ISSN 1936-5098

CAE Working Paper #07-10

The Role of Expectations in Sudden Stops

by

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July 2007

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Abstract

This paper presents a flexible-price small open economy model with a "peso problem" in productivity states. Agents rationally adjust their beliefs about future productivity growth after the arrival of news. A downward revision of expectations triggers a Sudden Stop, together with large declines in GDP, employment, consumption and investment. There need not be any actual change in productivity growth to generate large fluctuations. Quantitatively, the model goes a long way in matching the 1998 Korean Crisis and subsequent swift recovery.

JEL classification: E2, E3, F3, F4
Keywords: sudden stops, small open economy, expectations, peso problem

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I would like to thank Giancarlo Corsetti, Elvira Prades, Morten Ravn, Pontus Rendahl and seminar participants at the European University Institute.

1 Introduction

In October 1997, Standard & Poor's downgraded South Korea's sovereign risk status. During the first quarter of 1998, Korea's net exports-to-GDP ratio rose by more than 18%, GDP contracted by 8.7%, consumption by 13%, and investment by 30%. One year later, GDP, consumption and investment were growing at 10% or more. What causes these abrupt declines in capital inflows, known as "Sudden Stops" (Calvo, 1998), and why are they accompanied by depression-sized, but short-lived, contractions in economic activity?

This paper argues that a shift in expectations about future productivity growth can trigger a Sudden Stop such as the one experienced by South Korea. I propose a small open economy model that suffers from a "peso problem": There is a non-zero probability that productivity growth switches to a bad regime. In response to news signals about future productivity growth, agents revise the probability of the bad regime occurring. The model displays equilibrium paths which, after agents receive bad news, are characterized by an increase in net exports, and a decrease in aggregate output, employment, investment and consumption. Agents are fully rational and during the Sudden Stop, there is never any actual change in productivity growth. When the news signal turns out to be false, the economy quickly reverts to its previous growth path, which requires a period of above-trend growth. To quantitatively account for the Korean experience without unrealistic adjustments in expectations, the model relies on a number of amplification mechanisms, such as variable capacity utilization, predetermined labor, a working capital constraint and an expectation-elastic country risk premium. Because Sudden Stops are phenomena that lead the economy far away from steady states and given the focus on expectations, I solve the model using a nonlinear global approximation method.

The idea that shifts in expectations can drive macroeconomic fluctuations goes back as far as Pigou (1927), but has received renewed attention in the context of modern business cycle models.[1] This is also not the first paper to explore the role of adverse expectations in emerging markets crises. They are an inherent feature of all models in which crises are self-fulfilling events, such as for instance Obstfelt (1986) or Chang and Velasco (2001). However, the model in this paper does not display equilibrium indeterminacy. With Corsetti, Pesenti and Roubini (1999) and Burnside, Eichenbaum and Rebelo (2001), it shares the emphasis that future, rather than current, events cause crises.[2] But the model in this paper is not one of perfect foresight, such that the occurrence of a crisis does not hinge on the future event materializing. The implication is that it is not only difficult to predict crises, they may also be hard to rationalize ex post.

In the literature, there are several approaches to modeling Sudden Stops in a Dynamic Stochastic General Equilibrium (DSGE) framework. In a sense, the most closely related is by Aguiar and Gopinath (2007). They show in a standard small open economy model that a large and persistent decrease in productivity growth generates a Sudden Stop, together with contractions in GDP, consumption and investment. With a *persistent* shock, agents also revise expectations about future productivity growth. The persistence is crucial for obtaining responses that are typical of Sudden Stops. In contrast with Aguiar and Gopinath (2007), in this paper a Sudden Stop occurs without any change in productivity growth. Aguiar and Gopinath (2007) base their evidence for a negative TFP growth shock on the estimation of Solow residuals. However, as the authors themselves point out, the large decreases in measured TFP are to a large extent only indicative of endogenous links between measured

[1]Examples include Danthine, Donaldson and Johnsen (1999), Beaudry and Portier (2004), Jaimovich and Rebelo (2006), Den Haan and Kaltenbrunner (2007) and Prades (2007).

[2]In the case of Corsetti et al. (1999) and Burnside et al. (2001), it are the large prospective fiscal deficits associated with implicit bailout guarantees to failing banks that trigger currency crises.

TFP and Sudden Stops. I allow for variable capacity utilization such that a Sudden Stop is accompanied by a change in the *measured* Solow residual.

