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Spain, Japan, and the Dangers of Early Fiscal Tightening*

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Abstract

Spain's current recession was preceded by an extended period of rapid growth in real estate and equity prices. The recent sudden and sharp decline in these asset prices has been followed by a deep economic contraction. Is this recession a large but transient phenomenon? Or is it perhaps instead the harbinger of a protracted period of depressed asset prices and economic stagnation? Japan experienced a similar pattern of growth in land and equity prices in the late 1980s. The collapse of the Japanese bubble economy was followed by a protracted period of declines in asset prices and depressed economic activity. We compare Japan's experience in the 1980s and 1990s with current developments in Spain. One message that emerges from this narrative is that a fiscal tightening in Japan in 1997 may have been premature. We develop a prototypical New Keynesian model, calibrate it to replicate the Japan's experience in the 1980s and 1990s, and use it to evaluate the risks of tightening fiscal policy too early when the nominal interest rate is low. We find that a premature fiscal tightening can have large and negative effects on the real economy.

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1 Introduction

Spain currently finds itself in the midst of the most severe recession in recent memory. Spain's recession was preceded by over a decade of rapid real economic growth. What were the economic foundations of Spain's growth? On the one hand, the level of per capita GDP in Spain was low relative to its more affluent northern neighbors and it is possible that Spain's rapid growth reflected convergence due to a lowering of barriers to adoption within the European Union. One the other hand, productivity growth in Spain has been lower than in other European countries (see e.g. Castiglionesi and Ornaghi (2009)). Instead, Spain's rapid economic growth appears to have been closely associated with rapid increases in real estate prices. Well before the current crisis concerns began to be raised in *The Economist* (2004) and other popular publications that the rapid increase in Spanish real estate prices was unsustainable.

In July of 2007 Spanish real estate and equity prices started to fall. This was followed by a slow down in real economic activity that began in the second quarter of 2008 and accelerated as the year progressed. Spain now finds itself in a situation with negative real GDP growth, steep declines in manufacturing activity, an unemployment rate that has doubled and a sudden and rapid increase in nonperforming loans.

Is this reversal just a temporary blip along the path to prosperity? Or does this reversal instead represent the beginning of a protracted period of economic stagnation?

One way to gain insights into this question is to study the experiences of other countries. Japan is a particularly interesting example for Spain. Japan's experience in the 1980s bears many resemblances to recent developments in Spain. Japan in 1980 also had a relatively low level of per capita GDP. However, during the 1980s the Japanese economy experienced rapid growth. So much so that it became the second largest economy in the world. Japan's real growth was also accompanied by large increases in both land and stock prices. The "Japanese bubble economy" came to an end in 1990 when asset prices started to fall. The ensuing "Lost Decade" was characterized by ongoing declines in land and equity prices and economic stagnation.

Our paper has two objectives. First we provide a narrative account that compares and contrasts current developments in Spain with Japan's experience in the 1980s and 1990s. That narrative identifies some common themes. The movements in asset prices are very similar in Japan and Spain. Both economies experienced increases in equity and real estate prices that were of about the same magnitude over about the same interval of time. Moreover, the magnitude and timing of the declines in asset prices over the first two years after the peak is quite similar in the two countries. There are also some differences. Japan ran a trade surplus both before and after the asset price bubble collapsed. Spain had a trade deficit of nearly 10 percent of GNP. Initially, Japan's real economy weathered the sudden collapse of asset prices remarkably well. Real economic activity slowed in Japan but did not suddenly collapse as in Spain.

A second objective of this paper is to investigate the fiscal and monetary policy responses. We will consider in some detail whether the course of fiscal policy in Japan was reversed too quickly. In 1997 against a background of an incipient recovery, Japanese policy makers increased the value added tax by 2 percent, rolled back temporary income tax cuts, increased out of pocket expenses for medical insurance and sharply reduced government expenditures. Spain is planning to follow a similar course of action in the coming months. Recent research by Christiano (2004), Eggertsson (2008) and Christiano, Eichenbaum and Rebelo (2009) points out that fiscal policy is a very potent tool when the nominal interest rate is close to zero. Our results here confirm their finding. We will see that Japan's experience suggests that a sudden sharp reversal in fiscal policy may be ill-advised.

The remainder of the paper is organized as follows. In Section 2 we provide a narrative that compares current developments in Spain with Japan's experience in the 1980s and 1990s. Then in Section 3 we describe an economic model that we use to investigate the quantitative effects of a sudden reversal in fiscal policy in a low interest rate environment. In Section 4 we explain how we parameterize the model and set the shocks. Section 5 reports results that document the economic consequences of a sudden fiscal reversal in a low interest rate environment. Section 6 contains our concluding remarks.

2 A comparison of the current recession in Spain with Japan's bubble economy of the late 1980s

The Spanish economy has been buffeted by some big shocks to the global economy in the past three years. One of the most pressing issues for private sector participants and policy makers alike is whether recent developments are a sharp but temporary aberration from a more general pattern of rapid growth and catch up or perhaps the harbinger of a protracted period of stagnation.

It would be wonderful if we could move the clock forward and see how the Spanish economy will look three years from now. Unfortunately, that is not possible. Instead we will roll the clock backwards and compare Spain's current experience with Japan's experience during and after its bubble economy in the late 1980s.

Stock Markets

Figure 1 shows the evolution of stock prices in Japan from 1987 to 1998 relative to their peaks. For purposes of comparison we also plot the evolution of the IBEX 35 from the current recession. Dates on the horizontal axis at the bottom of Figure 1 are for Japan. Dates on the horizontal axis at the top of Figure 1 are for Spain. Stock prices in both countries anticipate the turning points in GDP. In Spain the IBEX 35 peaks in July 2007. In Japan the NIKKEI 225 peaks in January of 1990. For purposes of comparison the turning point of GDP in Spain occurs in the first quarter of 2008 and the turning point of GDP in Japan occurs in the first quarter of 1991. The evolution of asset prices across the two events is eerily similar. Both economies experience increases of a similar magnitude in the four years prior to the turning point. Equity prices doubled in both economies over the same interval of time. The pattern of the decline in the two economies immediately after the turning point is also remarkably similar with stock prices falling by about 40 percent over the next two years. In Japan the asset price collapse was followed by many years of depressed stock prices. By 1998 the Nikkei had fallen to 35 percent of its 1991 level. When the Nikkei hit its most recent high in July 2008 its value was the same as its value in May 1986.

For the remainder of the variables we will use a common reference point. We date the turning point of the Japanese bubble economy to the first quarter of 1991 using data on GDP. For monthly variables we set the turning point to February 1991. In order to compare Japan's experience in the 1990s with the current recession in Spain we set the turning point for Spain to quarter 1 of 2008. This is the quarter where Spanish real GDP achieved its most recent peak. For monthly indicators the turning point is chosen to be February 2008.

Real Estate

Figure 2 reveals a striking similarity between the recent evolution of real estate prices in Spain and Japan in the 1980s.[1] Between January 1986 and January 1991 Japanese land prices increased by a factor of 2.9. This is just a bit lower than the three fold increase in real estate prices experienced by Spain between 1996 and 2008. From Figure 2 we can also observe that both the build up and the collapse in land prices in Japan was very sudden. The most disturbing feature of this figure though is that the subsequent decline and stagnation of Japanese land prices was very persistent. The most recent peak in the Japanese land price index occurred in 2008. At that point the index was 1 percent above its 1987 level.

New housing starts are reported in Figure 3. Housing starts in both economies are high before the turning point (recall that we date the turning point in Spain to the February 2008). In Spain housing starts are falling from July 2006, which is twenty months prior to the turning point. In Japan housing starts begin to fall in June 2000.

Housing starts fall by about the same amount in the two countries in the first year after the turning point. But then Japanese housing starts stabilize. Japanese starts are only about 10 percent below their pre-1991 values in the period between 1992 and 1996. They then show further declines after 1996. In Spain housing starts fall steadily through the end of our sample By June 2009 they have fallen to 41 percent of their February 2008 level.

Gross Domestic Product (GDP)

We have seen that the rise and collapse of asset and land prices in Japan and Spain are remarkably similar in timing and magnitude. When we consider the evolution of the real side of the economy though an important difference emerges between the two countries. In Japan these financial shocks did not immediately transmit to the real sector. Consider Figure 4 which reports GDP for Japan and Spain. Japanese real GDP continues to increase in Japan through 1996. Spain, in contrast, experiences robust growth in GDP the three years prior to its turning point in 2008:Q1 but then GDP falls sharply thereafter. By the second quarter of 2009 Spain's GDP is down 4 percent from its peak in 2008:Q1.

We will see below that one reason for the weaker transmission is that exports in Japan continued to hold up even after the bubble economy ended. The current recession, is global in nature and has been associated with a sharp decline in trade in many economies including Japan.

Manufacturing

The collapse of asset prices is associated with a decline in manufacturing in both countries. However, the transmission of the financial shock to the manufacturing sector is again much weaker in Japan. Japanese

[1]For Japan there is no data on real estate prices from this period. Instead we use urban land price data from the MLIT. In Japan the value of the land constitutes anywhere from 70 to 90 percent of the total price of a free standing home.

industrial production reported in Figure 5 declines after February 1991. Between February 1991 and February 1993 industrial production in Japan falls by a total of 8 percent. Spain experiences a much more sudden and sharp decline in manufacturing activity. Spanish industrial production falls by 24 percent between February 2008 and July 2009.

