + I_t = 100 \sum_{i=1}^{N} \frac{(C^r_{it} + I^r_{it})}{(C^r_{it_0} + I^r_{it_0})}, \tag{9}$$

where C^r_{it} is real consumption and I^r_{it} real investment for country i at time t, $i = 1, 2, \ldots, N$, for $N = 5$ countries, and the subscript t_0 denotes the observation in the trough of the crises. Similarly, credit is

$$D_t = 100 \sum_{i=1}^{5} \frac{D_{it}/P_{it}}{D_{it_0}/P_{it_0}}, \tag{10}$$

where D_t is nominal credit and P_t is the GDP deflator.

U.S. post-war data The credit data for the U.S. post-war period are obtained from the Federal Reserve Boards flow of funds data, Table F.1 "Total Net Borrowing and Lending in Credit Markets" and are the sum of lines 3–6. The GDP data are from the Bureau of Economic Analysis, nominal GDP from Table 1.1.5, line 1, real consumption and investment from Table 1.1.6, line 2 and 6, and the GDP deflator from Table 1.1.4 line 1.

The variables are constructed as follows. Private demand growth is

$$y_t = 100 \frac{Y^r_t - Y^r_{t-4}}{Y^r_{t-4}},$$

where $Y^r_{t-4} = \frac{1}{4} \sum_{i=0}^{3} (C^r_{t-i} + I^r_{t-i})$, C^r_t is real consumption and I^r_t real investment, and credit growth is

$$d_t = 100 \frac{D_t/P_t - D_{t-4}/P_{t-4}}{D_{t-4}/P_{t-4}},$$

where D_t is nominal credit and P_t is the GDP deflator. Finally, the credit impulse is defined as

$$ci_t = 100 \left(\frac{D_t - D_{t-4}}{\frac{1}{4} \sum_{i=0}^{3} Y^n_{t-i}} - \frac{D_{t-4} - D_{t-8}}{\frac{1}{4} \sum_{i=0}^{3} Y^n_{t-4-i}} \right),$$

where Y^n_t is nominal GDP.

C Mathematical Appendix

We will show that OLS applied to one equation in a simultaneous equations model leads to a parameter estimate that, while biased, is only zero if both structural parameters are zero. We further show that the t-statistic of the OLS parameter from one equation is the appropriate test statistic to test whether both parameters are zero.[1]

Consider the model

$$y_t = \beta x_t + \varepsilon_t, \quad \varepsilon_t \sim \text{iid}\,\text{N}(0, \sigma_\varepsilon^2), \tag{11}$$

$$x_t = \gamma y_t + \eta_t, \quad \eta_t \sim \text{iid}\,\text{N}(0, \sigma_\eta^2), \tag{12}$$

where y_t and x_t are observed scalar variables, β and γ the structural parameters, and $t = 1, 2, \ldots, T$ indicates the observations.

It follows that

$$x_t = \gamma(\beta x_t + \varepsilon_t) + \eta_t = \frac{\gamma\varepsilon_t + \eta_t}{1 - \beta\gamma},$$

and therefore $\text{E}(x_t\varepsilon_t) = \gamma\sigma_\varepsilon^2/(1 - \beta\gamma)$. The asymptotic estimate of β when OLS is applied to (11) is therefore

$$\hat{\beta} = \beta + \sigma_x^{-2}\frac{\gamma\sigma_\varepsilon^2}{1 - \beta\gamma} = \beta + b,$$

where $\sigma_x^2 = \text{E}(x_t^2)$, and b is the bias of the OLS estimate due to the endogeneity. Using $\beta = \hat{\beta} - b$, we have that

$$y_t = \hat{\beta}x_t - bx_t + \varepsilon_t = \hat{\beta}x_t + u_t. \tag{13}$$

[1] We thank Jerzy Niemczyk for suggesting this simplification of our initial the proof. See Kiviet and Niemczyk (2007) for a more general treatment of OLS under endogeneity.

