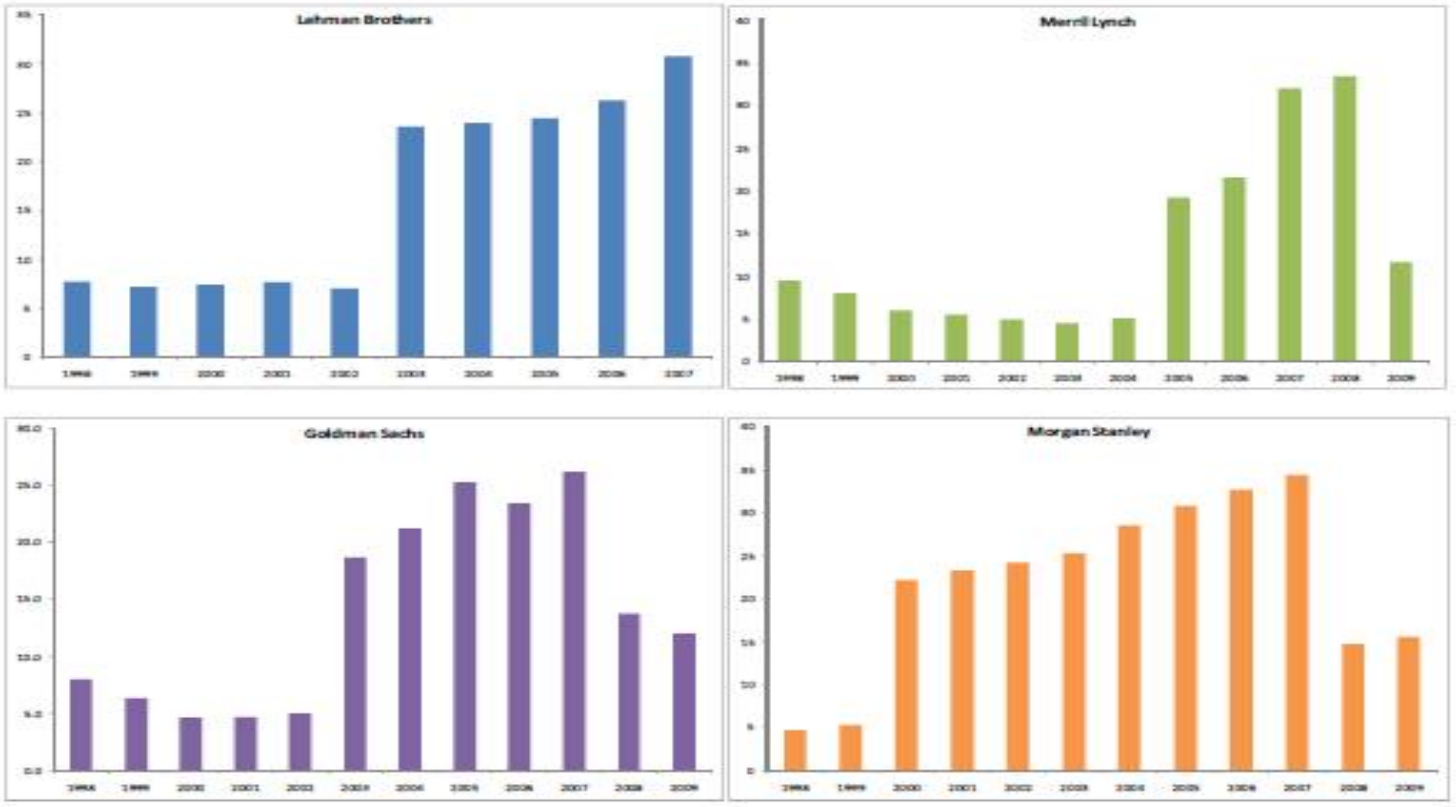
Chapter 6
Financial Crises

Leverage

- The leverage of a firm or a bank is measured by the ratio of its assets over equity (i.e. net worth).
- Leverage ratios were low (i.e. below 10) in the late 1990s and early 2000s (see figure - Morgan Stanley being an exception). By 2003-2004, leverage ratios were clearly on the up rise and by 2007 had reached 30.
- Out of these four banks, only two survived the financial crisis – Goldman Sachs and Morgan Stanley – though they converted to commercial banks, Lehman Brothers filed for bankruptcy and Merril Lynch was bought by Bank of America.

Leverage

Figure 1. Leverage ratios



Source: SEC Annual Report (Form 10-K) filed by each company each year

Leverage

- Very low interest rates combined with the ability to pool risk by securitizing mortgages and the perception that housing prices would keep rising gave financial institutions strong incentives to make profits on borrowed money.
- It is clear in retrospect that large financial institutions were not internalizing any systemic risk derived from their own actions.