Labor Markets

A similar picture emerges in labor market statistics. Consider unemployment reported in Figure 6. Spain experiences a dramatic increase in unemployment over a very short interval of time. Spanish unemployment starts to rise from 2007:Q3 and doubles by the end of our sample in 2009:Q2. Japanese unemployment, in contrast, continues to fall until 1992 which is well after the turning point in equity prices (January 1990). From the 1992:Q2 unemployment rises in a gradual but steady fashion. It is not until 1998 that the unemployment index in Japan rises to the level of the 2009:Q2 Spanish unemployment index.

Japan also shows rising and then stable employment in the 1990s (see Figure 7). This is quite different from Spain where we see a sharp decline in employment after 2008:Q2.

Some of the difference in Japanese and Spanish labor market indices is due to a difference in labor market institutions in the two countries. A substantial fraction of Japanese workers have implicit lifetime employment guarantees and firms adjust hours for these workers in times of recession.[2] Braun, Esteban-Pretel, Okada and Sudou (2006) document lots of variability in hours per worker over the business cycle. In fact, hours per worker in Japan are more variable than employment. Japanese hours per worker in Japan start falling in 1990 or one year before the turning point of Japanese GDP. Between 1989 and 1992 hours per worker in Japan fall by 5.5 percent. In Spain, hours per worker fall by 3 percent between June 2006 and June 2009.

International Trade

Evidence on the evolution of trade in the two countries is reported in Figures 8 through 10. Figures 8 and 9 report export and import indices and Figure 10 reports the trade balance as a percentage of GDP. Rising asset prices were associated with large increases in both imports and exports in the two countries. Japan experiences more pronounced increases with exports increasing by 20 percent and imports increasing by about 30 percent in the three years prior to 1991. In Spain both indices also rise but the magnitudes of increase are smaller. Exports increase by about 10 percent and imports increase by about 20 percent between 2006 and 2008. With imports rising more rapidly then exports the trade balance deteriorates prior to the peak in both countries. However, as can be seen in Figure 10, the sign of the trade balance is different in the two countries. Japan has a large surplus prior to the collapse of asset prices whereas Spain has a trade substantial deficit.

Spain's current recession has been associated with sharp declines in both imports and exports and the trade balance narrows after 2008:Q1. In Japan the collapse of the 1980s bubble economy is associated with declining imports but stable exports (see Figures 8 and 9). The result is that the trade balance surplus actually increases in Japan between 1991 and 1993. It is worth emphasizing that the current recession in

[2] Moriguchi and Ono (2006) report that 43 percent of Japanese workers have tenure with the same firm of 10 years or more.

Spain is a global event that has been disrupted trade patterns in many countries including Japan.

Consumer Price Inflation

Japan's real estate and asset price bubble occurred against a background of low inflation (see Figure 11). Although inflation rose during the bubble, CPI inflation tops out at 4 percent in November 1990. The Japanese CPI inflation rate declines from February 1991 but does not turn negative until 1995. The uptick in inflation in 1997 is due to a 2 percent increase in the value added tax from April of that year.

Spain also experienced rapid asset and real estate price increases against a background of moderate inflation. Prior to 2007 the CPI inflation rate in Spain is positive but moderate even though land and asset prices are rising rapidly. CPI growth gradually accelerates from 2.2 percent per year in July 2007 and to 5.3 percent in June 2008. After that inflationary pressure quickly abates and Spanish CPI growth falls into negative territory in March 2009.

Bank Lending

The Japanese bubble economy was fueled by a massive increase in bank lending. Figure 12 reports bank lending in Japan between 1988 and 1998 and Spanish loan growth from January 2005 through September 2009. Between January of 1988 and January of 1991 bank lending increased by 40 percent in Japan. Our comparison of the patterns of bank lending in Spain and Japan shows that the two lines are sitting practically right on top of each other. In both countries loan growth slows somewhat after asset prices start to fall but remains positive.

The current global financial crisis was triggered by weak lending practices in the U.S. or what has come to be called the subprime lending problem. The rapid rise in land prices that Japan experienced in the late 1980s was also fueled by weak lending practices. One particularly striking example of weak lending practices was concentrated in Japanese mortgage lending organizations called Juusen. Juusen were independent private lending organizations that were set up by the private banking sector with the support of the government in the early 1970s. The goal of the Juusun was to facilitate mortgage lending. The Juusun were already in poor shape before the bubble collapsed. At the peak of the asset price bubble in 1991 already 38 percent of their loans were nonperforming (see Milhaupt and Miller (1997)). As land prices fell, nonperforming loans skyrocketed. After several failed bailout attempts it was decided in 1996 to liquidate the Juusen and transfer about 6.6 trillion Yen in mostly non-performing assets to a new public entity.[3]

Other aspects of the regulatory environment in Japan also contributed to the problems that the Japanese banking sector faced when the bubble economy collapsed after 1991. Most interest rates were regulated in Japan until the end of the 1980s. However, there were no rules that prevented banks from taking equity positions in firms to whom they lent funds. This led banks to compete with each other by acquiring stocks in their commercial clients. A second important characteristic of the Japanese banking system was that prior to the 1990s land was the principal collateral for both commercial and residential lending. Land was immobile and land prices had appreciated steadily in the post World War II period. Once real estate and land prices started to fall bank balance sheets were affected in two ways. Falling real estate prices lowered the value of

[3]see Hoshi and Kayshup (2001) for more details.

the collateral of virtually all loans. At the same time falling equity prices meant that bank assets were also deteriorating. As the size of the problems in Japan's banking sector became apparent, international markets began to perceive that there were systemic risks in the Japanese financial system and from the summer of 1995 international lenders demanded a premium on overnight loans to Japanese counter-parties.

Given the similarity of the patterns of loan growth in Japan and Spain in Figure 12 one can't help but feel concerned about the possibility that delinquencies will also become a big issue for the Spanish banking sector.

Monetary Policy

Figure 13 reports policy interest rates for Japan (uncollaterized call rate) and the Euro (Eonia). One of the more interesting common elements between Spain and Japan in the 1990s concerns monetary policy. In Europe the advent of the Euro has taken away the option of fine tuning monetary policy to domestic conditions in Spain. A possible result of this change is that short-term interest rates set by the ECB may have been to low for Spain. Excessively low interest rates may have driven loan growth and thereby fostered Spain's real estate bubble. Low interest rates and easy credit are also thought to have played an important role in Japan's bubble economy. After the Plaza Accord in September 1985 the Bank of Japan coordinated with other countries to devalue the U.S. dollar. In order to sterilize the effects of the massive interventions in the foreign exchange market, short-term Yen rates were lowered. This policy was successful and the dollar depreciated sharply against the Yen. Between March 2005 and March 2007 the dollar lost 45 percent of its value against the Yen. The low short term interest rate policy of the Bank of Japan was maintained through 1988. As the pace of asset and land price gains accelerated concerns grew that monetary policy was too loose and the Bank of Japan raised interest rates from 4.1 percent in January of 1989 to a high of 8.2 percent in February of 1991. After it became clear that the bubble had been pricked the Bank of Japan reversed course and lowered interest rates until they fell to nearly zero in 1998.

Given the current low rates and unorthodox monetary policies being pursued by central banks it is perhaps helpful to the reader to briefly summarize the conduct of Japanese monetary policy in the period of zero nominal interest rates. Between 1999 had 2006 Japan had effectively zero nominal interest rates. With the nominal interest rate at zero, the Bank of Japan pursued unorthodox measures. From 2001 to 2006 the Bank of Japan pursued a quantitative easing policy. In practice quantitative easing was an excess reserve targeting policy that was designed to flood overnight markets with cash until banks, having no better use for the funds, choose to hold them as excess reserves. Quantitative easing was associated with a massive increase in monetary base (see Braun and Oda (2009) for a detailed analysis of this policy). They also pursued other unorthodox measures such as purchasing equity. Quantitative easing ended in March 2006 and the policy rate was gradually increased to 0.25 percent and then to 0.5 percent over the course of the next year. From Figure 13 we see that these increases were reversed in the fall of 2008. From the fourth quarter of 2008 the Bank of Japan adopted emergency quantitative easing measures to help restore liquidity to overnight loan markets.

Fiscal Policy

Government debt is reported in Figure 14. The rapid rise in asset and real estate prices was good news for the fiscal authority. The debt-GDP ratio fell steadily in Japan between 1987 and 1991. This pattern of decline is remarkably similar to Spain's experience prior to the first quarter of 2008. After the turning point (quarter 1 of 2008 for Spain and quarter 1 of 1991 for Japan) the debt-GDP ratios in the two countries part company. In Japan the ratio continues to fall until the first quarter of 1992 where as in Spain it shoots up sharply.

Figure 15 reports the ratio of government purchases to GDP. Spain entered the current recession with a government purchases to output ratio of 0.19. In Japan this ratio was a bit higher at about 0.2. The ratio of government purchases to output rose in both countries after GDP starts to slow. Spain, however, shows a much more rapid increase in government purchases than Japan. A concern is that Spain may be exhausting its possibilities of further fiscal stimulus. Spain is bound by the European Monetary Union Growth and Stability Pact that limits government deficits to three percent of GDP when output is growing. Obviously, Japanese fiscal policy was not bound by any such agreement.

We now turn to discuss the policy reaction after the collapse of the Japanese bubble economy in more detail. We saw above that equity and land prices decline sharply from 1990. Real output growth continued and unemployment was stable between 1991 and 1992. From 1993 though GDP growth slowed and unemployment started to increase. Policy makers in Japan were concerned. Viewed from the perspective of the very rapid growth and low unemployment of the 1980s, slow growth and even moderate increases in unemployment were a matter for concern. Between 1991 and 1993, the Bank of Japan lowered the call rate from 8.2 percent to 2.4 percent. Fiscal expenditures increased from 20 percent of GDP to 24 percent of GDP between 1991 and 1996. Starting in 1994 Japanese fiscal authorities tried to stimulate the economy using temporary tax cuts. In 1994 Japan introduced a temporary income tax cut that saw income tax liabilities for a typical household fall by 20 percent. This policy was renewed in 1995 and 1996 but the reduction was reduced to 15 percent and a maximum benefit cap of 50,000 Yen was imposed.