Furthermore,

$$
\begin{aligned}
\mathrm{E}(x_t u_t) &= \mathrm{E}[x_t(-bx_t + \varepsilon_t)] \\
&= \mathrm{E}\left[x_t(-\sigma_x^{-2}\frac{\gamma\sigma_\varepsilon^2}{1-\beta\gamma}x_t + \varepsilon_t)\right] \\
&= -\frac{\gamma\sigma_\varepsilon^2}{1-\beta\gamma} + \mathrm{E}(x_t\varepsilon_t) = 0.
\end{aligned}
$$

Therefore, the Gauss-Markov conditions hold for (13). Also note that u_t in (13) is asymptotically normal as it is a linear combination of the underlying normally distributed errors from the structural equations (11) and (12). Given that the Gauss-Markov conditions hold, the t-statistic based on $\hat{\beta}$ and $\hat{\sigma}_\beta^2 = \hat{\sigma}_u \left(\sum_{t=1}^T x_t^2\right)^{-1}$, where $\hat{\sigma}_u = \frac{1}{T-1}\sum_{t=1}^T (y_t - \hat{\beta}x_t)^2$ and $\hat{\sigma}_\beta^2$ is an estimate of the variance of $\hat{\beta}$, is the appropriate test for $H_0 : \hat{\beta} = \beta_0$. From (13) it follows that $\hat{\beta}$ is only zero if both β and γ are zero, that is, there is no causal link between y_t and x_t in either direction.

References

Basel Committee on Banking Supervision (2004) 'Bank failure in mature economies.' BIS *Working Paper* 13

Bernanke, Ben S. (1983) 'Nonmonetary effects of the financial crisis in the propagaion of the great depression.' *American Economic Review* 73(3), 257–276

Bernanke, Ben S., and Alan S. Blinder (1988) 'Credit, money, and aggregate demand.' *American Economic Review Papers and Proceedings* 78(2), 435–439

Bernanke, Ben S., and Mark Gertler (1989) 'Agency costs, net worth, and business fluctuations.' *American Economic Review* 79(1), 14–31

Calvo, Guillermo A., Alejandro Izquierdo, and Ernesto Talvi (2006a) 'Phoenix miracles in emerging markets: Recovering without credit from systemic financial crises.' NBER *Working Paper* 12101

—— (2006b) 'Sudden stops and Phoenix miracles in emerging markets.' *American Economic Review* 96(2), 405–410

Claessens, Stijn M., Ayhan Kose, and Marco E. Terrones (2008) 'What happens during recessions, crunches and busts?' IMF *Working Paper* 08/274

Driscoll, John C. (2004) 'Does bank lending affect output? Evidence from the U.S. states.' *Journal of Monetary Economics* 51(3), 451–471

Greenwald, Bruce C., and Joseph E. Stiglitz (1993) 'Financial market imperfections and business cycles.' *Quarterly Journal of Economics* 108(1), 77–114

International Monetary Fund (2009) *World Economic Outlook: Crisis and Recovery* (IMF)

Kiviet, Jan F., and Jerzy Niemczyk (2007) 'The asymptotic and finite sample distributions of OLS and simple IV in simultaneous equations.' *Computational Statistics and Data Analysis* 51(7), 3296–3318

Kiyotaki, Nobuhiro, and John Moore (1997) 'Credit cylces.' *Journal of Political Economy* 105(2), 211–248

Monacelli, Tommaso (2009) 'New Keynesian models, durable goods, and collateral constraints.' *Journal of Monetary Economics* 56(2), 242–254

Peek, Joe, Eric S. Rosengren, and Geoffrey M. B. Tootell (2003) 'Identifying the macroeconomic effect of loan supply shocks.' *Journal of Money, Credit and Banking* 35(6), 931–946

Reinhart, Carmen M., and Kenneth S. Rogoff (2008) 'Is the 2007 US subprime financial crisis so different? An international historical comparison.' *American Economic Review* 98(2), 339–344

Sterk, Vincent (forthcoming) 'Credit frictions and the comovement between durable and non-durable consumption.' *Journal of Monetary Economics*