The arithmetic of leverage

- Let the balance sheet of a financial institution be given by

Balance Sheet	
qk	d
	n

  - where k is the stock of a certain asset, q is the price of the asset, d is debt, and $n = qk - d$ is net worth. The leverage ratio is defined as $\theta = qk/n$.
  - Let r the interest on debt, The expected return on the asset is $r* = \frac{\Delta q}{q}$.

The arithmetic of leverage

- The expected return of the financial institution on its net worth is

$$\frac{(k\Delta q - rd)}{n} = \frac{r * qk - rqk + rn}{n} = \theta(r *- r) + r$$

  - If the leverage ratio is equal to 40, the financial institution will make a return on its wealth equal to the interest rate plus 40 times the spread between the return on the asset and the interest rate.
  - If the price of the asset increases by 3.5 percent, and the interest rate is equal to 1 percent, the return for the financial institution is 101 percent.
  - If the price of the asset decreases by 1.5 percent the return for the financial institution is -99 percent.

The arithmetic of leverage

- In the former case, the net worth of the financial institution is almost wholly erased. Imagine if the price of the asset decreased by 5 percent!

- Why do financial institutions accept such a risky (but lucrative with a bit of luck) gamble? CV presents a model of a small open economy with two periods. The productivity of capital is constant. Households finance the capital in the second period on their own wealth and by borrowing from the international market. The productivity of capital in the second period is uncertain and can be above or under the world interest rate.

The arithmetic of leverage

- Then, CV establishes with his model that the stock of capital in the second period and the leverage of the economy (i.e. of its households) increases with the *expected value* of the productivity of capital in the second period. They decrease with the dispersion (standard deviation) of this productivity, with the households' risk aversion and with the interest rate.
- The early 2000s were a period of reduced uncertainty (because of the ability to pool risk by securitizing mortgages), low interest rate, good economic prospects and high tolerance for risk (because the Fed or the ECB or the government will help you in case of difficulties). Hence, the model gives a good explanation of the increase in leverage.

The arithmetic of leverage

- CV presents a second model inspired by an idea of Krugman. The model has two agents: households and financial institutions. Financial institutions are subject to a leverage constraint whereby the value of their assets cannot exceed a certain proportion of their net worth. When the leverage constraint is binding, the financial institution's demand for assets is a *positive* function of the price of the asset.
- Intuitively, a rise in the price of the asset increases the value of the asset. Thus it increases net worth, and allows for further purchases of the asset in question.

The arithmetic of leverage

- A positively-sloped demand for the asset implies that, in response to a negative demand shock to the households that puts downward pressure on asset price, the degree of leverage magnifies the fall in asset price.
- This model can thus rationalize a steep fall in asset prices in response to a shock that, in and of itself, might only have led to a small fall in asset prices.

The arithmetic of leverage

- More precisely, in the first period the balance sheet identity is, as before:

$$n_0 = q_0 k_0 - d_0$$

  - The balance sheet in the second period is:

$$n_1 = q_1 k_1 - d_1$$

  - The leverage constraint is $q_1 k_1 = \theta(q_1 k_0 - d_0)$
  - This constraint means that the value of the assets demanded in the second period is the fraction θ of the value of the net worth, inherited from the first period, evaluated with the price of the second period.

The arithmetic of leverage

- Finally, the demand of asset in the second period by the financial intermediary is

$$k_1 = \theta\left(k_0 - \frac{d_0}{q_1}\right)$$

This function is increasing in the price of the asset.

- The more leveraged the economy, the larger the effect on asset prices caused by a negative demand shock.
- This model could explain the dramatic fall in housing prices starting in mid-2006.