Many models in the literature focus on the role of credit frictions. One common approach is to model a Sudden Stop as an exogenous tightening of a collateral constraint. Chari, Kehoe and McGrattan (2005) show that this type of shock tends to stimulate output unless further frictions are included. Christiano, Gust and Roldos (2004) impose advance payment constraints on intermediate inputs to produce output drops. Gertler, Gilchrist and Natalucci (2003) model the Korean crisis as caused by an exogenous increase in the country risk premium and rely on a financial accelerator framework to explain the depth of the crisis. I also incorporate a financial propagation mechanism in the form of a working capital constraint and an expectation-elastic risk premium. The approach in this paper is different, however, as both the Sudden Stop and the associated recession arise endogenously after an adjustment in expectations. The financial friction is not necessary to *qualitatively* match the Korean crisis experience, but is nevertheless important to obtain fluctuations that are *quantitatively* similar.

In the business cycle models of Mendoza (2006) and Mendoza and Smith (2006), Sudden Stops are also endogenous. In their setup, when the economy moves towards a high debt state, shocks of standard magnitudes can force a collateral constraint to bind, triggering highly nonlinear dynamics that resemble Sudden Stops. Their model does not hinge on large unexpected shocks; it captures precautionary motives; and Sudden Stops are rare events nested within regular business cycle movements. The model in this paper can also explain Sudden Stops without large exogenous shocks to TFP, interest rates or the terms of trade. However, to trigger a Sudden Stop, a fairly large (but not unrealistic) shock to expectations is necessary. As in Mendoza (2006), agents engage in precautionary behavior, and since I model shocks to expectations necessary to generate a Sudden Stop as rare events, they arise infrequently within regular business cycles. In contrast with Mendoza (2006), the economy does not need to be in a high debt state to experience a crisis. Indeed, this property is important for the Korean case, as its foreign debt-to-GDP ratio was far lower at the onset of the crisis than for instance in the 1980s.

The rest of the paper is organized as follows: Section 2 describes the theoretical model; Section 3 discusses the calibration to South Korean data and the numerical solution technique; Section 4 presents the model response to a news shock, compares it with the Korean experience and performs a sensitivity analysis of the key parameters; Section 5 concludes.

2 The Model

The model is that of a single good neoclassical small open economy that faces stochastic shocks to the growth rate of productivity. Agents receive stochastic news about future productivity growth and are fully rational in judging the reliability of the news. Both households and domestic firms trade a non-contingent real bond. As in Neumeyer and Perri (2005), Mendoza (2006) and Uribe and Yue (2006), the latter trade in the asset because of the presence of a working capital constraint that requires firms to advance the wage bill before final output is available. Following Neumeyer and Perri (2005), the model also allows for a country risk premium that is decreasing in expected future productivity. Together, these two features amplify news shocks through changes in interest rates. Two other model ingredients are variable capacity utilization and the requirement that firms choose labor input before the realization of present period uncertainty. Variation in the utilization rate of the capital stock leads to propagation mainly through the effect on the marginal product of labor. Predetermined labor input means that firms hire workers based on expected rather than actual productivity levels. The rest of the model closely resembles the canonical small open economy real business cycle models in for instance Mendoza (1991), Correia, Neves and Rebelo (1995) or Schmitt-Grohé and Uribe (2003).

Time is discrete and in each period t, there are two subperiods: t^- in the beginning of t and t^+ at the end of t. Time t^+ and $(t+1)^-$ are arbitrarily close. All uncertainty is revealed to the agents in period t^-. Table 1 summarizes the timing of events.

Firms and Technology. At time t^- a representative firm rents capital services k_t^s and, in combination with labor input h_t, produces y_t of an international tradable good, which becomes available in t^+. The firm's labor input decision must be made in $(t-1)^+$, i.e. *before* the realization of period t uncertainty. The firm is entirely owned by domestic households. Factor markets are perfectly competitive, and production occurs through the constant returns to scale technology

$$\begin{aligned} y_t &= (k_t^s)^\alpha (\Gamma_t h_t)^{1-\alpha} \ , 0 < \alpha < 1 \ , \\ \Gamma_t &= g_t \Gamma_{t-1} \ . \end{aligned} \tag{1}$$