By 1996, the economy was showing signs of recovery. Annualized year on year GDP growth hit 3.7 percent in the fourth quarter of 1996. As the economy recovered concerns of policy makers shifted to managing the deficit. In 1997 the temporary reduction in the income tax was removed, the consumption tax was increased by two percentage points and out of pocket contributions for medical expenses were increased. Government expenditures as a fraction of GDP started falling from the first quarter of 1996. What followed was Japan's deepest recession since World War II.

The recession brought with it further declines in stock and land prices. These declines hit balance sheets of financial services firms hard. A rash of bankruptcies occurred in the fall of 1997 culminating with the collapse of Yamaichi Securities. By 1998 Japan was experiencing deflation, a crippled banking sector, and a rapidly increasing stock of government debt.

The fact that the fiscal tightening was followed almost immediately by a recession raises the question as to whether the government reversed course to soon. Spain is also planning to increase its value added tax by two percent in 2010 and there are current discussions about whether the recent rapid growth in government expenditures should also be reigned in. The anecdotal evidence from Japan seems to indicate that a quick reversal of fiscal policy may have bad implications for the economy. It is hard though to draw any firm conclusions using a narrative form of analysis because correlations do not imply causality. So we now turn to conduct a quantitative assessment of the Japanese fiscal policy reversal in 1997 using an economic model.

3 The Model Economy

We consider a prototypical New Keynesian economy. The actors in this economy include a representative household, a representative final good producer, a continuum of intermediate good producing monopolists, a government and a central bank.

3.1 Households

The representative household chooses sequences of consumption, $\{c_t\}_{t=0}^{\infty}$, real balances, $\{M_{t+1}/P_t\}_{t=0}^{\infty}$, and leisure, $\{1-h_t\}_{t=0}^{\infty}$, to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \prod_{t=0}^{t} d_t \left\{ \frac{(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{1-\sigma} + \Upsilon\left(\frac{M_t}{P_t}, \psi_t\right) \right\} \tag{1}$$

where c_t is consumption of the composite good, M_t is per capita holdings of money at the end of period t, and h_t is hours worked expressed as a fraction of a time endowment of one. Parameter β denotes the discount factor, and parameter ν is the weight the household attach to consumption. There are two shocks to preferences: d_t is a shock to the subjective discount rate which evolves according to

$$\ln(d_t) = \rho_d \ln(d_{t-1}) + \epsilon_{d,t}. \tag{2}$$

and ψ_t is a shock to preferences for real balances which evolves according to

$$\psi_t = Z_{\psi,t} exp(v_{\psi,t}) \tag{3}$$

$$v_{\psi,t} = \rho_{\psi}(v_{\psi,t-1}) + \epsilon_{\psi,t} \tag{4}$$

$$Z_{\psi,t+1} = \mu_{\psi} Z_{\psi,t}. \tag{5}$$

We assume that the demand for real balances has a bliss point. That is, we assume that in any period t there exists an $\overline{m}_t$ such that $\Upsilon'(m_t) > 0$ for all $m_t < \overline{m}_t$, and that $\Upsilon'(m) = 0$ for all $m_t \geq \overline{m}_t$.[4] We will consider a balanced growth path in which consumption is growing over time. In order for real balances to matter along the balanced growth path the bliss point of the money demand shock also has to grow over time. This is why ψ has a trend component. The shock $e_{\psi,t}$ is assumed to be an *i.i.d.* conditionally homoscedastic Gaussian random variable.

The household's period t budget constraint is

$$(1+\tau_{c,t})c_t + x_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} =$$
$$\frac{M_{t-1}}{P_t} + (1+R_{t-1})\frac{B_{t-1}}{P_t} + \int_0^1 \frac{\Pi_t(i)}{P_t} di + T_t + (1-\tau_{k,t})r_t k_{t-1} + (1-\tau_{w,t})w_t h_t + \tau_{k,t}\delta k_{t-1}/q_t \tag{6}$$

[4]If $\Upsilon'(m) > 0$ for all m, then the zero interest rate bound never binds. Since we want to analyze monetary policy under a binding zero nominal interest rate constraint, we need to allow for $\Upsilon'(m_t) = 0$.

where P_t is the price level, B_t is the household's end-of-period holdings of nominal debt, k_{t-1} is the end-of-period stock of capital, and x_t is investment. Households hold equal amounts of shares in each intermediate goods producing firm, and $\Pi_t(i)$ denotes the per capita nominal profits from firm i. Households pay proportional taxes $\tau_{k,t}$ and $\tau_{t,w}$ on capital and labour income, and they receive from the government a lump-sum transfer of size T_t. Finally, q_t is a technology shock to the production of investment goods. In equilibrium the shock defined in this way will also turn out to be the relative price of investment goods. This shock evolves according to:

$$q_t = Z_{q,t}e^{v_{q,t}} \tag{7}$$

$$v_{q,t} = \rho v_{q,t-1} + \epsilon_{q,t} \tag{8}$$

$$Z_{q,t}/Z_{q,t-1} = \mu_q \tag{9}$$

There are two components to q_t: a deterministic trend component that grows at the rate μ_q and a stationary stochastic component $v_{q,t}$. The shock $e_{q,t}$ is a strictly stationary, homoscedastic, *i.i.d.* Gaussian random variable. We assume that capital is subject to a quadratic adjustment cost, and it is accumulated according to

$$k_t = (1-\delta)k_{t-1} + q_t x_t - \frac{\phi}{2}\left(\frac{q_t x_t}{k_{t-1}} - \mu_k + 1 - \delta\right)^2 k_{t-1} \tag{10}$$

Solving the households' problem

The Lagrangean for the household's problem is:

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \prod_{t=0}^{t} d_t \left(\frac{(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{1-\sigma} + \Upsilon\left(\frac{M_t}{P_t}, \psi_t\right)\right) \tag{11}$$

$$+\beta^t \prod_{t=0}^{t} d_t \lambda_{c,t} \Bigg[-c_t - x_t - \frac{M_t}{P_t} - \frac{B_t}{P_t} + \frac{M_{t-1}}{P_t} + (1+R_{t-1})\frac{B_{t-1}}{P_t} + \int_0^1 \frac{\Pi_t(i)}{P_t} di + T_t \tag{12}$$

$$+(1-\tau_{k,t})r_t k_{t-1} + (1-\tau_{w,t})w_t h_t + \tau_{k,t}\delta k_{t-1}/q_t \Bigg] \tag{13}$$

$$+\beta^t \prod_{t=0}^{t} d_t \lambda_{k,t} \left(-k_t + (1-\delta)k_{t-1} + q_t x_t - \frac{\phi}{2}\left(\frac{q_t x_t}{k_{t-1}} - \mu_k + 1 - \delta\right)^2 k_{t-1} \right) \tag{14}$$

The first order conditions are:

$$\frac{\nu(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{c_t} = \lambda_{c,t}(1+\tau_{c,t}) \tag{15}$$

$$\frac{(1-\nu)(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{1-h_t} = \lambda_{c,t}(1-\tau_{w,t})w_t \tag{16}$$

$$\lambda_{c,t} = \lambda_{k,t}\left[q_t - \phi\left(\frac{q_t x_t}{k_{t-1}} - \mu_k + 1 - \delta\right) q_t \right] \tag{17}$$

$$E_t \beta d_{t+1} \lambda_{c,t+1} \left[(1-\tau_{k,t+1}) r_{t+1} + \tau_{k,t+1} \delta / q_{t+1}\right] - \lambda_{k,t} + E_t \beta d_{t+1} \lambda_{k,t+1} \times$$
$$\left[1 - \delta + \phi \left(\frac{q_{t+1} x_{t+1}}{k_t} - \mu_k + 1 - \delta\right) \frac{q_{t+1} x_{t+1}}{k_t} - \frac{\phi}{2} \left(\frac{q_{t+1} x_{t+1}}{k_t} - \mu_k + 1 - \delta\right)^2\right] = 0 \tag{18}$$

$$\Upsilon_1 (m_t, \psi_t) = \lambda_{c,t} \frac{R_t}{1 + R_t} \tag{19}$$

$$-\lambda_{c,t}/P_t + E_t(1 + R_t) \beta d_{t+1} \lambda_{c,t+1}/P_{t+1} = 0 \tag{20}$$

were E_t is the expectations operator conditioned on all variables dated t and earlier.

3.2 Final Good Firms

We assume that perfectly competitive final good firms assemble the intermediate goods and they transform them into a single final good. They have access to the production technology described by

$$y_t = \left(\int_0^1 y_t(i)^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}} \tag{21}$$

The profit maximizing input demands of the final good firm are

$$y_t(i)^d = \left(\frac{p_t(i)}{P_t}\right)^{-\theta} y_t \tag{22}$$

where $p_t(i)$ denotes the price of the good produced by firm i.