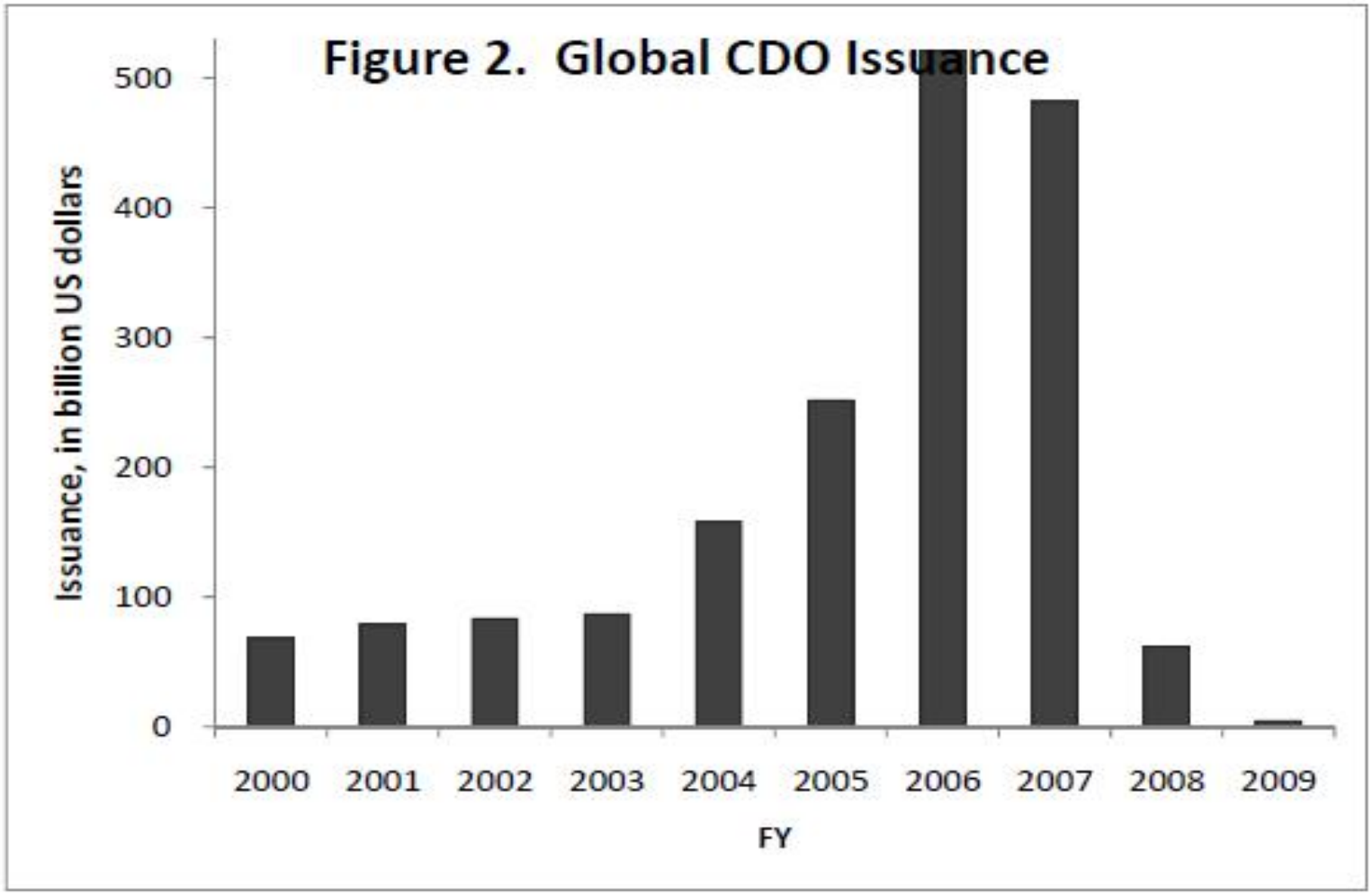
Mortgages and CDOs

- According to Calvo a key ingredient of the financial crisis in the United States was the development of a « shadow » banking system that grew very large and without supervision. This shadow banking system succeeded in « printing money » through financial innovations such as colletarized debt obligations (CDOs).
- CDOs are a type of asset-backed security whose value and payments are derived from a portfolio of fixed-income underlying assets. They are typically sliced into different « tranches » depending on the level of risk. CDOs were first created in 1987 by Drexel Burnham Lambert, a defunct dealer in junk bonds.

Mortgages and CDOs

- This process greatly increased the degree of liquidity or "moneyness" associated with the underlying asset.
- The figure plots global CDO issuance in billion of dollars for the period 2000-2009. CDO issuance peaked in 2006 at around 520 billion dollars. It plummeted in 2008 to around 62 billion dollars.

Mortgages and CDOs



Mortgages and CDOs

- CV presents a model, which is a little difficult but very convincing. I have simplified the model a bit.
  - I consider a small open economy with only one tradable good. The economy operates under fixed exchange rate, set to one, and the price of the good is assumed to be one. Money is modeled as yielding liquidity services that provide utility.
  - The consumer lifetime utility is given by

$$\int_0^{\infty} [u(c_t) + v(m_t + \eta_t p_t \ell_t)]\, e^{-\beta t} dt,$$

  - c is consumption, m are interest-bearing money balance, l is land, p is the price of land and $0 < \eta < 1$ captures the degree of liquidity of land (land is less liquid than money). The functions u and v are increasing and concave

Mortgages and CDOs

- Consumers' total assets are

$$a_t \equiv b_t + p_t l_t + m_t.$$

b represents international bonds with constant return r

- Production takes the linear form $y_t = \rho l_t.$
- The consumer's flow constraint reads as

$$\dot{a}_t = rb_t + (\rho + \dot{p}_t)l_t - c_t + i_t m_t$$

where i_t is interest paid on money balances

We have the identity

$$a_0 + \int_0^{\infty} (\dot{a}_t - ra_t)e^{-rt}dt = a_0 + |a_t e^{-rt}|_0^{\infty} = 0$$

(we have used the transversality condition: $\lim_{t\to+\infty} a_t e^{-rt} = 0$)

