Macroeconomics of the Prolonged Slump

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Abstract

In a market-clearing economy, declines in demand from one sector do not cause large declines in aggregate output because other sectors expand. The key price mediating the response is the interest rate. A decline in the rate stimulates all categories of spending. But in a low-inflation economy, the room for a decline in the rate is small, because of the notorious lower bound of zero. I build a general-equilibrium model that focuses on the behavior of an economy when the nominal interest rate is pinned at zero. Equally important is that the real rate is pinned at a rate above the market-clearing rate because inflation responds only weakly to the presence of slack. I concentrate on two closely related sources of declines in demand: the buildup of excess stocks of housing and consumer durables and the corresponding expansion of debt that financed the buildup. The model introduces a new analysis of the rationing of customers in the output market when the interest rate is pinned at zero and connects the rationing to the labor market. It provides a coherent rationale for the common-sense notion that the reason that employers don't hire all available workers during a slump is that they don't have enough customers.

1 Introduction

Big events are the most informative about the structure of the economy. We have learned a great deal about the macroeconomics of big negative shocks over the past two years. Five of the important lessons are:

- The zero lower bound on the nominal interest rate matters a lot.
- Product price inflation slowed only slightly during the contraction and there was only a small tendency for inflation to fall by more for categories that saw the largest declines in sales volumes.
- Wage inflation was equally unresponsive to the large increase in unemployment.
- Declines in productivity had nothing to do with the huge contraction.
- More than two years past the financial shock of September 2008, the economy remains slack—in particular, unemployment is only barely below its maximum value.

A basic principle of my investigation of these issues and resulting model-building is that the past matters only through the values of the state variables of the economy. The ultimate goal is to build a coherent formal model that delivers a slump with 10 percent unemployment lasting several years, when started with values of its state variables in 2007.

The view that I push here has roots in both traditional and modern macro. The starting point is that the intertemporal market for goods now and goods later does not clear, but rather has excess supply of goods now and excess demand later because the real interest rate is too high. The failure for real interest rates to fall to a low enough level results in rationing of customers to suppliers.

One force that can trigger a recession or a depression is serious deflation. When prices begin to fall at 10 or 20 percent per year, as during the period from 1929 to 1933, the real rate accompanying the zero lower bound is far, far above the full-employment real rate and high unemployment would result even without any other adverse force. But the decline in inflation that occurred during the recession starting at the end of 2007 was no more than two percent. Extreme price stickiness in the face of large amounts of slack has saved the economy from a repetition of the experience of the Great Depression.

The contractionary force that I emphasize here is a familiar one—the buildup of housing and consumer durables stocks that occurred during the middle of the 2000s. I estimate that

the real stock of durables (a term I will use to include housing and consumer durables) was 14 percent higher in 2007 than it would have been if the conditions of the period from 1990 to 2000 had prevailed in that year. Thus, I take the initial level of the stock of durables to be 14 percent above its stationary level when solving the model. The high initial stock tends to make the initial interest rate lower than its stationary level. If inflation is close to zero or negative, the bound on the real interest rate could bind at the outset. That economy would start with excess unemployment.

Another state variable, consumer debt, rose during the 2000s. Durables secured most of the debt. Households had dissaved by taking on debt and using the proceeds to buy durables—new houses and new cars. The model starts with debt above its stationary value. As families work off their unusually high holdings of durables, they save by paying off the corresponding debt.

A third state variable, the stock of business capital, appears to have been at its stationary value in 2007. There was no impetus toward recession from business investment. Though investment fell during the recession, the model interprets this response as induced by a recession whose origins lay elsewhere and not the result of a business-related state variable that starts at a value different from its stationary value.

Starting with these state variables in 2007, the model goes into immediate recession—output is low and unemployment is high. The Fed tries to offset the recession by lowering the interest rate but cannot do more than drive its policy rate to zero, which leaves the economy still in a condition where people want to produce now but purchase later. The bulging stock of durables discourages further purchases and the overhang of consumer debt precludes higher purchases for a substantial fraction of households.

The model provides an account of a prolonged slump. The economy remains below full employment as long as the excess durable stock and accompanying debt persists and the zero bound on the interest rate continues to bind.

Stripped to its basics, the story of the paper is that in the years leading up to the slump, households borrowed much more than usual and used the proceeds to buy more houses and cars than usual. They used the credit market to speed up purchases—they bought first and planned to save later. In an economy without a floor on it real interest rate, households not subject to borrowing constraints would have taken over purchasing unusual volumes once the constrained households reached their saving phase. But the interest rate could not fall

far enough to induce that response. Instead, output fell and unemployment rose.

Of course, this story leaves out a lot. In particular, the crisis of September 2008 is portrayed as only a response to the more fundamental forces of overextended households and not a separate causal factor. In fact, the increase in financial frictions from the crisis surely made its own contribution. But it is important to bear in mind that effective but very expensive policies prevented a collapse of financial institutions. One should not confuse the grave concerns of the week of September 15, 2008, with the actuality of a Depression-like breakdown. In my view, the story of the the financial crisis is mostly one of what could have happened without aggressive countermeasures, not the source of an actual collapse.

2 The Lessons

2.1 The zero lower bound

Riskless short-term interest rates have been close to zero in the United States and many other countries since late 2008. The three-month Treasury bill rate in December 2008 was around 5 basis points and rose only to 16 basis points in May 2010. Further depression of these rates, to levels below zero, is impossible because investors have the alternative of holding paper money with a zero nominal return or, in some cases, reserves, which earn 25 basis points.

2.2 Prices and wages

The Great Recession brought slacker product markets to the U.S. economy than had existed at any time since the depression in the 1930s. A line of thought rather deeply embedded in macroeconomics holds that product prices fall in slack markets. The logic is that sellers have much to gain by increasing output when output is low. On the reasonable assumption that marginal-cost curves slope upward, a contraction in output will cause a price-setting firm, irrespective of the amount of its market power, to cut its price in an attempt to take business away from its rivals.

Recent experience requires a fundamental reconsideration of the views that producers find it desirable to expand output by cutting prices. Their behavior across all industries suggests, to the contrary, that price cutting is not the answer to any problem they perceive in a time of extreme slack.

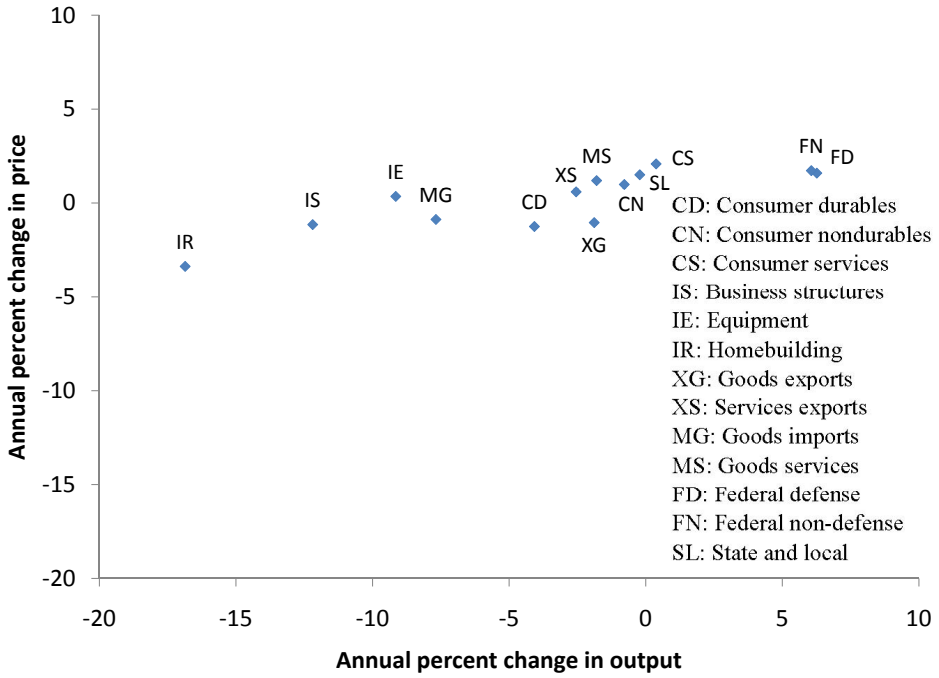


Figure 1: Annual Percent Changes in Output and Prices, 2007 Q4 to 2009 Q4

Figure 1 shows annual rates of change of output and price for a number of components of GDP, over the two-year period from 2007 Q4 to 2009 Q4. The points lie along a line with a slightly positive slope—the line connecting the left-most observation to the right-most has a slope of 0.22 percentage points of price change per point of output decline. The most informative observation is for residential construction, where output declined at a 17-percent annual rate but price declined by only 3.4 percent per year. Construction is a good test case, because existing theories of sticky prices do not seem to apply to this component.