Γ_t measures the level of labor-augmenting technology, which grows at a stochastic rate $\ln(g_t)$. The firm needs to borrow working capital in advance: In order to transfer $w_t h_t$ to workers in t^+, where w_t is the real wage, the firm needs to issue bonds worth $w_t h_t$ in t^- at a rate R_{t-1}. Given prices, the firm chooses k^s to maximize time t^+ profits $y_t - r_t k_t^s - R_{t-1} w_t h_t$, subject to the technological constraint in (1). The firm chooses h_t to maximize the appropriately weighted expectation of time t^+ profits, given by

$$\mathrm{E}_{t-1} \left[\lambda_t \left(y_t - r_t k_t^s - R_{t-1} w_t h_t \right) \right] \ . \tag{2}$$

The firm takes λ_t, the marginal utility of consumption of its owner, as exogenous.

Households and Preferences. The economy is populated by identical, infinitely-lived households with preferences described by

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \exp\left(-\sum_{\tau=0}^{t-1} \beta\left(c_\tau, l_\tau\right)\right) \left[\frac{\left(c_t - \Gamma_{t-1}\zeta\frac{l_t^{1+\psi}}{1+\psi}\right)^{1-\gamma} \Gamma_{t-1}^{\gamma}}{1-\gamma}\right], \tag{3}$$

$$\begin{aligned} \beta(c_\tau, l_\tau) &= \xi \ln\left(1 + \Gamma_{\tau-1}^{-1} c_\tau - \zeta \frac{l_\tau^{1+\psi}}{1+\psi}\right), \\ &\psi > 0\,, \gamma > 1\,, 0 < \xi \leq \gamma\,, \zeta > 0\,, \end{aligned}$$

where c_t denotes consumption and l_t is time spent in the workplace. As in Mendoza (1991), these preferences feature an endogenous rate of time preference that increases with the past level of consumption. The inclusion of an endogenous discount factor is one way to avoid a unit root in bond holdings and otherwise has little implications for the model dynamics (Schmitt-Grohé et al., 2003). The momentary utility function is of the form proposed by Greenwood, Hercowitz and Huffman (1988). With this specification, optimal labor effort depends only on the contemporaneous real wage. These preferences are popular in small open economy models because they generate more realistic business cycles moments (Correia et al., 1995). They also facilitate the numerical solution procedure by eliminating a root-finding operation. The term Γ_{t-1} enters the utility function to ensure the existence of a balanced growth equilibrium. Given these preferences, the marginal utility of consumption λ_t is given by

$$\lambda_t = \left(c_t - \Gamma_{t-1}\zeta\frac{l_t^{1+\psi}}{1+\psi}\right)^{-\gamma} \Gamma_{t-1}^{\gamma} - \xi\left(1 + \Gamma_{t-1}^{-1} c_t - \zeta\frac{l_t^{1+\psi}}{1+\psi}\right)^{-1} e^{-\beta(c_t, l_t)} \frac{V_t}{\Gamma_{t-1}}, \tag{4}$$

where

$$V_t \;=\; \mathrm{E}_t\left[\frac{\left(c_{t+1}-\Gamma_t\zeta\frac{l_{t+1}^{1+\psi}}{1+\psi}\right)^{1-\gamma}}{1-\gamma}\Gamma_t^{\gamma}+e^{-\beta(c_{t+1},l_{t+1})}V_{t+1}\right] .$$

At time t^-, households supply labor and capital services. At time t^+ they receive factor payments and make consumption and investment decisions. Households own a stock of capital k_t, and capital services k_t^s are equal to the product of the capital stock and the rate of capacity utilization u_t. The households' budget constraint in period t is

$$c_t+x_t+R_{t-1}d_t\leq d_{t+1}+w_tl_t+r_tu_tk_t \ , \tag{5}$$

where x_t are resources for investment and d_{t+1} is the households' foreign debt position. Long-run solvency is enforced by imposing an upper bound on foreign debt, $d_{t+1}<\Gamma_t\bar{d}$. This condition precludes households from running Ponzi-type schemes.[3]

The law of motion for capital is

$$\begin{aligned} k_{t+1} \;&=\; x_t+\left(1-\delta-\eta\frac{u_t^{1+\omega}}{1+\omega}\right)k_t-\frac{\phi}{2}\left(\frac{k_{t+1}}{k_t}-\mu\right)^2k_t \ , \\ &\phi>0\ ,\mu>1\ ,\eta>0\ ,\omega>0\ . \end{aligned} \tag{6}$$

As in Baxter and Farr (2001), the rate of capital depreciation depends positively on capital utilization. There is a quadratic capital adjustment cost, and μ is the economy's average productivity growth factor.