3.3 Intermediate Goods Firms

We assume that there is a continuum of monopolistically competitive intermediate goods firms, and that each one of them produces one differentiated intermediate good according to the technology described by

$$y_t(i) = k_{t-1}(i)^{\alpha} (A_t h_t(i))^{(1-\alpha)} \tag{23}$$

where A_t is a technology shock with the following law of motion

$$A_t = Z_{A,t} e^{v_{A,t}} \tag{24}$$

$$v_{A,t} = \rho_A v_{A,t-1} + \epsilon_{A,t} \tag{25}$$

$$Z_{A,t}/Z_{A,t-1} = \mu_A. \tag{26}$$

In the above expression the state of technology has a deterministic growth component $Z_{A,t}$ and a persistent stationary component $v_{a,t}$. The shock $e_{A,t}$ is a strictly stationary, homoscedastic *i.i.d.*Gaussian random variable. A typical intermediate goods firm's dynamic profit maximization problem can be solved in two steps.

The first step is cost minimization and it implies that

$$r_t = \alpha \chi_t k_{t-1}(i)^{\alpha-1} (A_t h_t(i))^{1-\alpha} \tag{27}$$

$$w_t = (1-\alpha)\chi_t A_t^{(1-\alpha)} k_{t-1}(i)^{\alpha} h_t(i)^{-\alpha} \tag{28}$$

$$\chi_t = \frac{(r_t)^{\alpha} w_t^{1-\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha} A_t^{1-\alpha}} \tag{29}$$

The second step is price setting. In this step each intermediate goods firm chooses the sequence $p_t(i)$. We introduce price rigidity assuming that there is a convex cost of adjustment in prices as in Rotemberg (1996). The price setting problem of a typical intermediate goods producer is

$$\sum_{t=0}^{\infty} \beta^t \prod_{t=0}^{t} d_t \lambda_{c,t} \left[p_t(i) y_t(i) - P_t \chi_t y_t(i) - \frac{\gamma_0}{2} P_t (\pi_t - \gamma_{1,t})^2 y_t \right] / P_t \tag{30}$$

subject to (22), where $1 + \pi_t(i) = p_t(i)/p_{t-1}(i)$ denotes the gross inflation rate, and where $\lambda_{c,t}$ denotes the Lagrange multiplier on the household budget constraint.

Consequently, the optimal price sequence satisfies

$$\beta \frac{d_{t+1}\lambda_{c,t+1} y_{t+1}}{\lambda_{c,t} y_t} \gamma_0 (\pi_{t+1} - \gamma_{1,t+1})(1+\pi_{t+1}) = -\left[1 - \theta + \theta \chi_t - \gamma_0(\pi_t - \gamma_{1,t})(1+\pi_t)\right] \tag{31}$$

3.4 Monetary Policy

We consider interest rate targeting rules of the following form:

$$R_t = \max[R(y_t, \pi_t, R_{t-1}), 0] \tag{32}$$

where the function R represents a feedback mechanism. Interest rate targeting rules have been found to be good empirical specifications of monetary policy by Taylor (1993) and others, and we will hereafter refer this interest rate targeting rule as a Taylor rule. Our Taylor rule allows for persistence in the nominal interest rate and also explicitly recognizes that the nominal interest rate has a lower bound of zero. A negative nominal zero interest rate is inconsistent with an equilibrium where both money and bonds are held. We will consider equilibria in which the nominal interest rate hits its lower bound.

3.5 Fiscal Policy

The fiscal authority finances its expenditures and transfers levying distortionary taxes and issuing nominal risk-free bonds that satisfy the following budget constraint each period

$$g_t + (1 + R_{t-1}) \frac{B_{t-1}}{P_t} = \frac{B_t}{P_t} - T_t + \tau_{w,t} w_t h_t + \tau_{c,t} c_t + \tau_{k,t} k_{t-1}(r_t - \delta/q_t) + \frac{M_t - M_{t-1}}{P_t} \tag{33}$$

Let $b_t \equiv \frac{B_t}{P_t}$, and $m_t \equiv \frac{m_t}{P_t}$, then the government budget constraint can be rewritten as:

$$g_t + (1 + R_{t-1}) b_{t-1} \frac{1}{1+\pi_t} = b_t - T_t + \tau_{w,t} w_t h_t + \tau_{c,t} c_t + \tau_{k,t} k_{t-1}(r_t - \delta/q_t) + m_t - m_{t-1} \frac{1}{1+\pi_t} \tag{34}$$

In the simulations that follow we hold the labor and capital taxes fixed. We will however, allow the tax rate on consumption and government purchases to vary. We assume that the law of motion for these variables is:

$$\tau_{c,t} = (1 - \rho_{\tau_c})\bar{\tau}_c + \rho_{\tau_c} \tau_{c,t-1} + u_{\tau_c,t} \tag{35}$$

$$g_t/y_t = (1 - \rho_g) \frac{g}{y} + \rho_g \frac{g_{t-1}}{y_{t-1}} + u_{g,t} \tag{36}$$

We assume that the shocks $u_{\tau_c,t}$, $u_{g,t}$ are independent and identically distributed. Our model satisfies the Ricardian Equivalence proposition. In practice we will assume that lump-sum transfers adjust to ensure that the government budget constraint is satisfied in each period.

3.6 Aggregate Resource Constraint

The aggregate resource constraint that we use to close the model is

$$g_t + c_t + x_t = y_t \tag{37}$$

This resource constraint abstracts from the resource costs of price adjustment. Much of the previous New Keynesian literature uses log-linear methods to solve similar models around a steadystate with zero inflation. Under these assumptions the aggregate resource constraint used when actually solving the model is the log-linear version of (37). In order to facilitate comparison with the literature we follow the example of Christiano, Eichenbaum and Rebelo (2009) and omit the resource costs of adjusting prices and capital. We will discuss the affect of this assumption on our conclusions below.

3.7 Equilibrium

The possibility that the nominal interest rate can hit its zero bound raises some interesting computational issues. Previous research by Christiano, Eichenbaum and Rebelo (2009) and Eggertsson (2008) finds that the dynamic properties of the New Keynesian model are quite different when the nominal interest rate is zero. The government purchase multiplier, for instance, can increase by a magnitude of four when the nominal interest rate is zero. These properties of the model motivate us to use exact nonlinear methods when solving for the equilibrium. We start by defining a perfect foresight competitive equilibrium.

Definition of Equilibrium

The model developed above has a perfect foresight symmetric monopolistically competitive equilibrium. We use a sequential definition of equilibrium because it is consistent with the method we use to solve the model. Given the initial conditions (P_{-1}, R_{-1}, k_0, m_0, b_0) and the sequences of exogenous shocks $\{d_t, A_{c,t}, q_t, T_t\}_{t=0}^{\infty}$, a symmetric monopolistically competitive equilibrium is an allocation, $\{c_t, h_t, x_t, k_t, m_t, b_t, \lambda_{c,t}, \lambda_{k,t}, y_t\}_{t=0}^{\infty}$, a government policy, $\{R_t, \tau_k, \tau_{c,t}, \tau_w, g_t, l_t\}_{t=0}^{\infty}$, a sequence of prices, $\{r_t, w_t, \chi_t, \pi_t\}_{t=0}^{\infty}$, and a finite set of integers, I_B, that satisfies the following conditions:

(a) the households' optimality conditions;

(b) the firms' optimality conditions;

(c) a monetary policy rule that satisfies the following properties: the zero interest rate constraint binds for all $t \in I_B$, and $R_t = R(y_t, \pi_t, R_{t-1})$ for all other $t \geq 0$; when $R_t > 0$, the monetary authority supplies M_{t+1} that satisfies (43); when $R_t = 0$ the monetary authority supplies the minimum amount of money that is needed to satiate household's demand for real balances.

(d) the aggregate resource constraint.

Equilibrium conditions

Our model economy has three exogenous variables, $\{d_t, A_{c,t}, q_t, \tau_{c,t}\}$ and our equilibrium determines the following 15 variables $\{c_t, h_t, x_t, k_t, m_t, \lambda_{c,t}, \lambda_{k,t}, y_t, r_t, w_t, \chi_t, \pi_t, T_t, g_t, R_t\}$. The endogenous variables are determined by the following system of equations. [5]

$$k_t = (1-\delta)k_{t-1} + q_t x_t - \frac{\phi}{2}\left(\frac{q_t x_t}{k_{t-1}} - \mu_k + 1 - \delta\right)^2 k_{t-1} \tag{38}$$

$$\frac{\nu(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{c_t} = \lambda_{c,t}(1+\tau_{c,t}) \tag{39}$$

$$\frac{(1-\nu)(c_t^{\nu}(1-h_t)^{1-\nu})^{1-\sigma}}{1-h_t} = \lambda_{c,t}(1-\tau_{w,t})w_t \tag{40}$$

$$\lambda_{c,t} = \lambda_{k,t}\left[q_t - \phi\left(\frac{q_t x_t}{k_{t-1}} - \mu_k + 1 - \delta\right) q_t\right] \tag{41}$$

$$\beta d_{t+1}\lambda_{c,t+1}\left[(1-\tau_{k,t+1})r_{t+1} + \tau_{k,t+1}\delta/q_{t+1}\right] - \lambda_{k,t} + \beta d_{t+1}\lambda_{k,t+1}\times$$
$$\left[1-\delta+\phi\left(\frac{q_{t+1}x_{t+1}}{k_t} - \mu_k + 1 - \delta\right)\frac{q_{t+1}x_{t+1}}{k_t} - \frac{\phi}{2}\left(\frac{q_{t+1}x_{t+1}}{k_t} - \mu_k + 1 - \delta\right)^2\right] = 0 \tag{42}$$

$$\Upsilon_1(m_t, \psi_t) = \lambda_{c,t}\frac{R_t}{1+R_t} \tag{43}$$

$$-\lambda_{c,t}(1+\pi_t) + (1+R_t)\beta d_{t+1}\lambda_{c,t+1} = 0 \tag{44}$$

$$\beta\frac{d_{t+1}\lambda_{c,t+1}y_{t+1}}{\lambda_{c,t}y_t}\gamma_0(\pi_{t+1}-\gamma_{1,t+1})(1+\pi_{t+1}) = -\left[1-\theta+\theta\chi_t - \gamma_0(\pi_t-\gamma_{1,t})(1+\pi_t)\right] \tag{45}$$

$$y_t = k_{t-1}^{\alpha}(A_{c,t}h_t)^{(1-\alpha)} \tag{46}$$

$$r_t = \alpha\chi_t k_{t-1}^{\alpha-1}(A_{c,t}h_t)^{1-\alpha} \tag{47}$$

$$r_t/w_t = \frac{\alpha}{(1-\alpha)}\frac{h_t}{k_{t-1}} \tag{48}$$

$$R_t = \max[R(y_t, \pi_t, R_{t-1}), 0] \tag{49}$$

$$g_t + \frac{(1+R_{t-1})}{1+\pi_t}b_{t-1} = b_t - T_t + \tau_{w,t}w_t h_t + \tau_{c,t}c_t + \tau_{k,t}k_{t-1}(r_t - \delta/q_t) + m_t - \frac{m_{t-1}}{1+\pi_t} \tag{50}$$