An adverse shift in the terms of trade may be an influence favoring unresponsive prices. If an increase in input prices occurs at the same time that product demand falls, product prices may hardly move at the same time that output falls. A spike in oil prices occurred in the summer of 2008. But the spike reversed by the end of 2008 and there was no meaningful shift in the terms of trade during the two years included in Figure 1. The ratio of the price indexes for imports and exports fell by 17 basis points per year during the period.

I interpret the experience of 2008 and 2009 as undermining the view of price stickiness or rigidity embedded in mainstream macro models, where sellers are unable to change prices or face high costs in the mechanics of changing prices. I draw a more general conclusion that cutting prices in the face of slack is not value-maximizing for most businesses. Rather than

being prevented from cutting prices, they generally choose not to do so.

Evidence from American and Canadian car prices is highly informative about the weak response of retail prices to changes in cost. Thanks to NAFTA, the production of cars in North America is thoroughly integrated. The cost of building a car is the same whether sold in Canada or the U.S. Most cars have components from both countries (as well as Mexico and Taiwan) and many are assembled in both countries, with little correlation of location of production with country of sale. The Canadian dollar production cost of a car sold in Canada is very close to the exchange rate times the American dollar cost of a car sold in the U.S. Standard theories of stable markup ratios for oligopoly products suggest that an appreciation of the Canadian dollar relative to the American dollar will cause a combination of an increase in the American dollar prices of cars in the U.S. and a decrease in the Canadian dollar price of cars in Canada so that the markups remain constant. Thus the Canadian price of cars translated into American dollars at the exchange rate should be stable in relation to the American price. Figure 2 tests this hypothesis. Far from being stable, the ratio of the U.S. dollar translation of the Canadian retail price to the American retail price, shown in the heavy red line, is highly volatile and persistent. Further, the movements of the price ratio are highly correlated with the movements of the exchange rate. When the Canadian dollar is strong, the profit margin for sales of North American cars in Canada widens in proportion. When it is weak, car makers continue to sell in Canada at very low margins. The phenomenon of stabilization of prices against cost changes associated with exchange rates is well known (but not well explained) in a large literature in international trade.

Nominal wages were even less responsive to the development of huge slack in 2008 and 2009. The best measure of hourly wages, inclusive of benefits and all other types of compensation, is the Employment Cost Index of the Bureau of Labor Statistics. Figure 3 shows the annual changes in employment and hourly wages for an 8-industry of private employment. The line is almost exactly flat. The slope is 3 basis points of wage change per percentage point of output change. Again, construction is the most informative data point. Compensation per hour *rose* at the same time that employment was falling by 13 percent per year.

Macroeconomists need to redouble their efforts to understand the behavior of prices and wages, especially the lack of the expected negative response to forces that cause large declines in output. Price-wage stickiness is not a universal rule for the U.S. and other economies.

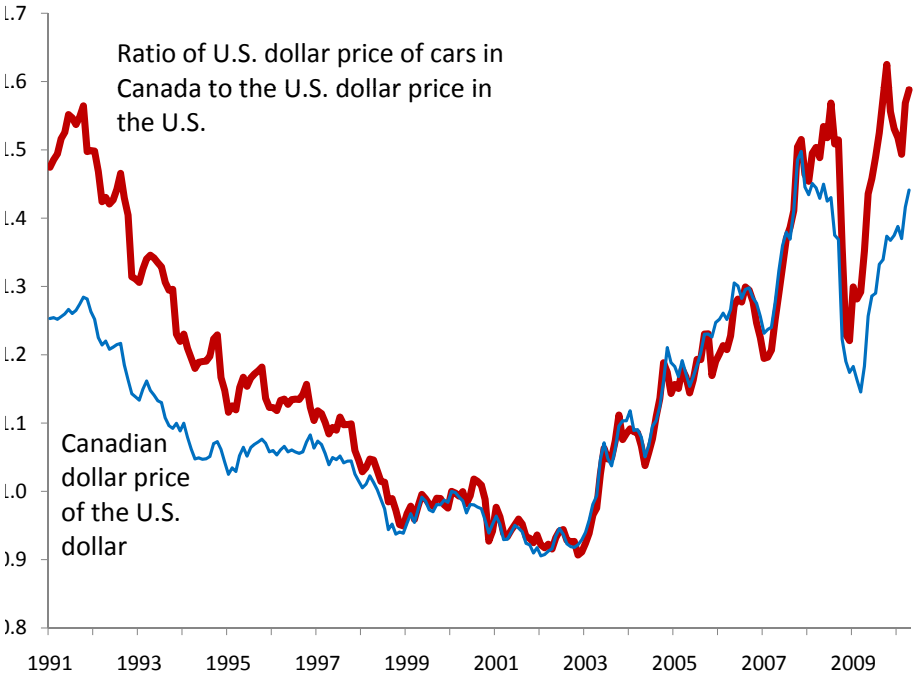


Figure 2: Canadian and American Car Prices and the Exchange Rate, 1991 to 2010

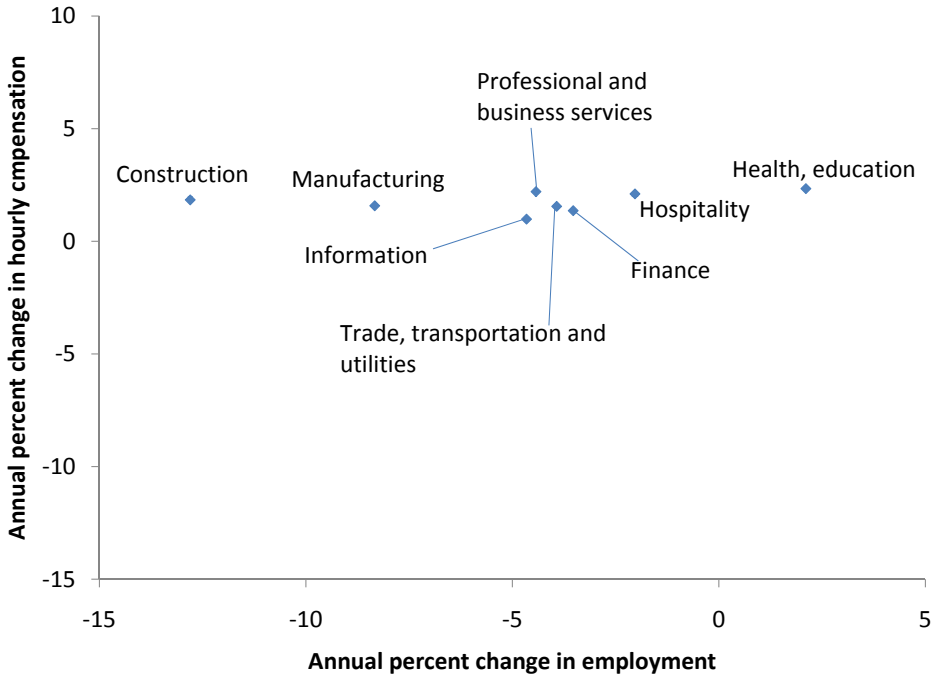


Figure 3: Annual Percent Changes in Employment and Hourly Compensation, end of 2007 to end of 2009

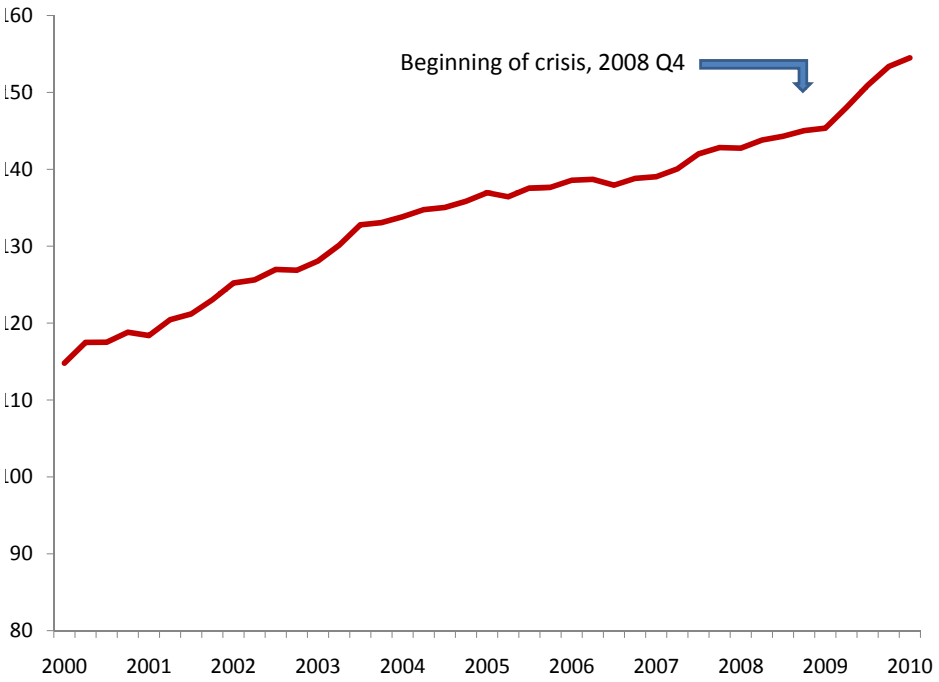


Figure 4: Index of Output per Hour, Total U.S. Economy

Prices and wages fell dramatically during the much more severe contraction that began in 1929.