The households' problem is to choose state-contingent sequences of c_t, l_t, x_t, u_t, k_{t+1} and d_{t+1} to maximize expected utility (3), subject to the budget constraints (5), the borrowing

[3]Choosing a large value for $\bar{d}$, the probability of reaching the debt limit in the stochastic steady state can be made arbitrarily small.

constraints and the law of motion for capital (6), for given prices w_t, r_t and R_t and initial values k_0 and d_0.

The Interest Rate. A large mass of international investors is willing to purchase the economy's bonds at a rate R_t. The bonds are risky assets because default on payments to foreigners is possible. The interest rate faced by the small open economy is given by

$$R_t = \rho D_t \,, \tag{7}$$

where ρ is the international rate for riskless assets and D_t is the country risk premium. As in Neumeyer and Perri (2005), private domestic lenders always receive the full loan plus interest, but there is a probability that the local government will confiscate all interest payments to foreign lenders. Foreign bond holders determine the interest rate and, given the small open economy assumption, domestic agents take R_t as given. To be consistent with this interpretation, I verify that in the numerical analysis foreign lenders always lend positive amounts in equilibrium. Default decisions are not modelled explicitly. As in Neumeyer and Perri (2005), the risk premium depends negatively on expected future productivity. For practical purposes, the dependence on expected productivity is captured by the following functional form:

$$D_t = \chi_1 \left(1 + \mathrm{E}_t\left[g_{t+1}\right] - \mu\right)^{-\chi_2} \,, \chi_1 > 1 \,, \chi_2 \geq 0 \,. \tag{8}$$

Arrelano (2006) provides a model in which a negative relation between default incentives and expected productivity arises endogenously.

News and States of Technology. I discipline the modelling of the news and technology processes by maintaining the assumption of rational expectations and by pursuing extreme parsimony in the number of parameters. This is to counter any suggestion that a purely arbitrary formation of expectations explains the fit of the model.

Productivity growth g_t is a discrete Markov chain with support $\mu = \{\mu_B, \mu_G\}$, i.e. there is a "bad" state and a "good" state. The transition matrix is

$$P = \begin{bmatrix} p_{BB} & 1 - p_{GG} \\ 1 - p_{BB} & p_{GG} \end{bmatrix}, \tag{9}$$

where the ij-th entry is $\Pr(g_{t+1} = \mu_i | g_t = \mu_j)$. Agents receive news n_t about the growth rate two periods in advance. A two period lead is the minimum to ensure that firms alter labor input in response to news, while larger leads come at significant computational cost. The agents' perception of the news accuracy is captured by a matrix Q, given by

$$Q = \begin{bmatrix} q & 1 - q \\ 1 - q & q \end{bmatrix}, \tag{10}$$

where the ij-th element is $\Pr(n_t = \mu_i | g_{t+2} = \mu_j)$. The parameter $0.5 \leq q \leq 1$ is a measure for the news precision. To avoid over-parametrization, the news signal contains no information about uncertainty in $t+1$ and its accuracy is independent of the history of shocks up to time t. Suppose in period t the economy is in the good state μ_G and news arrives of a switch to the bad state in $t+2$. When $q = 0.5$ the news signal does not contain any information and the time t expectation of productivity growth in $t+2$ equals the unconditional expectation. When $q = 1$, the signal is perfect and expected productivity in $t+2$ equals μ_B. When $0.5 < q < 1$, agents expect productivity growth to be in between these two values.

Given the rationality assumption, the agents' subjective assessment of the news accuracy corresponds to the objective accuracy. Let n_t^- denote the previous period value of n_t and let x_t^i be shorthand notation for $x_t = \mu_i$. Then all the above assumptions imply the following transition probabilities for the technology/news processes:

$$\Pr(g^i_{t+1}, n^n_{t+1}, n^{-v}_{t+1} \mid g^j_t, n^l_t, n^{-s}_t) = d_{vl} \Pr(n^n_{t+1} \mid g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) \Pr(g^i_{t+1} \mid g^j_t, n^l_t, n^{-s}_t) \; . \tag{11}$$