Mortgages and CDOs

- We deduce from this identity, the consumer's flow constraint and the consumers' assets identity, the consumer's lifetime budget constraint:

$$a_0 + \int_0^{\infty} [(\rho + \dot{p}_t - rp_t)l_t - c_t - (r - i_t)m_t]e^{-rt}dt = 0$$

- The consumer chooses $\{c_t, m_t, l_t\}$ to maximize his lifetime utility subject to his intertemporal budget constraint. Setting up the Lagrangean:

$$\int_0^{\infty} [u(c_t) + v(m_t + \eta_t p_t l_t)]\, e^{-\beta t} dt,$$

$$+\lambda\left\{a_0 + \int_0^{\infty} [(\rho + \dot{p}_t - rp_t)l_t - c_t - (r - i_t)m_t]e^{-rt}dt\right\}$$

Mortgages and CDOs

- Assuming that $\beta = r$ (equivalent to the condition $(1 + r)\beta = 1$ for a model written in discrete time as in chapters 1, 2 and 3), the three foc are:

$$u'(c_t) = \lambda$$
$$v'(m_t + \eta_t p_t l_t) = \lambda(r - i_t)$$
$$v'(m_t + \eta_t p_t l_t)\eta_t p_t = -\lambda(\rho + \dot{p}_t - r p_t)$$

- The first equation means that the consumption flow is wholly smoothed: $c_t = \bar{c}$
- The central bank holds its assets in international bonds h_t. Its liabilities are equal to the money balance of the consumers m_t. Its flow budget constraint is

$$\dot{h}_t = r h_t + \dot{m}_t - i_t m_t$$

Mortgages and CDOs

- The overall stock of land is fixed, so equilibrium in the land market requires that

$$l_t = \bar{l}$$

- Combining the consumer's and the central bank's flow constraints (slides 17 and 19), we obtain

$$\dot{a}_t + \dot{h}_t = r(b_t + h_t) + (\rho + \dot{p}_t)\bar{l} + \dot{m}_t - c_t$$

- As the derivation of the consumer's total wealth identity (slide 17) is

$$\dot{a}_t = \dot{b}_t + \dot{p}_t\bar{l} + \dot{m}_t$$

The economy's flow constraint is

$$\dot{b}_t + \dot{h}_t = r(b_t + h_t) + \rho\bar{l} - \bar{c}$$

Mortgages and CDOs

We have the identity

$$b_0 + h_0 + \int_0^\infty \left(\dot{b}_t + \dot{h}_t - rb_t - rh_t\right)e^{-rt}dt = 0$$

Hence

$$b_0 + h_0 + \int_0^\infty (\rho\bar{l} - \bar{c})e^{-rt}dt = 0$$

Finally the consumer consumes

$$\bar{c} = r(b_0 + h_0) + \rho\bar{l}$$

- The central bank sets the value of the interest rate paid on money balances, Assume that it is set at the constant value $i < r$.
- Assume that the liquidity of land is constant over time, η

Mortgages and CDOs

- We divide the 3rd foc by the 2nd foc (slide 19)

$$\eta p_t = -\frac{\rho + \dot{p}_t - r p_t}{r - i}$$

- We have the differential equation

$$\dot{p}_t = [(1-\eta)r + \eta i]p_t - \rho$$

The only non diverging solution of this equation is

$$p_t = \bar{p} \equiv \frac{\rho}{r - \eta(r-i)}$$

- We divide the 2nd foc by the 1st foc

$$\frac{v(m_t + \eta \bar{p} \bar{l})}{u'(\bar{c})} = r - i$$

Mortgages and CDOs

- The money balance held by the consumer is

$$m_t = \bar{m} = v'^{-1}[(r - i)u'(\bar{c})] - \eta\bar{p}\bar{l}$$

- Suppose that starting from this equilibrium there is an unanticipated and permanent increase in η that is in the liquidity of land. The economy immediately adjusts to a new stationary equilibrium . We deduce from the previous equations that
  - $\bar{p}$, the price of land increases (slide 22).
  - $\bar{c}$ consumption is unchanged (slide 21).
  - $\bar{m}$, the consumer's money balance decreases.

Mortgages and CDOs

- As emphasized by Calvo, this experiment captures an essential element of the rise in housing price before the fall of Lehman in September 2008. The creation of new instruments (such as CDOs) increased the liquidity associated with land or derivatives of land.
- Consider an unanticipated and permanent fall in the interest rate paid on money balance *i*.
  - $\bar{p}$, the price of land increases (slide 22).
  - $\bar{m}$, the consumer's money balance decreases (slide 23).
  - The reduction in *i* implies that the opportunity cost of holding money balance $r - i$ increases. As a result, households shift away from money and toward land. This increases the price of land.

Mortgages and CDOs

- This exercise offers a rationale for the extremely loose policy implemented by the Federal Reserve since the fall of Lehman and the drop in housing prices.
- This exercise also illustrates the idea that easy monetary policy on the part of the Federal Reserve might have caused the housing price bubble that eventually led to the financial crisis of 2008, as argued by John Taylor.