I conclude that fixity of prices and wages is a reasonable basis for studying fluctuations in the U.S. economy in recent years.

2.3 Productivity

Macroeconomics has spent a lot of effort understanding how fluctuations in productivity drive overall fluctuations, but it is completely clear that the economy's collapse starting in 2008 was not the result of a decline in productivity, as Figure 4 shows.

2.4 Durables

The Great Recession concentrated its initial effect in durables: plant, equipment, and inventory investment, construction, and consumer durables. Figure 5 breaks down the shortfall of major components of GDP from trend into the sum of all the durables components and the other major components—consumption of non-durables and services, net exports, and government purchases. Durables purchases fell dramatically at the outset and have now recovered to some extent, while non-durable consumption has widened its shortfall and

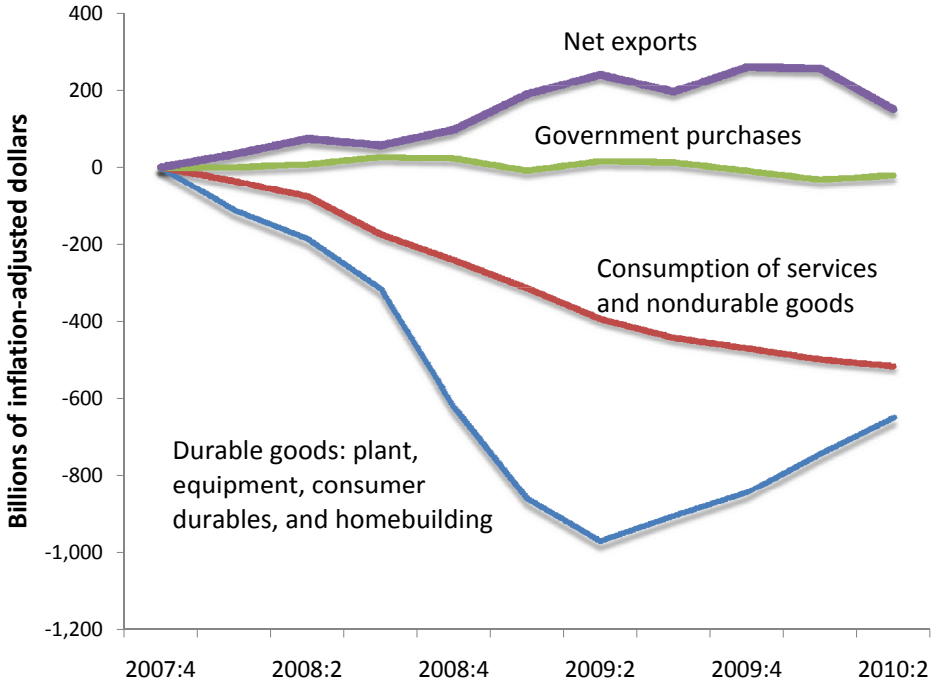


Figure 5: Components of GDP Shortfall since 2007 Q4

threatens to exceed durables soon.

3 The Zero Lower Bound on the Interest Rate

I discuss the zero lower bound (ZLB) on the nominal interest rate in a model with a single interest rate. Most of the discussion would carry over to an economy with many interest rates and asset returns.

The basic intuition describing the operation of the ZLB economy is straightforward—see Krugman (1998) in the context of Japan in the 1990s and Christiano, Eichenbaum and Rebelo (2009) in the recent U.S. context. The bound keeps the real interest rate above its equilibrium level. Households respond by offering to work harder in the current period but to defer consumption to the future. Investment is low because of the high real rate. The economy suffers from an incipient shortfall of investment below saving. Income has to fall enough to bring saving into equality with investment. Some adverse shock has brought the economy into the ZLB state but the bound amplifies its effect. Or, to put the point in reverse, a stimulus, such as an increase in government purchases, has a bigger effect on output in the ZLB economy than in a hypothetical alternative economy where the nominal interest rate can be negative.

Recent work on ZLB macroeconomics has been, without exception as far as I know, embedded in the standard New Keynesian framework whose canon is Christiano, Eichenbaum and Evans (2005). That model is complicated because of its objective of matching many of the dynamic features of the economy. Christiano, Ilut, Motto and Rostagno (2007) and Christiano, Trabandt and Walentin (2010) add an important feature missing from earlier New Keynesian models, an explicit treatment of unemployment.

The model in this paper focuses on the fundamentals of macroeconomic equilibrium when the zero lower bound binds. An initial point is that the bound arises from the willingness of the government to issue a security that pays a needlessly high return. At the zero bound, no private bank would issue currency, because the real return to issuing currency—the nominal interest rate less the cost of printing and managing the currency—is negative and thus commercially impractical. Absent the government's willingness to take losses on currency (and possibly reserves), an economy could function with a negative nominal interest rate. Currency would disappear or would be subject to holding charges. The government would charge banks for the privilege of holding reserves whose real values would rise over time. Buiter (2009) discusses these issues in detail, with cites to recent and vintage writings. The essence of the ZLB drag on the economy is that the government forces the real interest rate above its equilibrium, creating excess supply and rationing in the output market, as the high real rate induces workers and firms to defer demand for consumption and investment. Because removal of the zero bound through fundamental reorganization of the monetary institutions of the U.S. and other advanced countries appears politically impractical, I take the bound as a permanent property of the economy.

To simplify the discussion and focus on the central issue, I treat money as only a store of value and not as a medium of exchange. In the model, no money is actually held, either in normal times (when its return falls short of the market real return) or when the ZLB binds. Its only role is to create output rationing in the latter case because each household correctly perceives an opportunity to lend to the government at an above-market rate. The presence of money in this economy dictates that the real interest rate be the return to holding money, the rate of deflation. This point is familiar in discussions of the zero lower bound on the nominal rate. Given the opportunity to earn the higher real rate on money, nobody will lend at a lower rate, in an economy without risk. On the other hand, in standard economies, the nominal interest rate can be positive, so the real return to money is less than the return

to other investments. But that monetary equilibrium requires that money provide a service as well as a financial return. Absent a service value, the public will not hold money under standard conditions. Standard models describe two different monetary regimes. In normal times, the government provides and the public willingly holds a moderate amount of money even though it pays less than financial assets. In times of deep recession, the government saturates the economy with much more money, the nominal interest rate goes to zero, money loses any marginal service value, and the zero lower bound controls the real interest rate. The model here agrees with standard models in the ZLB case but assigns money no role or effect when the ZLB does not bind.

The model focuses on rationing in the product market that reflects into the labor market. The novelty in the model is the explicit treatment of product-market rationing. The model combines a rationing mechanism with a traditional view of the underlying supply and demand for output. Under normal conditions, absent a binding ZLB, the real interest rate clears the intertemporal market connecting adjacent periods.

4 The Price of Output and Rationing in the Output Market

I take the lack of almost any response of the U.S. price level to extreme slack since late 1998 as the basis for the simple assumption that the price of output in dollar terms is fixed. This assumption would not make sense in other eras. Deflation occurred at high rates in the early 1920s and again in the early 1930s. Inflation was high and variable in the 1970s and early 1980s. But, following a period of exceptionally stable inflation beginning in the mid-1980s, inflation remained remarkably stable in 2008 through 2010.

Unresponsive prices and rationing of sales opportunities in the output market are closely connected topics. Economists believe instinctively that product prices should fall when businesses are capable of producing more output than they are currently selling. But in the modern environment, businesses do not seem to believe that undercutting their rivals is the right way to deal with low sales volumes. A fragmentary literature in macroeconomics and, almost independently, in marketing science, explains why price cuts may not be in the interest of sellers in particular settings. It is a remarkable fact, supported by Figure 1, that sellers in virtually all settings have not tried to take sales away from their rivals by cutting prices.