[5] We have omitted profits from the list of endogenous variables. They can be derived from the household budget constraint.

$$g_t/y_t = \Xi\left(\frac{g_{t-1}}{y_{t-1}}, u_{g,t}\right) \tag{51}$$

$$g_t + c_t + x_t = y_t \tag{52}$$

Braun and Waki (2006) conduct an analysis of Japan's experience with zero interest rates under the assumption of perfect foresight. Perfect foresight is very convenient but has the property that agents adjust their plans today to reflect events that don't occur for many periods. We are interested in modeling uncertainty about future outcomes and the resolution of uncertainty in each period as the economy evolves sequentially through time. To entertain this possibility consider a particular (myopic) rule of expectations formation and solve the model using what is called and extended shooting method. More details on our solution method can be found in the Appendix.

4 Calibration

We calibrate the model economy parameters, instead of estimating them. This is because the standard approach of Bayesian estimation uses a linearized system, and in this article we focus specifically on non-linear dynamics. Braun and Waki (2010) find that modeling nonlinearities is important when the zero nominal interest rate constraint is an explicit part of the model. A second reason that justifies our decision is that for a sizable part of the sample period that we consider (1978-1990) the dynamics of the model economy are dominated by the transitional dynamics associated with a low capital stock. Chen, Imrohoroglu and Imrohoruglu (2006) and Braun, Ikeda and Joines (2009) have found that a low capital stock in conjunction with measured variation in total factor productivity are very important for understanding Japan's Post World War II experience.

The calibration of the model closely resembles parameterizations found elsewhere in the literature. We choose a capital share parameter $\alpha = 0.362$, a capital depreciation rate $\delta = 0.085$ and we set θ, the parameter that governs the substitutability of intermediate goods in final goods production, to yield an average markup of 15 percent. For the coefficient of relative risk aversion we choose $\sigma = 2$, for the share of consumption in the utility function we choose $\nu = 0.4$, and for the time discount rate we choose $\beta = 0.9995$. This final value is rather high for an annual time period but it helps us to reproduce the average value of the return on capital in our sample. We choose the Taylor rule coefficients on output and inflation to be 0.4 and 2. These choices are very similar to those in Braun and Waki (2006). The inflation coefficient is somewhat higher: 2 as compared to the value of 1.7 used in Braun and Waki (2006). This choice helps us to replicate the value of the nominal rate in Japan before 1985. For the adjustment cost of investment we choose $\phi = 2$. This is somewhat lower than the value of 3 used for example in Christiano, Lawrence and Rebelo (2009). The adjustment cost parameter of prices $\phi_0 = 80$. This would correspond approximately to a probability of firms not being able to adjust their prices of 0.75 under a Calvo price adjustment scheme.[6] This value is also somewhat lower than the value of 109 used in Braun and Waki (2006). The serial correlation coefficients

[6] We are using the fact that Rotemberg and Calvo price adjustment cost specifications have the same log-linear representations for suitable choice of model parameters to derive this result.

for the shock processes of most variables are set to 0.9. The only exception is the nominal interest rate persistence parameter in the Taylor rule which is set to 0.4.

A second issue that we face is that the preference shocks are not directly observable. We want to give these shocks a prominent role, so we identify them as follows: First, we simulate the model with only shocks that are observable. From the research cited above we know that we can account from a large part of the Japanese experience in the period under consideration with a total factor productivity shock, so we use this shock first.

There are some important monetary policy surprises during our sample period. The first monetary policy surprise occurred in 1986-88 after the Plaza Accord when Japan and other countries agreed to devalue the United States dollar. In order to sterilize the effects of a higher yen-dollar exchange rate on the domestic economy the Bank of Japan lowered its policy interest rate. To model this policy surprise, we allow for negative shocks to the monetary policy rule during this period. These surprises are interesting because many economists believe that the easy monetary policy during this period played an important role in triggering Japan's construction and stock market bubbles. Second, we also assume that there were large positive monetary policy surprises in 1990 and 1991. We make this assumption because it is generally accepted that the sharp increase in the call rate from 3.5 percent in 1988 to 7.5 percent in 1991 was a monetary policy surprise engineered by the Bank of Japan mainly to stop the financial bubble.

Given these identifying assumptions we start by varying the monetary policy shock so as to replicate the behavior of the nominal interest rate. Then we use two demand shocks first to replicate the behavior of output and then to re-tune the behavior of the nominal interest rate.[7] This works reasonably well because the effects of the two shocks to preferences have distinct effects on output. The shock to the consumption share has a big effect on output. The preference discount rate shifter has a large effect on the interest rate but its affect on output is very modest. Thus we determine output for a given value of the monetary policy shock using the consumption share shifter. Next by varying the shock to the discount rate we can readjust the nominal interest rate without having to readjust output again.

Our strategy of using the model to recover the unobservable shocks using measured variation in total factor productivity and the large monetary policy shocks experienced in 1986-88 and 1990-1991 results in a sequence of shocks that does a reasonable job of reproducing the actual trajectories of output and the nominal interest rate between 1978 and 1990 (see Figures 16 and 17).

After 1990 we make the further identifying assumption that there are no more surprises to monetary policy. And we use the two demand shocks to tune the responses of output and the nominal interest rate for a given sequence of technology and government purchases so that the model reproduces the actual paths of these two variables between 1991 and 2000 (see Figures 16 and 17). In our simulations of the model economy the nominal interest rate is zero in 1999 and 2000, the last two periods of the simulation.

The Appendix contains a description of our solution strategy.

[7]The first one of these shocks perturbs the share of consumption and the second one the time discount rate. The shock to current consumption versus leisure is not included explicitly in the model. However, it affects the intratemporal wedge in a way that is identical to varying the tax rate on consumption. It also affect the intertemporal first order condition. However, in our simulations this second effect is very small. We thus induce this type of shock by altering τ_c.

5 Results

The fiscal tightening in 1997 had three important elements. First, the share of government purchases in output fell between 1996 and 1997 by 3 percent. Second, the value added tax was increased by two percent. Third, tighter fiscal policy occurred against a background of inflation rates of about zero and a very easy monetary policy. The uncollateralized call rate averaged 0.43 percent in 1997. In our model economy agents are expecting deflation and zero nominal interest rates in some future periods from 1994 on.

We have already explained that the Japanese recession of 1997 was a threshold event. And we asked whether the tightening of fiscal policy in 1996-7 came too early. Using the model economy described in the previous section we can now conduct counterfactual exercises to assess the quantitative role played by the tightening in fiscal policy in the recession that started in 1997. Instead of the value-added tax rising and reducing government purchases falling, as occurred in Japan, we assume that there was good news about fiscal policy at the beginning of 1997. Specifically we assume that the model economy agents are informed at the beginning of the period that government purchases will increase by 3 percent and that the value added tax will decrease by 2 percent in the current period. In short, the good news is that there is no fiscal tightening. The serial correlation parameter for both fiscal variables is set to be 0.9 so that this good news about fiscal policy is persistent but not permanent. As we saw above, Japan's debt was rising at the time, and it seems unreasonable to assume that the fiscal shocks were going to be permanent.[8] Table 1 reports results from this counterfactual simulation for a range of macroeconomic variables. The results are expressed as percentage changes relative to the baseline simulation.

The good news about fiscal policy stimulates economic activity in 1997. The stimulus has two distinct channels through which it affects the economy. First, higher government purchases produce intertemporal substitution effects that increase the real interest rate and output as in the classic analyses of Hall (1977) and Barro (1981). Higher government purchases also crowd out private consumption. However, the lower tax rate on consumption offsets this effect, and consumption rises moderately. The overall size of the government purchase multiplier on impact is 1.2.

Higher government demand for goods and services also raises the inflation rate in 1997. This in turn affects household expectations about future inflation. Expected inflation is higher in all periods except 1998 and households expect that the nominal interest rate will remain positive until 2000. For purposes of comparison, in the baseline simulation households observe higher consumption taxes and lower government purchases in 1997 and expect the nominal interest rate to fall to zero in 1998.

In 1998 a new set of shocks arrives in our counterfactual model economy and these shocks act to drive the nominal interest rate to zero in 1998. This is one period earlier than the baseline simulation and 2 periods earlier than what the agents were expecting. Hitting the zero bound has a depressing effect on the economy. The government purchases multiplier continues to exceed one but it is now negative.