Mortgages and CDOs

- Alan Greenspan, head of the Federal Reserve during the bubble disagrees with this view. His argument is that housing prices are determined by long-term interest rates and that the relationship between the federal fund rate (controlled by the Fed) and long-term market interest rates was tenuous at best during 2002-2005 when the increase in housing price was the largest. Actually, long-term interest rates could not have been influenced by orthodox monetary policy.

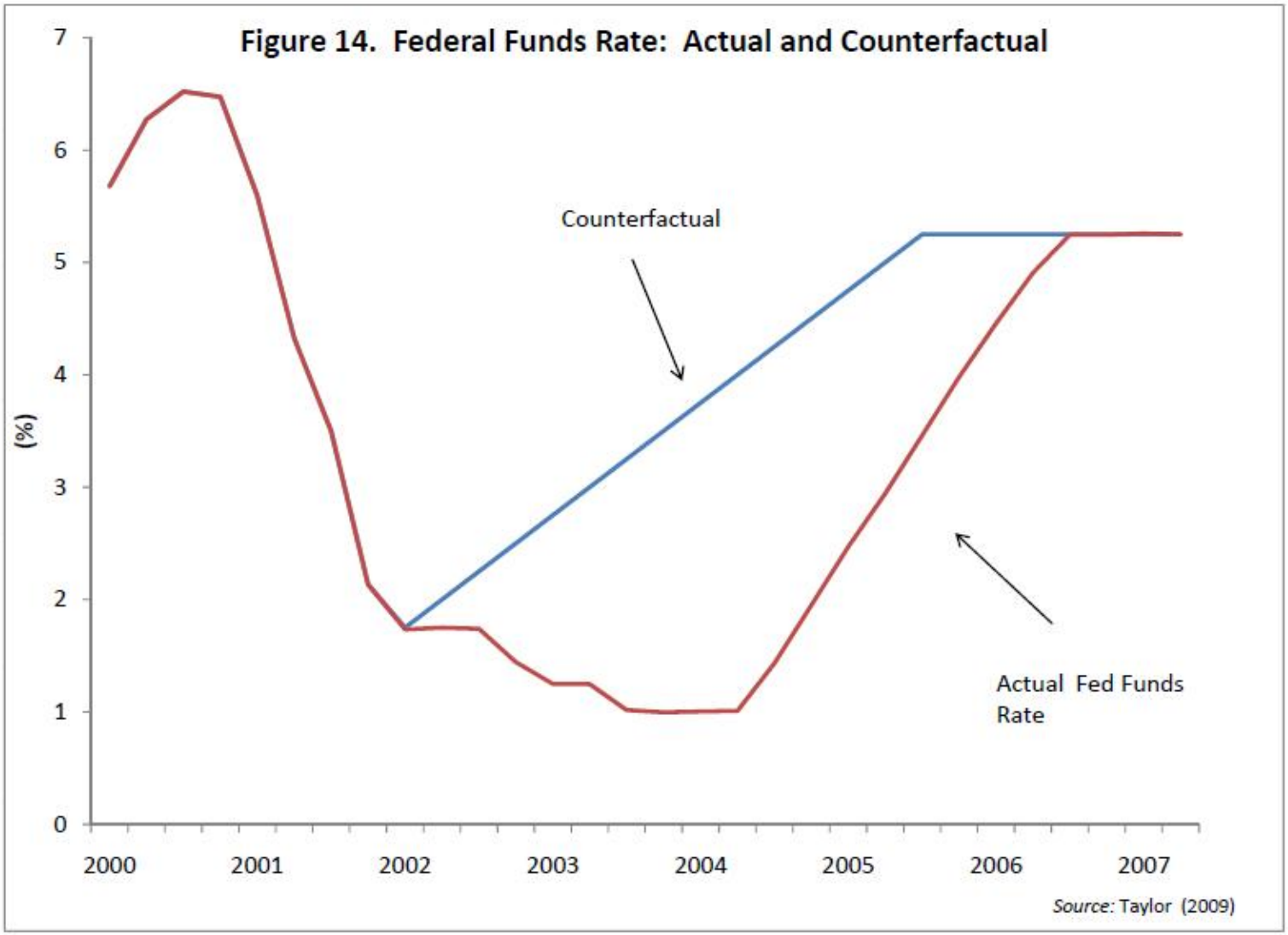
Mortgages and CDOs

- For Greenspan the decline in long-term interest rates was due to an increase in saving in the developing world and to a decline in investment in the developed world. Low interest rates led to excessive leverage, which proved unsustainable.
- In Taylor's view, had the Federal funds rate been higher, the bubble would not have occurred and the crisis would have been avoided. In Greenspan's view, preventing the bubbles was unfeasible, because it was driven by over-optimism by the buyers about future housing prices.