What difference does it make in a macro model if the money price of goods is fixed? Changes in the price level have important distributional effects. The rising real value of nominal debt during the Depression had important adverse consequences. But by far the most important result of fixed prices—at least from the perspective of the model in this paper—is its effect on interest rates. When the public believes that the price level is fixed now and in the future (possibly along a fixed growth path), nominal and real interest rates are locked together. The lower bound of zero in the nominal interest rate becomes a lower bound of the negative of the rate of inflation when current and future prices are fixed. When inflation is negative, the bound on the real rate is a positive amount. When inflation is at small positive levels, as in the past few years, the real interest rate cannot drop below a small negative level.

In the model I construct, the price *level* is immaterial. A slump is not a time when the price level is too high. Price-level irrelevance is obviously the result of drastic simplifications—ones that probably make sense only in an economy with a long history of low and stable inflation. In the model, only the rate of change, the inflation rate, matters. The key sticky price is the real interest rate. In normal times, the real rate clears the output market. If an excess supply of current goods threatens, the real rate declines. Consumers raise current consumption, especially purchases of durable goods, because they have become cheaper in relation to future goods. Businesses speed up purchases of plant and equipment for the same reason.

There is no scope for monetary policy in a fixed-price economy. In a different economy where inflation responds to the amount of slack, a central bank stabilizes inflation by adjusting the amount of slack. Today we usually portray the policy as a Taylor rule. The deep issues in constructing models with flexible but determinate prices given a monetary-policy rule are definitely beyond the scope of this paper. I invoke sticky money prices of output to rationalize treating the rate of inflation as exogenous. The evidence on recent price stability gives me comfort in this assumption.

When an economy is in a slump, firms could profit by taking sales away from rivals. By assumption, they have determined that using product prices for that purpose is not value-enhancing. Instead, in the model of this paper, firms use more resources than usual in gaining sales. The payoff to an additional sale is the product price less the marginal resources expended to gain the sale. In formulating its production plan—in particular, in

making decisions about how aggressively to recruit workers—the firm treats this net price as the payoff to hiring and production.

I adopt a really simple version of the Diamond-Mortensen-Pissarides (DMP) model to describe the labor market. In the standard version of that model, as in Mortensen and Pissarides (1994), the payoff to hiring an additional worker is that worker's marginal revenue product. The source of variation in the marginal revenue product generally cited in the DMP literature is productivity. As a result, the model is vulnerable to the critique that declines in productivity do not seem to be the driving force of recessions, at least since the 1980s. In the model of this paper, the source of fluctuations is the net benefit, the marginal revenue product less the resources devoted to overcoming the rationing of customers that occurs when the real interest rate is at its lower bound.

As Shimer (2005) demonstrated, the Nash wage bargain in the standard DMP model precludes significant fluctuations in unemployment. When the marginal revenue product of labor falls, the wage falls virtually in proportion, so the incentive to hire remains essentially the same and unemployment remains at its natural rate. I adopt a simple framework that implies less wage flexibility, along the lines of Hall (2009).

Macroeconomics has shed the view that declines in productivity are the source of recessions. How might other driving forces—notably ones that make the ZLB bind—result in higher unemployment in the search-and-matching model? When customers are rationed, firms can divert output from other sellers by incurring a resource cost (under the fixed-price assumption, they choose never to divert customers by offering a lower price). The cost is higher when the rationing is tighter—that is, when the gap between the ZLB real interest rate and the equilibrium real interest rate is greater. The benefit to a firm from a new hire, the key driving force in the DMP model, in this version of the model, is the fixed product price less the cost of diverting enough output from rivals to keep the worker busy. Thus when the excess supply of goods is high, the benefit of hiring another worker is low, because it is hard to find a customer for the worker's output. The way that the DMP model may be able to generate fluctuations in unemployment driven by changes in the benefit to the firm from hiring added workers is well understood. Shimer (2010) deals extensively with the conditions under which the model delivers an unemployment rate immune from aggregate influences. If the bargained wage is less flexible than under those conditions, cyclical unemployment fluctuations will occur.

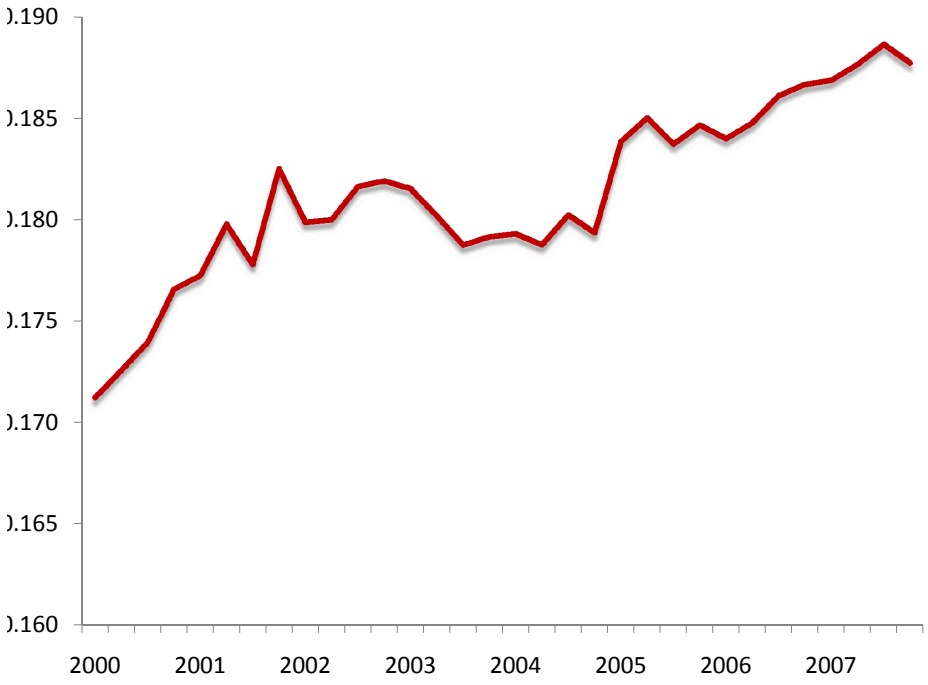


Figure 6: Financial Obligations as a Fraction of Income

5 Liquidity Constraints and Loan-Service Commitments

During the 2000s, prior to the crisis in 2008, U.S. consumers took on additional debt. Despite low interest rates, the fraction of income committed to paying interest and repaying principal rose. Figure 6 plots data since 2000 on that fraction. The measure of committed income includes rent for those who do not own their own dwellings. Mian and Sufi (2010) demonstrate large differences among states in the U.S. in durables purchases negatively correlated with indebtedness.

A significant fraction of American consumers appear to be liquidity-constrained. I take a family as liquidity-constrained if it holds less net liquid assets than two months of income. Net liquid assets are the difference between holdings in savings accounts and the like and borrowing from credit cards and other unsecured forms. In the 2007 Survey of Consumer Finances, households illiquid by this standard earned 58 percent of all income. The fraction of households that were constrained—74 percent—is much higher because lower-income households are more likely to be constrained.

I incorporate these facts into the model by dividing consumption into two parts. Consumption of unconstrained households obeys the standard life-cycle model, while consump-

tion of constrained households is their earnings less their committed payments for outstanding credit, which forces them to dissave.

In a full-employment economy containing this mix of households, the interest rate would clear the output market, absent any lower bound. When constrained households cut back consumption spending, including purchases of new houses and consumer durables, low rates would induce unconstrained households to consume more by borrowing, thus offsetting the saving of constrained households. The zero lower bound blocks the corrective force.

In the economy up to the end of 2007, consumers added substantially to their stocks of durables, mainly in new houses, but also in cars and other consumer durables. They took on additional debt in the process and raised the fractions of their incomes needed to repay the debt, as shown in Figure 6. Thus two critical state variables were at high values at the end of 2007, the durables stock and debt service commitments of constrained households.

The model starts at the end of 2007 with those state variables at the high values. I do not model the economy during the run-up, but others are working on that topic. Macroeconomists have built asset-price crashes into general-equilibrium models—Burnside, Eichenbaum and Rebelo (2010) is a recent example where beliefs about appreciation spread among homeowners like an epidemic disease. No view about the origins of bubbles or crashes is yet firmly established.

An economy starting with a stock of durables above its steady-state level and with consumers who have large commitments to save by repaying debt will reach equilibrium with a low interest rate if the rate is not bounded, or it will have excess unemployment if the rate hits the bound.

Note that the rate that matters here is the return to the saving of unconstrained households who would respond to low rates by dissaving to offset the saving of the constrained households. Consumer borrowing rates determine the burden of debt service but do not clear the output market, because constrained consumers are not marginal participants in that market.