The fiscal stimulus has the largest positive effects on the economy in 1999. Output in 1999 is up by 1.4 percent and consumption is up by 3.6 percent as compared to their baseline values. Christiano, Eichenbaum

[8]Below we repeat the policy exercise with various values of the persistence parameter to explore the robustness of our results to the amount of persistence of the shock to government purchases.

and Rebelo (2009) document that the government purchases multiplier is large when the nominal interest rate is zero. We can see an example of their finding here. With the nominal interest rate at its lower bound of zero, the value of the government purchases multiplier is 4 in 1999. This is about the same size as the government purchases multiplier reported by Christiano, Eichenbaum, and Rebelo (2009) for a similar New Keynesian model with capital accumulation.

The positive fiscal shock in 1997 also has positive effects on economic activity in 2000. But, the magnitude of the responses is somewhat smaller. Output is up 0.68 percent and labor input is up by 0.88 percent over its baseline value. The inflation response is also positive but small (0.07 percent). In years beyond 2000 the responses of most variables continue to be positive but diminish in magnitude as the effects of the shock wear off.

To get a handle on the overall effects of this policy we next average the responses across the four years (1997-2000) reported in Table 1. The conclusion that emerges is that the sudden fiscal tightening in 1997 had large and negative effects on Japanese economic activity. Economic activity is substantially higher when we undo the fiscal reversal. Per capita GNP is higher by on average 0.78 percent per year and consumption is higher by on average 0.55 percent per year. There are also pronounced effects on the labor market. Labor input is up on average 1.7 percent per year during this same period. Finally, deflationary pressure is attenuated and the value of the annual inflation rate rises by 0.45 percent on average.

We now turn to consider the individual role played by the two shocks. Table 2 reports results that obtain when we fix the consumption tax and increase government purchases only. Comparing Table 2 with Table 1 we find that the magnitudes of the responses are only slightly attenuated. The response of output in 1997 is now somewhat smaller. Consumption now falls in 1997 but investment is higher than the baseline simulation. Once again there is a depressing effect from the unanticipated early onset of zero nominal interest rates in 1998. However, higher government purchases continue to have positive effects on output in both 1999 and 2000. In addition the nominal interest rate remains positive until 2000. Recall that in the baseline simulation it is zero in 1999 and 2000. From this counterfactual we conclude that most of the action comes from higher government purchases and not from the lower consumption tax.

We have also conducted counterfactuals in which we lower the persistence of the shock to government purchases. Reducing the persistence of this shock acts to attenuate the output response. This is because in our simulations there are two effects operating. One effect is reported in Christiano, Eichenbaum, and Rebelo (2009). They find that reducing the persistence of the government purchases shock increases the size of the impact response of output to a very small change in government purchases increases. In their experiment the number of periods that the zero nominal interest rate is binding does not change. However, here we are considering large and empirically relevant shocks to government purchases. In our environment a large and persistent shock to government purchases acts to reduce the number of periods that the nominal interest rate is zero. This second effect dominates the effect that Christiano, Eichenbaum, and Rebelo (2009) emphasize and is responsible for our result that the overall response of output to a transient impulse in government purchases is smaller than the response of output to a persistent shock in government purchases.

6 Concluding Remarks

We have seen that there are many common elements in Spain's current situation and Japan's experience in the 1990s. In the 1990s, Japan rapidly ramped up government spending and used temporary income tax cuts to stimulate consumption. However, policy makers in Japan chose to reverse this course at the first signs of recovery. The result was a severe recession. This recession, following so quickly on the heels of the previous sharp declines in asset and land prices, weakened the Japanese financial sector balance sheets to the point that it drove some of the largest financial service companies in Japan to bankruptcy and left the survivors severely impaired. What followed was a period of stagnation that lasted until 2006. Results from the quantitative analysis we have conducted here suggest that the depth of the 1997 recession could have been significantly attenuated if fiscal policy had not been reversed so quickly. Our model simulations suggest that the sudden fiscal reversal in 1997 reduced output growth between 1997 and 2000 by an average of about 1 percent per year.[9] The fiscal reversal also increased deflationary pressure lowering the inflation rate by on average about one half of one percent over the same period. Although we have not established a causal link between the 1997 recession and the stagnation that followed in Japan, the results that we have discussed in this article warn against a sudden tightening of fiscal policy in Spain at the current time.

[9] Japanese per capita GNP fell at an annual average rate of 0.8 percent between 1997 and 2000. In our simulation with no sudden fiscal reversal per capita GNP growth averages 0.25 percent instead.

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Appendix: Solution Strategy

Our solution strategy is a bit unorthodox so we motivate briefly our choice. First, results in Braun and Waki (2009) suggest that non-linearities are very important and should not be ignored when solving a model in which the non-negativity constraint on the nominal interest rate constraint occasionally binds. Unfortunately, this type of slackness constraint is highly endogenous and the equilibrium is highly nonlinear. Braun and Waki (2006) emphasize that a complete definition of equilibrium includes a description of the dates that the nominal interest rate is zero and the dates when it is positive and these dates are highly endogenous. In principal there can be multiple periods where the nominal interest rate is zero. To simplify things Braun and Waki (2006) assume that the nominal interest rate is zero for only one continuous interval of time after which it turns positive. We make the same assumption here. Solving for this equilibrium once under perfect foresight even with this special assumption can be a daunting task. Methods such as Newton fail because the interval that the nominal interest rate is zero is endogenous and the policies jump when that interval changes.

Our second motivation is that we want to allow households to be hit with shocks in real time. The recent large swings in land and asset prices reflects the collective actions of investors to some big shocks. We want a model that allows us to see how households update their expectations in real time as they get hit with big shocks. These two motivations led us to use a variant on a technique called extended shooting (see e.g. Heer and Maussner (2008) for a description of extended shooting). Starting from the initial period we solve the model forward for 100 periods (years) and assume that the model is at its steadystate in period 101. We express the set of equilibrium conditions as a large set of nonlinear equations. All future shocks are set to zero. We then move time forward by one period. Households, experience a new set of shocks and have a new set of initial conditions. They once again solve forward for 100 periods. This is repeated for the entire sample period (1978-2000).

This approach allows us to solve the exact non-linear equilibrium conditions. Since we solve the model in real time and can also see how expectations change in real time. Finally, my solution strategy allows us to limit the problem of dealing with the zero bound constraint to a small set of periods. For most periods households assign zero probability to the constraint binding in equilibrium. Then in the last 5-8 periods where households anticipate/experience a binding constraint we solve the model by hand using guess and verify methods to find the interval where the nominal interest rate is zero.

The major limitation of this approach is that expectations about the future in any given period are degenerate. However, this solution strategy also highlights a hard problem. Any non-degenerate method of expectations formulation will require that agents form state dependent probabilities over the interval that the nominal interest rate constraint binds.

Table 1
Counterfactual with lower consumption tax and higher government expenditures

Percentage change relative to baseline	1997	1998	1999	2000
real interest rate	1.24	0.24	-1.38	-0.07
Output	0.64	-0.57	3.56	0.68
Consumption	0.22	-0.48	2.12	0.36
Hours	1.01	-0.89	5.78	0.88
Investment	-0.04	-1.80	4.52	0.23
Inflation rate	1.00	-0.65	1.39	0.07
Government purchases multiplier (dy/dg)	1.19	-1.83	3.99	1.61
Value of the nominal interest rate	2.55	0.00	0.00	0.00

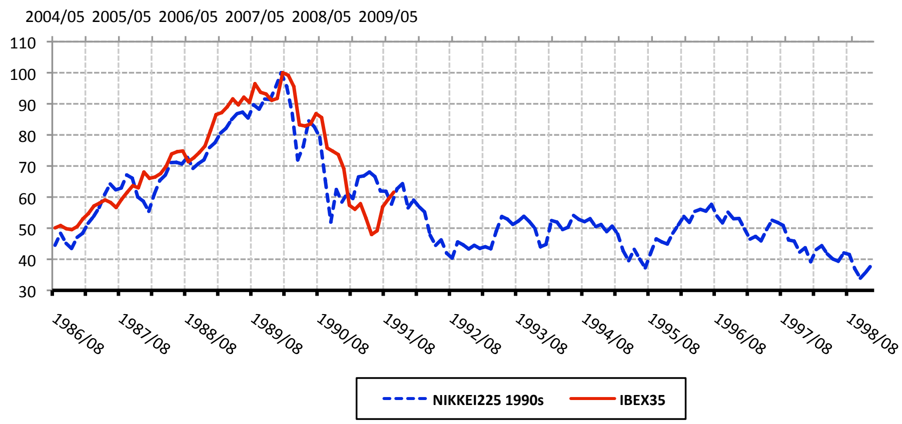
Table 2
Counterfactual with higher government expenditures only

Percentage change relative to baseline	1997	1998	1999	2000
Real interest rate	1.24	0.14	-1.35	-0.11
Output	0.38	-0.58	3.40	0.57
Consumption	-0.28	-0.74	1.78	0.09
Hours	0.59	-0.91	5.48	0.67
Investment	0.07	-1.46	4.58	0.34
Inflation rate	1.10	-0.52	1.45	0.11
Government purchases multiplier (dy/dg)	0.75	-1.84	3.92	1.40
Value of the nominal interest rate	2.65	0.03	0.08	0.00

Fig 1. Stock Market Performance IBEX35 vs NIKKEI225

IBEX 35 2004:05 - 2009:06 Base 2007:10 (max) = 100

NIKKEI 225 1986:08 - 1998:12 Base 1990:1 (max) = 100

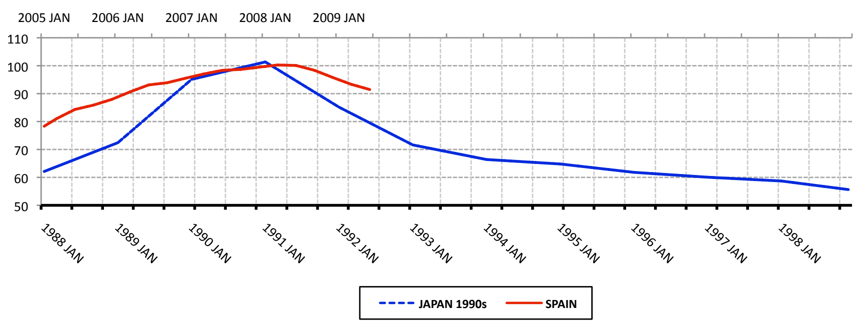


Source:	**Spain**	**Instituto Nacional de Estadística (INE), Spain**
	Japan	**Datastream**

Fig 2. Spain and Japan Real Estate Prices.