Decoupling and recoupling

- The trigger for the global financial meltdown of 2008-2009 was the crisis in the U.S. subprime real estate sector.
  - The expression "subprime" loans (as opposed to prime loans) refers to those mortgages that carried a high probability of default Most of these loans were adjustable-rate mortgages and were often bundled together (i.e. securitized) with the purpose of diversifying risk.
  - The rise in U.S. interest rate from about 1 to 5 percent between mid-2004 and 2006 (see figure) combined with lax lending standards led to a wave of defaults on mortgages, particularly in the subprime sector, that led to a sever slowdown in the housing market.

Decoupling and recoupling

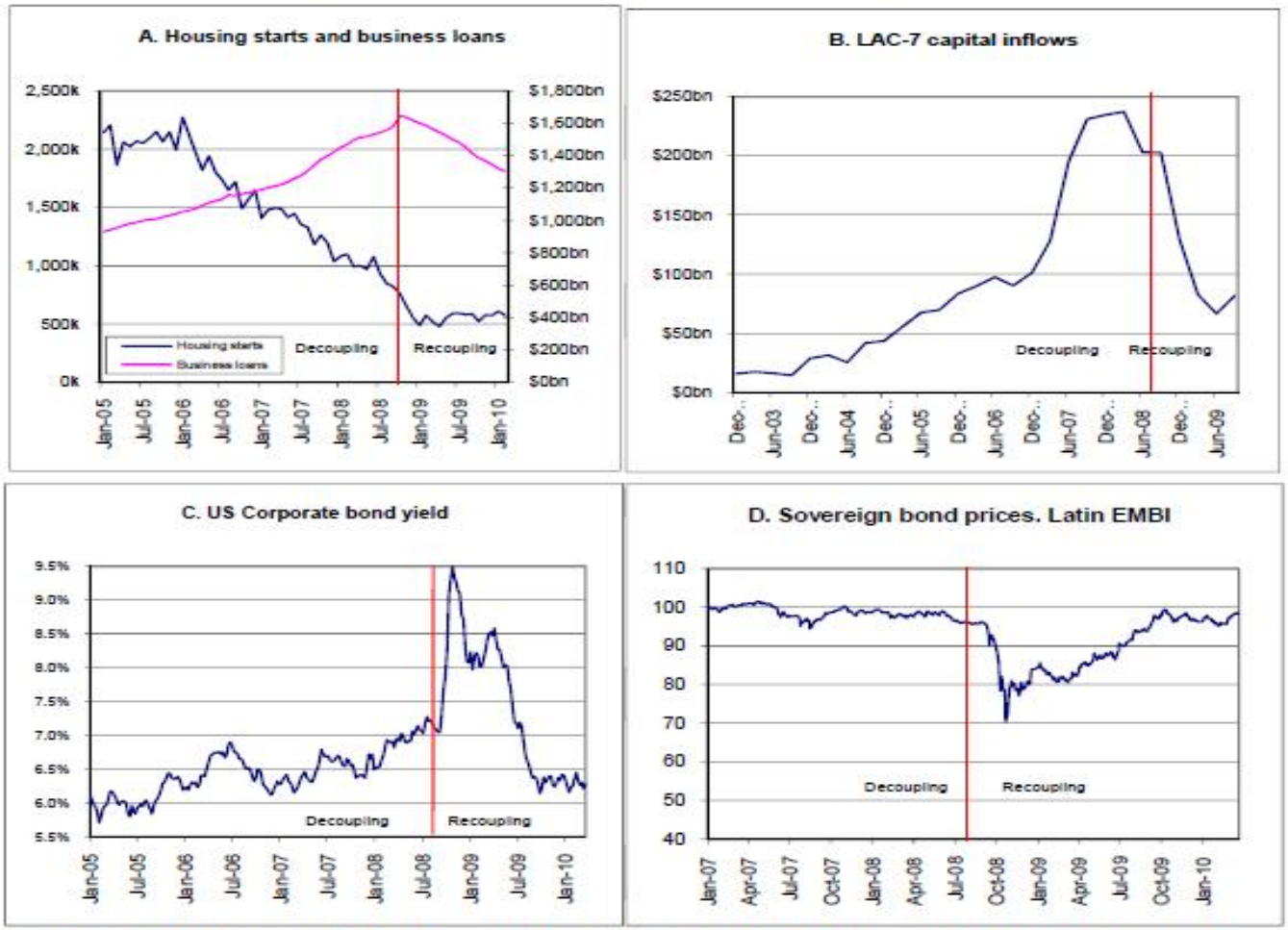


Decoupling and recoupling

- In panel A, housing starts peaked in early 2006 and fell dramatically thereafter.
- Until around May 2008, the crisis unfolding in the subprime sector did not affect the rest of the U.S. economy or foreign countries. In panel A, business loans in the United States continued to grow strongly throughout this period. Capital inflows to LAC-7 (the biggest economies in Latin America) increased more rapidly (panel B). Corporate yields and sovereign bond prices remained relatively stable during this period (panels C and D).