Figure 7 shows the ratios of business capital and durables-housing to GDP since 1990. Nothing special happened to capital, but the figure shows a conspicuous bulge in durables-housing from 2000 to 2006. The ratio is 14 percent higher in 2007 than it was in 2000 and the same 14 percent higher than the average from 1990 through 2000. Accordingly, I will start the model with its durables-stock state variable 14 percent above it stationary level.

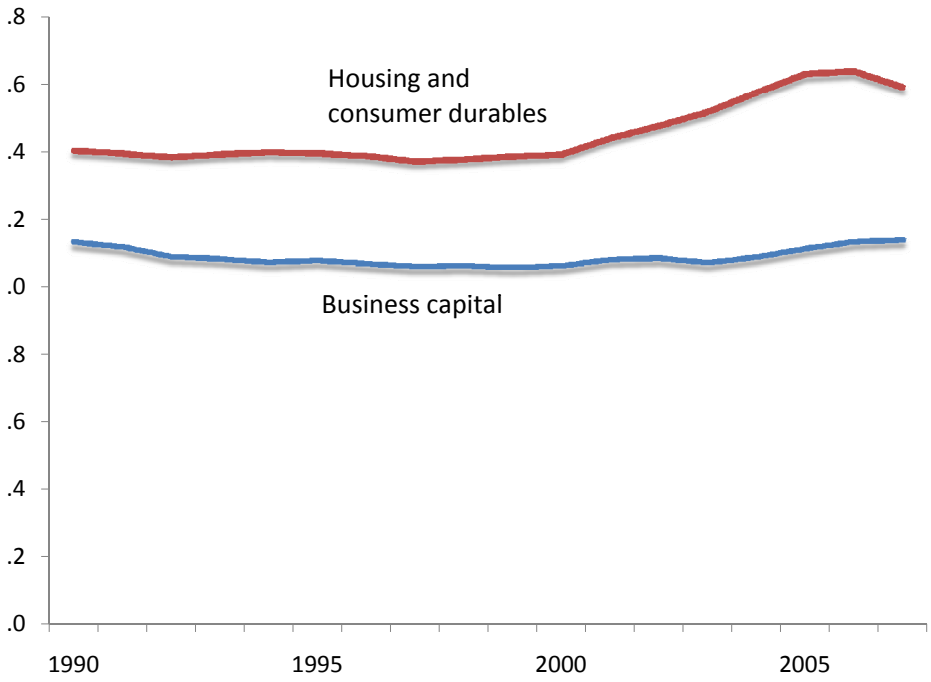


Figure 7: Ratios of capital and durables to GDP

6 Long-Horizon Dynamic Model

The economy in the model lasts for many years and households last as long as the economy. Households consume nondurable goods and services and the services of durables, including housing. Output is divided among three uses: nondurables consumption, investment in new durables and housing, and investment in business capital. The length of a period is a calendar quarter. Because the real interest rate is bounded by the negative of the rate of inflation, rationing of customers may occur in the product market in any quarter. Both types of investment incur standard quadratic adjustment costs, so Tobin's model of investment applies. Household preferences have constant intertemporal elasticity of substitution, not necessarily equal to one. Firms use resources to attract customers. The benefit of hiring a worker falls when customers become harder to find, so recruiting incentives fall and unemployment rises.

Uncertainty is not an important element in the model. In particular, the model lacks any second-moment effects. Decision-makers have perfect foresight. I don't regard this as a realistic assumption, but experience has shown that perfect-foresight models give surprisingly good accounts of what happens in a dynamic model once a major surprise becomes known. Thus I treat all the values of all the variables as one big vector of 792 unknowns and solve

792 nonlinear equations jointly for their exact values. The solution takes about 20 seconds on my laptop. I solve over a horizon of 40 years, though I show only the first 20 quarters of the solution.

6.1 Technology, Adjustment Costs, Rental Prices, and Capital Demand

The technology for producing output y is Cobb-Douglas with labor elasticity α:

$$y_t = n_t^{\alpha} k_{t-1}^{1-\alpha}. \tag{1}$$

Note that output is not real GDP. GDP includes both the services of housing, as a component of consumption, and the production of houses, as a component of investment. This double-counting is inconsistent with the way that business capital is treated in the national accounts. Here, output is the production of goods, which are used to make capital, houses, and consumer durables, or are consumed directly.

Capital installation occurs up to the point where the marginal adjustment cost equals the difference between the price of installed capital q_k and the price of uninstalled capital, 1:

$$\kappa_k \frac{k_t - k_{t-1}}{k_{t-1}} = q_{k,t} - 1. \tag{2}$$

The parameter κ measures capital adjustment cost—if $\kappa_k = 0$, q_k is always 1 and there are no adjustment costs.

Housing installation follows a similar equation with subscript d replacing k.

The rental prices of capital and durables are standard:

$$p_{k,t} = (1 + r_{t-1}) q_{k,t-1} - (1 - \delta_k) q_{k,t} \tag{3}$$

and

$$p_{d,t} = (1 + r_{t-1}) q_{k,t-1} - (1 - \delta_d) q_{d,t}. \tag{4}$$

The market-clearing condition for capital equates the marginal product of capital to the rental price:

$$(1 - \alpha) \frac{y_t}{k_{t-1}} = p_{k,t}. \tag{5}$$

6.2 Household product demand

Households fall into two categories, unconstrained ones that follow the standard life-cycle intertemporal model and constrained ones who are at the corner of their intertemporal choice resulting from an inability to engage in unsecured borrowing beyond a modest limit. Both types of households have active choices about the division of spending between consumption of non-durable goods and services on the one hand and the services of durable goods including housing, on the other hand. A tilde ($\tilde{}$) denotes unconstrained households and a bar ($\bar{}$) denotes constrained ones.

Consumption is a Cobb-Douglas composite of consumption of standard output, $c_{y,t}$, and the services of durables, d_{t-1}:

$$\tilde{c}_t = \tilde{c}_{y,t}^{\phi} \tilde{d}_{t-1}^{1-\phi}, \tag{6}$$

and similarly for constrained households. The price of composite consumption in output units is

$$p_{c,t} = \phi^{-\phi}(1-\phi)^{-(1-\phi)} p_{d,t}^{1-\phi}. \tag{7}$$

Here $p_{d,t}$ is the rental price of durables, as above. The unconstrained household's demand for the goods component of consumption satisfies:

$$\tilde{c}_{y,t} = \phi p_{c,t} \tilde{c}_t \tag{8}$$

and similarly for constrained households. Total non-durable consumption is:

$$c_{y,t} = \phi p_{c,t}(\tilde{c}_t + \bar{c}_t), t \in [2, T] \tag{9}$$

Unconstrained households order their paths of composite consumption according to the intertemporal utility function

$$\sum_t \beta^t \frac{\tilde{c}_t^{1-1/\sigma}}{1-1/\sigma}, \tag{10}$$

where σ is the intertemporal elasticity of substitution.

Constrained households' consumption is

$$p_{c,t}\bar{c}_t = \omega n_t w_t - s_t, \tag{11}$$

where ω is the fraction of constrained consumption and s_t is the committed debt service of constrained households.

Consumption of durables services is:

$$p_{d,t}\tilde{d}_{t-1} = (1-\phi) p_{c,t}(\tilde{c}_t + \bar{c}_t), \tag{12}$$

6.3 The financial market

Only unconstrained households participate in asset markets on the margin. They price assets with the discounter,

$$\mu_{t+1} = \beta \frac{p_{c,t}}{p_{c,t+1}} \left(\frac{\tilde{c}_{t+1}}{\tilde{c}_t} \right)^{-1/\sigma}. \tag{13}$$

Their Euler equation implies that the optimal choice of consumption growth results in a discounter that discounts the market real interest rate to one:

$$(1 + r_t)\mu_{t+1} = 1. \tag{14}$$

6.4 The output market

The price of output is a constant, which I normalize at one. Firms do not try to take sales away from each other by cutting price. Instead, they use resources (output) for that purpose. To sell another unit of output, a firm expends x_t units of output. When customers are not rationed and the output market clears, $x_t = 0$. When the lower bound on the interest rate binds, $x_t > 0$. The more severe the rationing, the higher is x_t. In effect, x_t clears the intertemporal output market when the ZLB disables the real interest rate from playing this role.

6.5 Employment

As in the standard Mortensen-Pissarides model, all workers desire to work a standard number of hours. The only source of variation in aggregate hours of work arises from unemployment.

Hall (2009) gives a compact summary of the search-and-matching model whose canon is Mortensen and Pissarides (1994), with wage determination generalized relative to the Nash bargain in that paper. One simplification is to consider only the stochastic equilibrium of labor turnover, which means that the employment rate n measures the tightness of the labor market. The vacancy rate enters the picture only in fast transitional dynamics of the matching process, which can be ignored in a quarterly model without losing much. Thus the recruiting success rate is a function $q(n)$ of the employment rate. Success is higher when employment is lower.