Spain: 2005:01 - 2009:6 Base 2008:2 = 100

Japan: 1988:01 - 1998:12 Base 1991:2 = 100

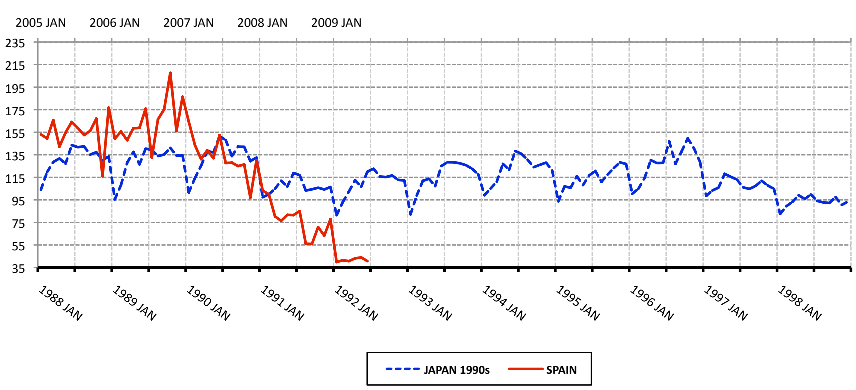


Source:	**Spain**	**Ministry of Housing (Price/m^2 of free standing houses less than two years old)**
	Japan	**Japan Real Estate Institute (Urban Land Price Index)**

Fig 3. Spain and Japan. Housing Starts.

Spain 2005:01 - 2009:07 Base 2008:02 = 100

Japan 1988:03 - 1998:12 Base 1991:02 = 100

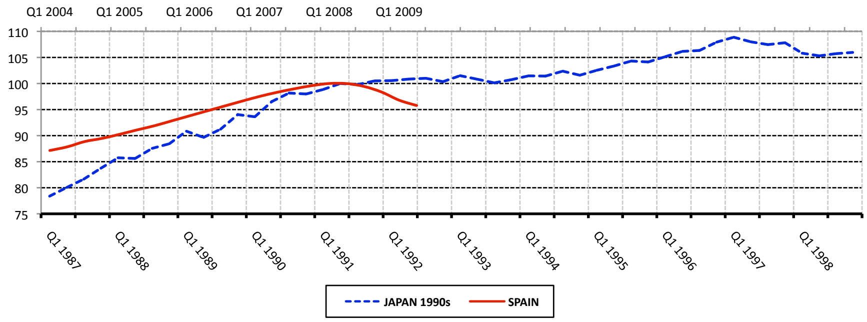


Source:	**Spain**	**Ministry of Housing**
	Japan	**MLIT Ministry of Land, Infrastructure, Transport and Tourism**

Fig 4. Spain and Japan. Real Gross Domestic Product Index.

GDP Spain (current prices) 2004:1Q - 2009:2Q Base 2008:1Q = 100

GDP Japan (current prices) 1987:1Q - 1998:4Q Base 1991:1Q = 100

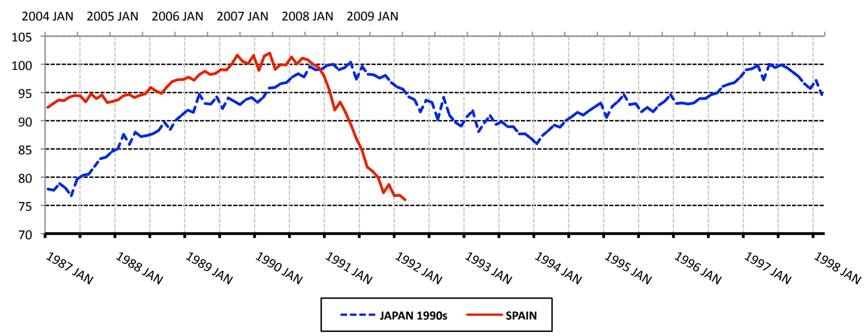


Source:	**Spain**	**Instituto Nacional de Estadística (INE), Spain**
	Japan	**Datastream. Cabinet Office, Japan**

Fig 5. Spain and Japan. Industrial Production Index.

IP Spain 2004:01 - 2009:07 Base 2008:02 = 100

IP Japan 1987:01 - 1998:02 Base 1991:02 = 100

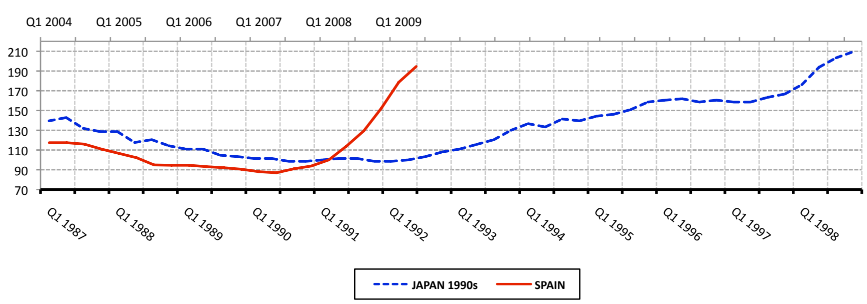


Source:	**IP Spain**	**Datastream. Ministerio de Economia y Hacienda, Spain**
	IP Japan	**Datastream. Ministry of Economy, Trade & Industry, Japan**

Fig 6. Spain and Japan. Job Market. Unemployment Rate Index

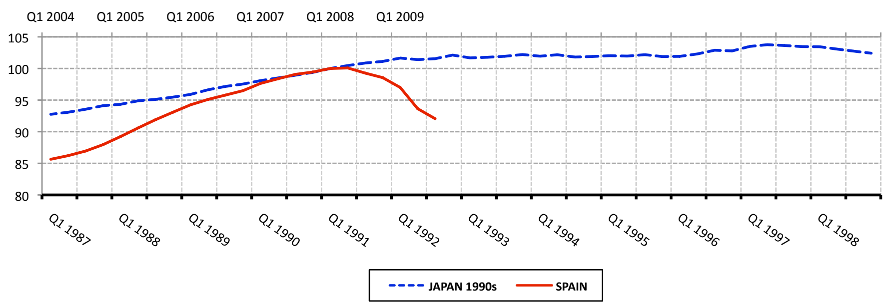
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100

Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



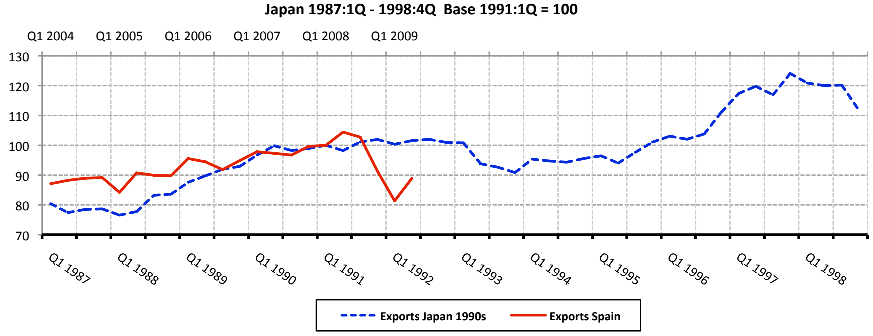
Source:	**Spain**	**Instituto Nacional de Estadística (INE), Spain**
	Japan	**Datastream. MINISTRY OF INTERNAL AFFAIRS & COMMUNICATIONS, Japan**

Fig 7. Spain and Japan. Job Market. Employment Index.
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100
Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



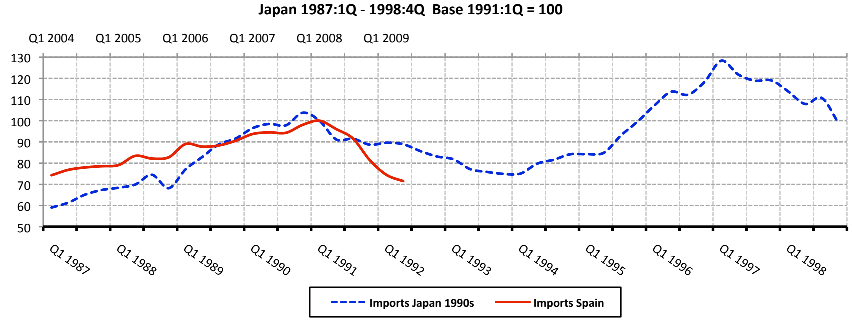
Source: Spain Instituto Nacional de Estadística (INE), Spain
Japan Datastream. MINISTRY OF INTERNAL AFFAIRS & COMMUNICATIONS, Japan

Fig 8. Spain and Japan. External Sector. Exports Index
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100
Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