Decoupling and recoupling

Figure 16. The decoupling-recoupling phenomenon



Sources: Federal Reserve Bank of St. Louis, U.S. Census Bureau, and Inter-American Development Bank

Decoupling and recoupling

- This "decoupling" period was viewed at the time as a validation of sound macroeconomic policies pursued by emerging countries during the 2000s. It was even argued that the world economy would weather any significant slowdown in the United States because emerging markets would become the world's "growth locomotive".
- This view came to a halt around May 2008 and particularly after « Lehman « day » (September 15, 2008). Corporate bond yields in the U.S. skyrocketed (panel C) and sovereign bond prices plummeted (panel D). In emerging countries, the value of currencies and stock markets fell dramatically.

Decoupling and recoupling

- CV presents a model of decoupling and recoupling. It considers a globalized or world's household sector lending to two countries A (Brazil) and B (the United States). A negative shock in country B will, at first, be transmitted negatively because the shock decreases the borrowing needs of country B and thus leads to a fall in the world interest rate.
- If the shock becomes bigger, however, the country defaults and cannot repay the household, which decreases the amount of savings for any given interest rate. As a result country A also suffers. This leads to recoupling.
- There are historical evidences that episodes of contagion typically involve a common lender.

Decoupling and recoupling

- Country B could also be interpreted as the housing sector in the U.S. and country A as its manufacturing sector (decoupling and recoupling could also be observed between these two sectors in the last figure).
- The model is simple but a little tricky. It has two periods. The production in each country and period is a function of the stock of capital. The marginal productivity of capital is decreasing. In the first period the entrepreneurs of each country borrow from the world's households and invest this borrowing and their own wealth in productive capital. Country A (Brazil) is a country without any problem. The global productivity of capital in country B (the US) can take three values in period 1.

Decoupling and recoupling

1. The productivity of capital in country B is high. The entrepreneurs of country B can reimburse their debt and their wealth increases. In the second period, they can borrow as much as they like, the marginal productivity of capital is the same in countries A and B, and this common value sets the world interest rate.

Decoupling and recoupling

2. The productivity of capital in country B is lower. The entrepreneurs of country B can reimburse their debt, but their wealth decreases. The world's households limit their lending to a maximum leverage ratio. Thus, in the second period, the entrepreneurs of country B cannot borrow as much as in the first scenario. The world's households supply more lending to the entrepreneurs of country A. The interest rate and the marginal productivity of capital are lower in country A than in country B. The production of country A is higher than in the first scenario (decoupling).

Decoupling and recoupling

3. The productivity of capital in country B is still lower. The entrepreneurs of country B cannot reimburse a part of their debt. Hence, the world's households become poorer and can lend to country A less than in the first scenario. The interest rate and the marginal productivity of capital are higher, and output lower in country A (recoupling).

- The setting by lenders of a maximum leverage ratio is standard in macroeconomics. This constraint can be micro-founded by a moral hazard model, which is also standard and explained by CV.

Currency Crises

- A currency crisis is identified by quick and large changes in the exchange rate and reserves. We have had few currency crisis since the Argentine crisis of 2002. For this reason I will just sketch a very famous model of this kind of crisis developed by Krugman (chapter 16 by CV gives many more details).
- I consider a small open economy with only one tradable good. The price of this good is 1 in the rest-of-the world currency and p in the currency of the economy. So p is also the exchange rate that is the price of the foreign currency in local currency.
- Production y is exogenous and constant over time.

Currency Crises

- The inflation rate, which is the same at the depreciation rate of the local currency, is $\frac{\dot{p}}{p}$. The demand of real money balance is $\frac{M}{p} = a\left(1 + \frac{\dot{p}}{p}\right)^{-\varphi} y$, with $a,\ \varphi > 0$
- The balance-sheet of the central bank is $pR + T = M$, where T represents the loans of the central bank to the government and R the international reserves (in foreign money or bonds).
- Let G the government's deficit (measured in commodity units), which is exogenous and constant. Assume that it is financed by loans by the central bank (that is by printing money). We have $\dot{T} = pG$.

Currency Crises

- The economy starts in a first stage where the exchange rate is fixed and equal to one, and the exchange reserves are positive $p = 1$ and $R > 0$.
  - Then the quantity of money is $M = ay$ and is constant.
  - Hence $\dot{M} = 0 = \dot{R} + \dot{T} = \dot{R} + G$.
  - Finally, exchange reserves decrease over time: $R = R_0 - Gt$
  - They will become zero in finite time.
- In its final stage the economy will be in a flexible exchange rate system and the central bank will have no exchange reserves. The inflation rate and the currency depreciation rate are constant: $\varepsilon = \dot{p}/p$

Currency Crises

- The real money balance is constant $\frac{M}{p} = a(1+\varepsilon)^{-\varphi} y$
- The balance-sheet of the central bank becomes $T = M$. Hence $\dot{M} = \dot{T} = pG$
- As $\frac{\dot{M}}{M} = \frac{\dot{p}}{p} = \varepsilon$, and $\frac{\dot{M}}{M}\frac{M}{p} = G$, the inflation and depreciation rates ε are determined by $a\varepsilon(1+\varepsilon)^{-\varphi} y = G$ (this equation in ε has a unique positive solution if $\varphi < 1$).