Without loss of generality, the wage paid to the worker can be decomposed into two parts, corresponding to a two-part pricing contract (the decomposition is conceptual, not a suggestion that actual compensation practices take this form). The worker pays a present

value J to the employer for the privilege of holding the job and then receives a flow of compensation equal to the worker's net contribution of revenue, which is the worker's marginal product less the cost of pushing another unit of output onto the market:

$$b_t = \alpha \left(\frac{n_t}{k_t} \right)^{1-\alpha} - x_t. \tag{15}$$

The firm passes this flow on to the worker except for a deduction with present value J.

The cost of recruiting (holding a vacancy open) is γ per period, taken to be constant. The zero-profit condition for recruiting equates the expected benefit of recruiting to its cost:

$$q(n_t) J_t = \gamma. \tag{16}$$

Thus unemployment rises if J falls. I take

$$J_t = J(b_t), \tag{17}$$

an increasing function of the net benefit to employment, so that, in slack markets with high x_t and thus lower b_t, a worker pays less for a job. I solve for employment as a function of b_t and take the function as constant-elastic:

$$n_t = \bar{n} \left(\frac{b_t}{\bar{b}} \right)^{\psi}, \tag{18}$$

where the elasticity ψ is positive, $\bar{b}$ is the normal level of b_t, and $\bar{n}$ is the normal level of employment.

The contraction in J when the net benefit of employment falls can be interpreted as wage stickiness, or, more accurately, compensation stickiness. If total compensation is sticky and the net benefit falls, then J must fall, because J is the present value of the difference between the net benefit and the worker's actual compensation.

6.6 Material balance

At the beginning of a period, the stock of installed capital is k_{t-1} and the stock of housing is d_{t-1}. At the end of the period, output y_t becomes available and is allocated to consumption of goods $c_{y,t}$, and investment in capital and housing, including adjustment cost, resulting in the new capital stock, k_t and new housing stock d_t. Firms expend $\gamma n_t / q(n_t)$ in recruiting cost and $x_t y_t$ in marketing cost each quarter. The equation for the economy's material balance

Parameter	*Description*	*Value*	*Source*
α	Labor elasticity of production function	0.646	
κ_k	Capital adjustment cost	8	
κ_d	Durables adjustment cost	8	
δ_k	Capital depreciation rate	0.0188	
δ_d	Durables depreciation rate	0.0129	
ϕ	Nondurables consumption share	0.82	
β	Utility discount factor	0.987	
σ	Intertemporal elasticity of substitution	0.5	
ω	Fraction of constrained consumption	0.58	
$\bar{n}$	Normal employment rate	0.945	
ψ	Elassticity of employmentt function	1	
γ	Vacancy posting cost		

Table 1: Parameter Values and Sources

is

$$k_t + \frac{\kappa_k}{2}\frac{(k_t - k_{t-1})^2}{k_{t-1}} + d_t + \frac{\kappa_d}{2}\frac{(d_t - d_{t-1})^2}{d_{t-1}} = (1-\delta_k)k_{t-1} + (1-\delta_d)d_{t-1} + y_t - c_{y,t} - \gamma\frac{n_t}{q(n_t)} - x_t y_t. \tag{19}$$

6.7 Customer rationing

Customer rationing occurs if the lower bound binds the interest rate, in which case firms attempt to take customers away from their rivals by expending resources. Thus the model satisfies the complementary slackness condition: If $r_t > \bar{r}_t$, $x_t = 0$.

6.8 Parameter values

Table 1 gives the parameter values I use in the base case and their sources.

7 Results

The first dynamic equilibrium I calculate is for an economy that begins with a binding ZLB and continues in that state for 17 quarters. It begins with a stock of durables 14 percent above the stationary value. No households are liquidity-constrained in this version of the

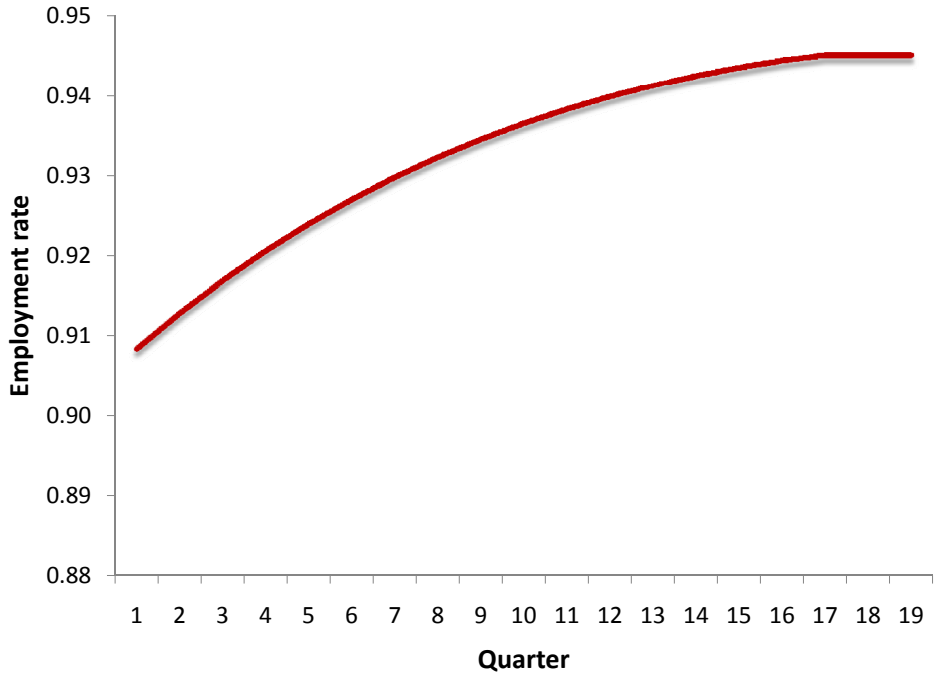


Figure 8: Employment with Elevated Durables Stock and Binding ZLB

model. Figure 8 shows the resulting path of the employment rate. Employment begins at 91 percent of the labor force, corresponding to 9 percent unemployment.

Figure 9 shows the paths of gross investment in capital and durables as fractions of full-employment output (the fractions are higher than ratios to GDP in the actual U.S. economy because the model economy has no government purchases and because the services of housing are not included in output, as discussed earlier). In a neoclassical full-employment economy, the resources not used for making durable goods would cause a bulge of capital investment, as interest rates fell during the transition back to normal levels of durables spending. Because the interest rate is held above the market-clearing level on account of the zero bound and because of the resulting decline in output, capital investment actually declines slightly.

Figure 10 shows nondurables consumption c_y as a fraction of full-employment output. This large component of output is depressed only moderately.

The model also considers the role of the overhang of consumer debt (mainly mortgages) resulting from the durables binge of the mid-2000s. The evidence I reviewed earlier suggests that 58 percent of consumption occurs in households that are constrained in the credit market and cannot spend more on consumption than their incomes less their debt-service obligations. These obligations are at least 18 percent of income among the constrained. The

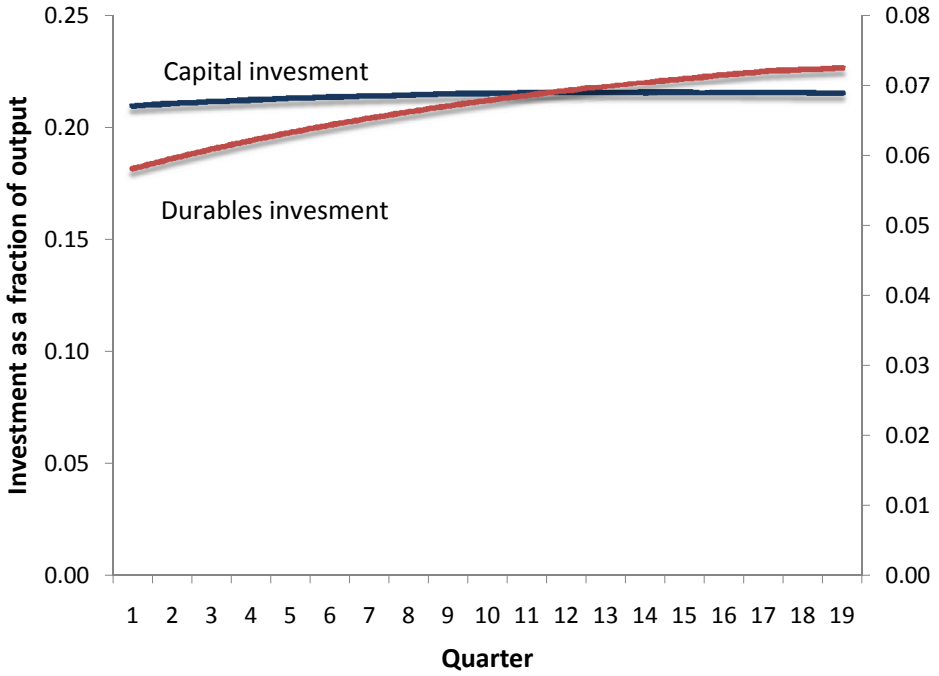


Figure 9: Investment in Capital and Durables with Elevated Durables Stock and Binding ZLB