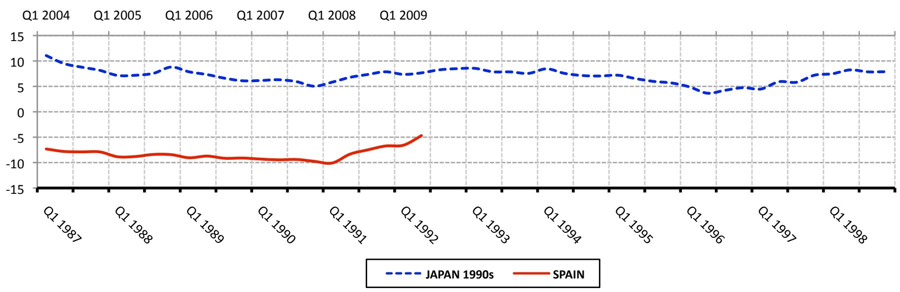
Source: Spain Instituto Nacional de Estadística (INE), Spain
Japan Datastream. Cabinet Office, Japan

Fig 9. Spain and Japan. External Sector. Imports Index
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100
Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



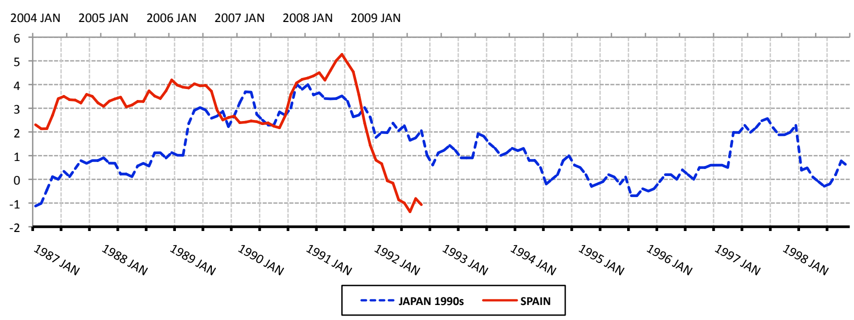
Source: Spain Instituto Nacional de Estadística (INE), Spain
Japan Datastream. Cabinet Office, Japan

Fig 10. Spain and Japan. External Sector. Imports and Exports over GDP
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100
Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



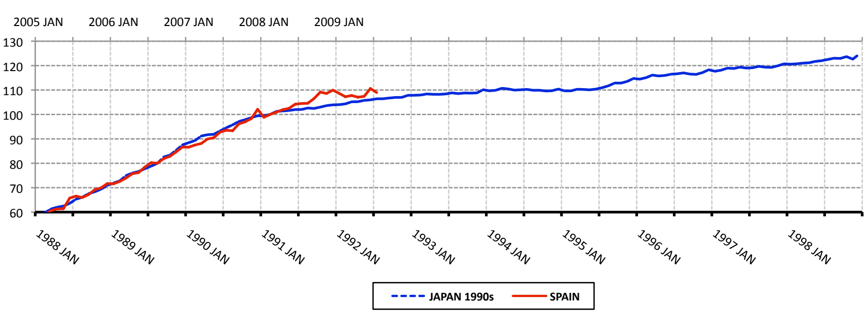
Source:	Spain	Instituto Nacional de Estadística (INE), Spain
	Japan	Datastream. Cabinet Office, Japan

Fig 11. Spain and Japan. Consumer Price Inflation.
CPI Spain 2004:01 - 2009:07 Base 2008:2 = 100
CPI Japan 1987:01 - 1998:12 Base 1991:2 = 100



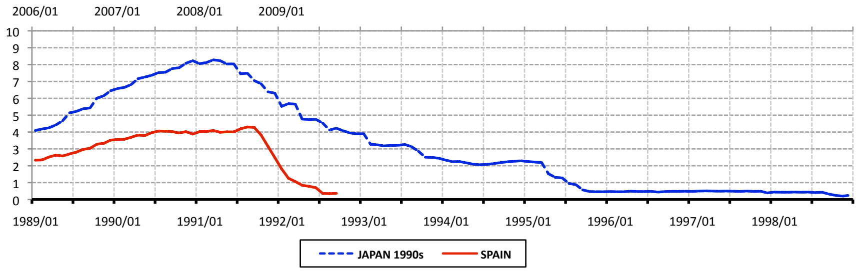
Source:	CPI Spain	Instituto Nacional de Estadística (INE), Spain
	CPI Japan	Datastream. Thomson Reuters & National Source

Fig 12. Spain and Japan. Loans.
Spain 2005:01 - 2009:07 Base 2008:02 = 100
Japan 1988:01 - 1998:12 Base 1991:02 = 100



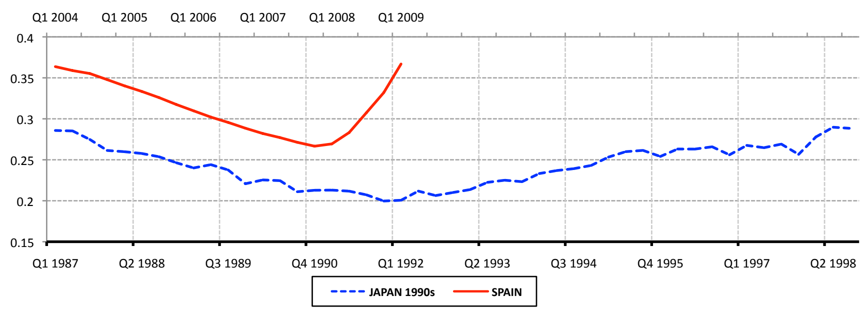
Source:	Spain	Banco de Espana
	Japan	Bank of Japan

Fig 13. Spain and Japan. Policy interest rates.
Spain 2006:01 - 2009:09
Japan 1988:03 - 1998:12



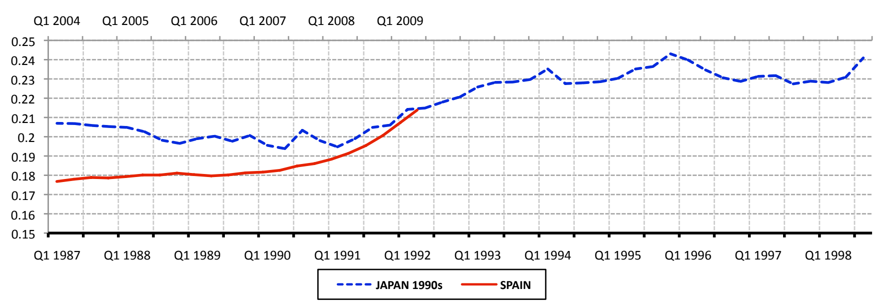
Source:	Spain	Eonia
	Japan	Bank of Japan

Fig 14. Spain and Japan. Government Net Debt/GDP
Japan 1987:1Q - 1998:3Q Base 1991:1Q = 100



Source:	Spain	Banco de España y Dirección General del Tesoro y Política Financiera
	Japan	Bank of Japan

Fig 15. Spain and Japan. Government Purchases/GDP.
Spain 2004:1Q - 2009:2Q Base 2008:1Q = 100
Japan 1987:1Q - 1998:4Q Base 1991:1Q = 100



Source:	GDP Spain	Instituto Nacional de Estadística (INE)
	GDP Japan	Datastream. Cabinet Office Japan

Figure 16. Output: Model and Japanese data. Deviations from 2 percent trend

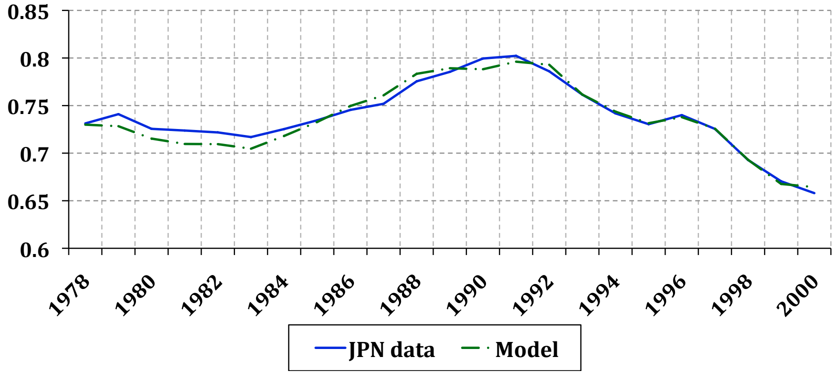
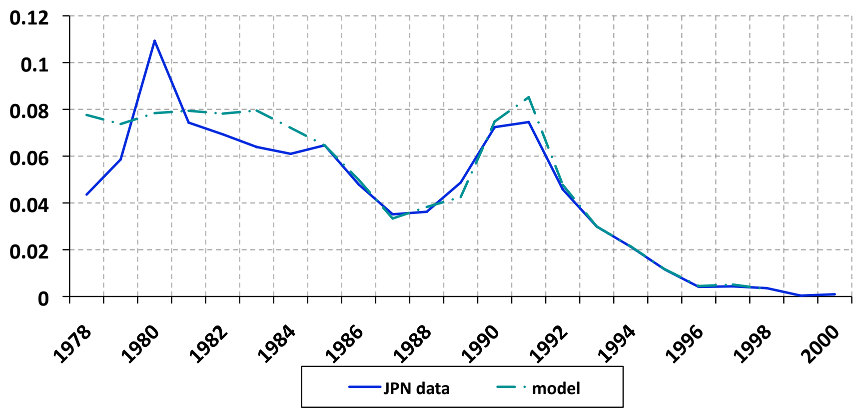


Figure 17. Nominal Interest Rate: Model and Japanese data.



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