- The crisis occurs when the central bank loses all its exchange reserves and is forced to give up the peg. Then, the real money balance $\frac{M}{p}$ held by the domestic residents jumps downward from ay to $a(1+\varepsilon)^{-\varphi} y$

Currency Crises

- The exchange rate p cannot jump. Otherwise, it would be possible to make huge profits by buying plenty of foreign money against local money just before the devaluation (when the exchange rare is still fixed) and selling it just after.
- Hence, the quantity of money balance jumps. Just before the crisis it is $R + T = ay$. Just after the crisis it is $T = a(1 + \varepsilon)^{-\varphi} y$.
- The day of the crisis there is a *run* on the exchange reserves of the central bank. The domestic residents sell $ay - a(1 + \varepsilon)^{-\varphi} y$ of domestic currency and exhaust the exchange reserves of the central bank. This speculative attack occurs though all events in the economy are perfectly anticipated.

Currency Crises

- The time of the crisis and the run, t, is given by $R_t = R_0 - Gt = ay - a(1+\varepsilon)^{-\varphi}y$. The run occurs at the point in time at which the run exactly depletes the central bank's international reserves.
- In this model the cause of currency crises are weak fiscal fundamentals.

Twin crises

- Kaminsky and Reinhart conducted an empirical analysis covering episodes in both advanced and developing countries for the period 1970-1995 (in addition to the Asian crises of 1997). The table shows the frequency distribution of currency and banking crises.
- The authors calculated the unconditional probability of either of these crises taking place in their sample. They also calculated conditional probabilities: does knowing that a banking crisis took place within the 24 months help predict a currency crisis? Then, the probability of a currency crisis conditional on a banking crisis would be greater than the unconditional probability of a currency crisis.

Twin crises

	Number of crises					
	1970-1995		1970-1979		1980-1995	
Type of crisis	Total	Average per year	Total	Average per year	Total	Average per year
Balance-of-payments	76	2.92	26	2.6	50	3.13
Twin	19	0.73	1	0.1	18	1.13
Single	57	2.19	25	2.5	32	2.00
Banking	26	1.00	3	0.3	23	1.44

Note: Episodes in which the beginning of a banking crisis is followed by a BOP crisis within 48 months are classified as twin crises.

Source: Kaminsky and Reinhart (1999)

Twin crises

- The table shows that knowing that a banking crisis took place increases the probability that a currency crisis will unfold: the unconditional probability of a currency crisis is 29 percent, whereas the probability conditional on the beginning of a banking crisis is 46 percent. Moreover, a banking crisis is more likely to take place after financial liberalization and the peak of a banking crisis usually follows a balance of payments crisis.
- We have the general pattern: financial liberalization, beginning of banking crisis, currency crisis, and peak of banking crisis.

Twin crises

Table 4. Probabilities of balance-of-payment and banking crises

Probabilities of balance-of-payment crises		Probabilities of banking crises	
Type	Value (in percent)	Type	Value (in percent)
Unconditional	29	Unconditional	10
Conditional on the beginning of a banking crisis	46	Beginning of a banking crisis conditional on a BOP crisis	8
Conditional on the peak of a banking crisis	22	Beginning of a banking crisis conditional on financial liberalization	14
		Peak of a banking crisis conditional on a BOP crisis	16

Source: Kaminsky and Reinhart (1999).

Twin crises

- The twin crises are a phenomenon of the 80s and 90s, being absent during the 70s when financial markets were repressed. The recent banking crises in Western Europe were not followed either by currency crises.
- CV develops a model, inspired from Velasco, where a financial crisis unfolds in a currency crisis. The model is very complicated, but its basic idea is simple.
- Take the Krugman's model of a currency crisis. But the government's deficit *G* is not simply assumed to be exogenous.

Twin crises

- The story starts with banks, which have borrowed at fixed rates and lent to risky businesses (e.g. the housing industry).
  - Things turn bad and the bank turn a permanent deficit and so find themselves with negative wealth.
  - At the beginning, they can survive by hiding their position and borrowing.
  - Soon, the weakness of their position is understood by everybody and they cannot borrow anymore.
  - In a second stage the banks are nationalized (this is the banking crisis). Then, their debt becomes public and their deficit is paid by their government.

Twin crises

- Hence, *G* in Krugman's model represents the deficit inherited from a failing bank system.
- As in Krugman's model, the government can keep its currency pegged for some time. But its exchange reserves vanish.
- When these reserves are low enough, they suffer a run, are quickly driven to zero, and the peg has to be abandoned (this is the currency crisis).