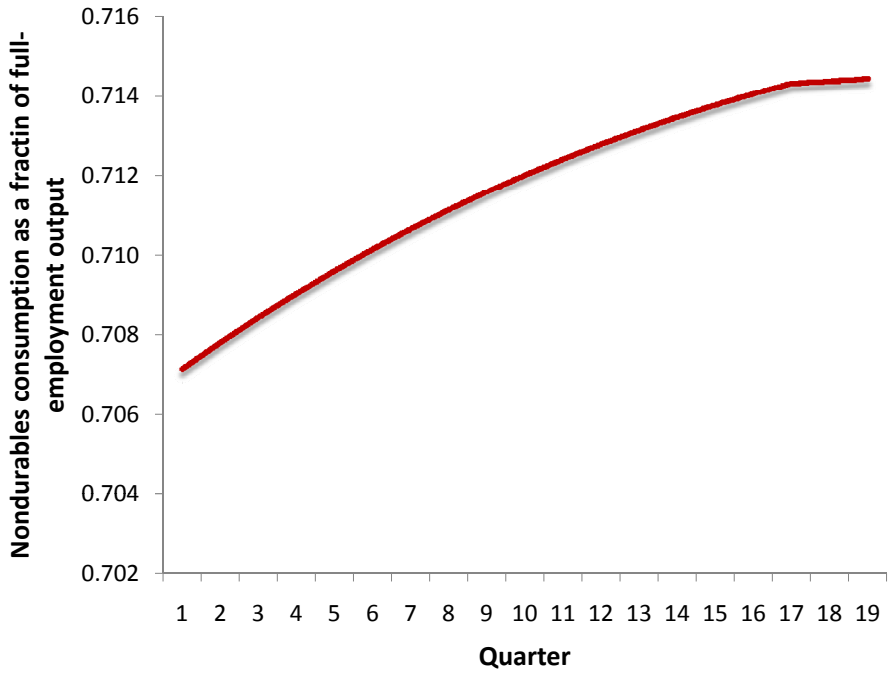


Figure 10: Nondurables Consumption with Elevated Durables Stock and Binding ZLB

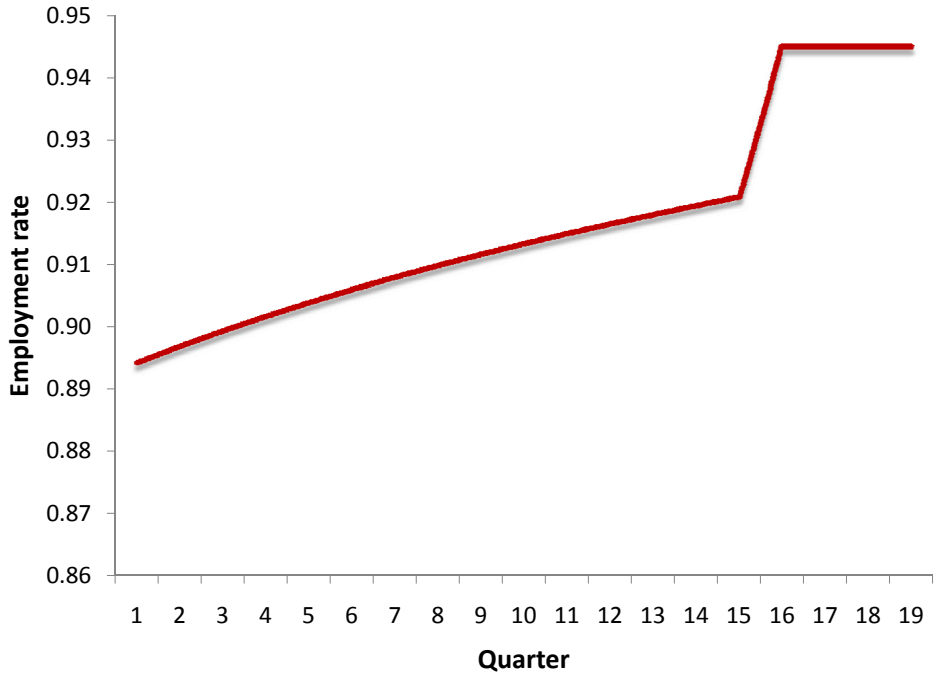


Figure 11: Employment with Constrained Consumption and Binding ZLB

model collapses if I use these values. Something worse than the Great Depression occurs in an economy weighed down by so much debt if it also suffers from a real interest rate that cannot clear the intertemporal market. To illustrate the power of the lethal combination of debt-service burden and the ZLB, I solved the model with 15 percent of consumption constrained and debt service of 10 percent among the constrained households. I started the durables stock at its stationary value, so this scenario involves a debt binge but not a homebuilding and car-buying binge prior to beginning of the model solution.

Figure 11 shows the path of employment in that economy. Initial unemployment is almost 11 percent. Figure 12 shows nondurables consumption. The decline in that category of output is about four times larger than in the first case, where on the overhang of durables caused recession. Thus debt overhang is a truly powerful adverse force an economy hobbled by the inability of the interest rate to fall enough to clear the market for output.

The response of the economy in the model to the two adverse forces of excess stocks of durables and the overhang of consumer debt turns out to be much less than the sum of the two when they operate separately. Figure 13 shows the response of employment to the combination of forces and Figure 14 shows the response of nondurable consumption.

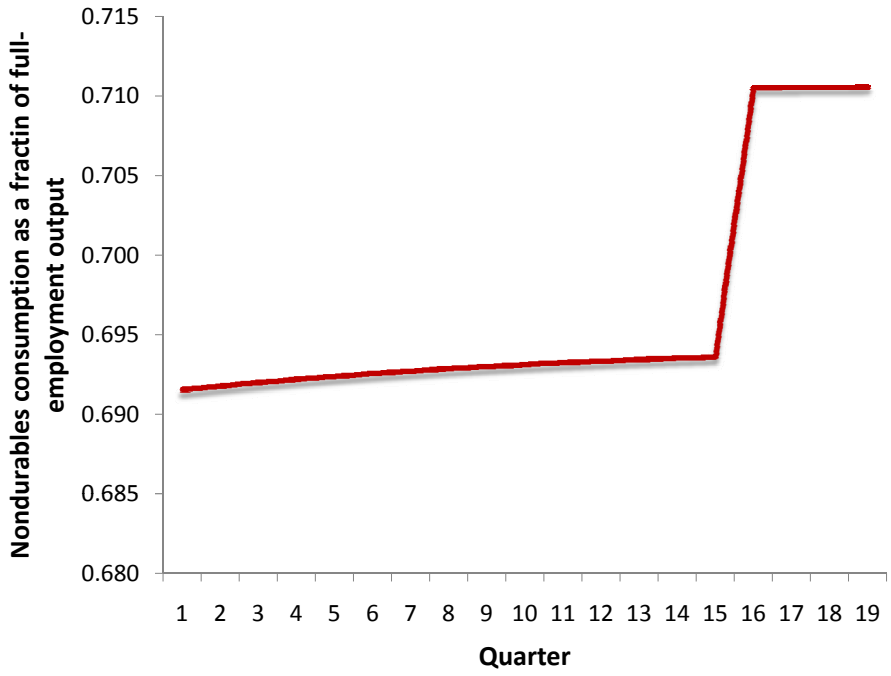


Figure 12: Nondurables Consumption with Constrained Consumption and Binding ZLB

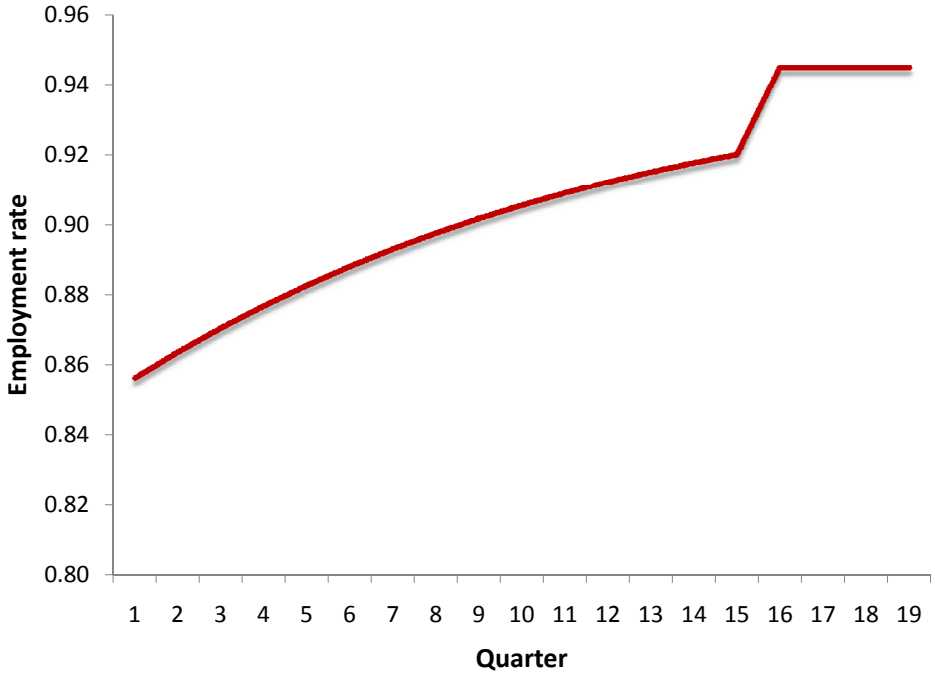


Figure 13: Employment with Elevated Durables Stock, Constrained Consumption, and Binding ZLB

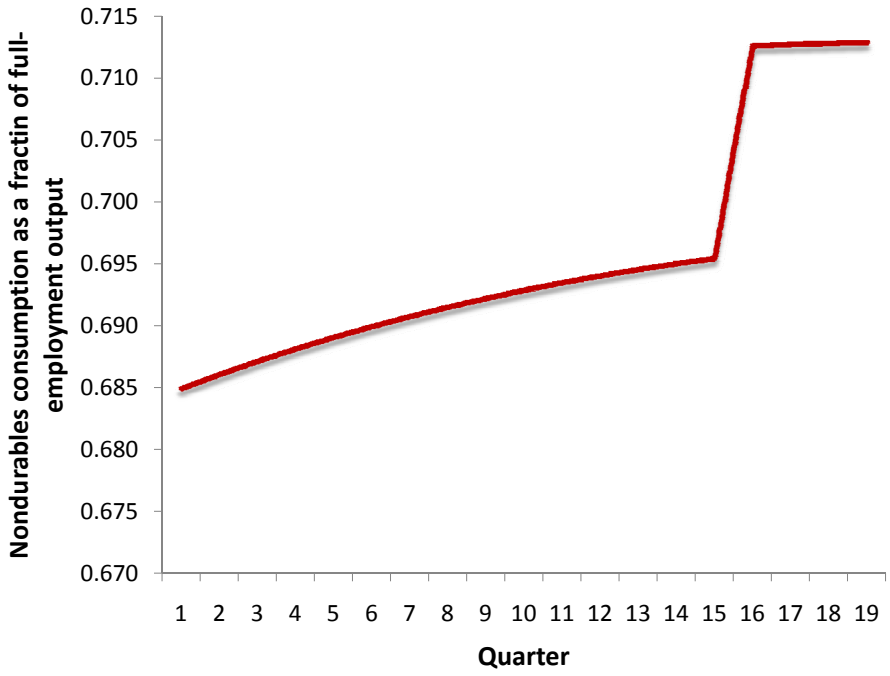


Figure 14: Nondurables Consumption with Elevated Durables Stock, Constrained Consumption, and Binding ZLB

8 Concluding Remarks

An economy with a disabled real interest rate is in deep trouble when one type of spending—homebuilding and consumer durables in the current slump—declines. A slump will last until the affected spending resumes its normal level. Consequently, the slump may last many years.

The analysis and calculations in this paper assume that the gradual price adjustment described by the Phillips curve does not occur. Inflation remains at the same rate. If inflation does decline and turn into growing deflation, the slump will worsen, as the real interest rate rises. So far in the current slump, notwithstanding episodes of grave concern, no slide into deflation has occurred.

Absent the radical and highly unlikely of a monetary reform that permits negative nominal interest rates, the types of policies that could ameliorate the slump are those that emulate the effect of low real rates—making current purchasing cheaper than future. A key feature of these policies is to defer the time when the policy reverses itself until after full employment prevails. The cash-for-clunkers program in 2009 induced a significant bulge in car purchases, but because it lasted only a few months, it only deferred purchases for that many months

and did nothing to shift purchases from a time of full employment to the present (Mian and Sufi (2010)). The effective program would place a high subsidy on current purchasing and phase out the subsidy, eventually becoming a consumption tax that financed the earlier subsidy. The shrinkage rate of the subsidy would amount to a negative real interest rate in consumer purchasing decisions.

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Appendix

A Model Details

Timing: Output in t uses workers n_t and end-of-period capital k_{t-1}. Consumption occurs at the end of t and comes out of output at the end of t, y_t. The real interest rate from t to $t+1$ is r_t. The rental price for capital used during t is $p_{k,t}$. Capital in use during period t occurs during the period governed by r_{t-1}. That capital was acquired in $t-1$ at price $q_{r,t-1}$. The stochastic discounter from t to $t+1$ is μ_{t+1}.

Auxiliary:

$$y: \ y_t = n_t^{\alpha} k_{t-1}^{1-\alpha}, t \in [2,T] \tag{20}$$

$$p_k: \ (1-\alpha)\frac{y_t}{p_{k,t}} = k_{t-1}, t \in [2,T] \tag{21}$$

$$p_c: \ p_{c,t} = \phi^{-\phi}(1-\phi)^{-(1-\phi)} p_{d,t}^{1-\phi}, t \in [2,T] \tag{22}$$

$$\mu: \ \mu_{t+1} = \beta \frac{p_{c,t}}{p_{c,t+1}} \left(\frac{\tilde{c}_{t+1}}{\tilde{c}_t}\right)^{-1/\sigma}, t \in [2,T-1] \tag{23}$$

$$w: \ w_t = \alpha \left(\frac{k_{t-1}}{n_t}\right)^{1-\alpha} \tag{24}$$

$$b: \ b_t = w_t - x_t \tag{25}$$

$$n: \ n_t = \bar{n} \left(\frac{b_t}{\bar{b}}\right)^{\psi} \tag{26}$$

$$\bar{c}: \ p_{c,t}\bar{c}_t = \omega n_t w_t - s_t \tag{27}$$

$$c_y: \ c_{y,t} = \phi p_{c,t}(\tilde{c}_t + \bar{c}_t), t \in [2,T] \tag{28}$$

$$q_k: \ \kappa_k \frac{k_t - k_{t-1}}{k_{t-1}} = q_{k,t} - 1, t \in [2,T] \tag{29}$$

$$q_d: \ \kappa_d \frac{d_t - d_{t-1}}{d_{t-1}} = q_{d,t} - 1, t \in [2, T] \tag{30}$$

Core:

$$k_t + \frac{\kappa_k}{2} \frac{(k_t - k_{t-1})^2}{k_{t-1}} + d_t + \frac{\kappa_d}{2} \frac{(d_t - d_{t-1})^2}{d_{t-1}} = (1-\delta_k)k_{t-1} + (1-\delta_d)d_{t-1} + y_t - c_{y,t}, t \in [2, T](T-1) \tag{31}$$

$$(1 + r_t)\mu_{t+1} = 1, t \in [2, T-1](T-2) \tag{32}$$

$$p_{k,t} = (1 + r_{t-1})q_{k,t-1} - (1 - \delta_k)q_{k,t}, t \in [3, T](T-2) \tag{33}$$

$$p_{d,t} = (1 + r_{t-1})q_{k,t-1} - (1 - \delta_d)q_{d,t}, t \in [3, T](T-2) \tag{34}$$

$$p_{d,t}d_{t-1} = (1 - \phi)p_{c,t}(\tilde{c}_t + \bar{c}_t), t \in [2, T](T-1) \tag{35}$$

Total core equations: $2(T-1) + 3(T-2) = 5T - 8$

Complementary slackness: If $r_t > \bar{r}_t$, $x_t = 0$

Unknowns: $T-1$ values of p_d and $\tilde{c}$ for $2T-2$, $T_c - 1$ for n, $T-2$ values of k and d for $2T-4$, and $T - T_c - 1$ for r, for a total of $5T-8$ unknowns.

Exogenous:

$$r_t = r_{m,t}, t \in [2, T_c] \tag{36}$$

$$n_t = \bar{n}, t \in [T_c + 1, T] \tag{37}$$