The first term in (11), d_{vl}, equals 1 if $v = l$ and zero otherwise. The second term is

$$\Pr(n^n_{t+1} \mid g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) = \sum_k \Pr(n^n_{t+1} \mid g^k_{t+2}, g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) \Pr(g^k_{t+2} \mid g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) \; , \tag{12}$$

where $\Pr(n^n_{t+1} \mid g^k_{t+2}, g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) = \sum_w Q_{nw} P_{wk}$ and $\Pr(g^k_{t+2} \mid g^i_{t+1}, g^j_t, n^l_t, n^{-s}_t) = Q_{lk} P_{ki} / \sum_k Q_{lk} P_{ki}$. Finally, the third term is

$$\Pr(g^i_{t+1} \mid g^j_t, n^l_t, n^{-s}_t) = \frac{\Pr(n^l_t \mid g^i_{t+1}, g^j_t, n^{-s}_t) \Pr(g^i_{t+1} \mid g^j_t, n^{-s}_t)}{\sum_i \Pr(n^l_t \mid g^i_{t+1}, g^j_t, n^{-s}_t) \Pr(g^i_{t+1} \mid g^j_t, n^{-s}_t)} \; , \tag{13}$$

where $\Pr(g^i_{t+1} \mid g^j_t, n^{-s}_t) = Q_{si} P_{ij} / \sum_i Q_{si} P_{ij}$ and $\Pr(n^l_t \mid g^i_{t+1}, g^j_t, n^{-s}_t) = \sum_k Q_{lk} P_{ki}$. The state transition matrix is fully determined by only three parameters: The productivity transition probabilities p_{GG} and p_{BB} and the news accuracy parameter q.

Equilibrium and Balanced Growth. Given initial conditions k_0 and d_0 and a sequence for productivity growth g_t and news n_t, an *equilibrium* is a sequence of allocations $\{k_{t+1}, h_t, l_t, d_{t+1}, c_t, x_t, u_t\}_{t=0}^{\infty}$ and prices $\{w_t, r_t, R_t\}_{t=0}^{\infty}$ such that the allocations solve the firms' and households' problems at the equilibrium prices and all markets clear. A balanced growth equilibrium is an equilibrium where $[k_t,\ d_{t+1},\ c_t,\ x_t]/\Gamma_{t-1}$ are stationary variables. The balanced growth equilibrium is summarized by a system of Euler equations, which is given in the Appendix.

3 Calibration and Solution Methodology

The time period in the model corresponds to six months. This choice follows from a trade-off between the computational burden of a larger number of news leads and the ability to match the Korean Crisis data.

News and States of Technology. The parametrization of the state space and transitions probabilities requires numerical values for five parameters: μ_B, μ_G, p_{GG}, p_{BB} and q. All of these determine the size of the change in expectations following a news shock. If a news shock is to explain the large macroeconomic volatility during Sudden Stop episodes, the shock can be thought to be fairly large. At the same time, large news shocks should be restricted to occur infrequently, as Sudden Stops within the same country are rare. Therefore, a natural approach for setting the parameter values is to construct a "peso problem", as in for instance Danthine and Donaldson (1999). I think of μ_B as a depression state with a very low probability of occurring and of μ_G as the actual productivity growth rate in the sample of observations. In practice, the probability that the economy moves from the good to the bad state μ_B is 1%, i.e. $p_{GG} = 0.99$, and $\mu_G = \mu = 1.019$ equals the value calibrated below for 1980-2002 Korean data. Since one period in the model corresponds to 6 months, the expected duration of the high growth regime is 50 years, the same as in Danthine and Donaldson (1999).

It is possible to compute $\mathrm{E}_t\left[g_{t+2} \mid g_t = \mu_G, n_t = \mu_B\right]$, the expected productivity growth in $t+2$ conditional on being in the good state in period t with a bad signal. Figure 1 plots this expectation for various values of μ_B and q. Evidently, it is non-increasing in productivity growth in the bad state μ_B, and decreasing in news precision q. When $q = 0.5$, the news signal does not contain any information and the time t expectation of productivity in $t+2$ equals the unconditional expectation, which is very close to μ_G. When $q = 1$, the signal is perfect and expected productivity growth in $t+2$ is μ_B. When $0.5 < q < 1$, the expectation lies in between μ_G and μ_B. Figure 1 makes clear that generating sizeable changes in expectations requires high values for q. The benchmark calibration will therefore have $q = 0.99$. I choose the value of μ_B such that $\mathrm{E}_t\left[g_{t+2} \mid g_t = \mu_G, n_t = \mu_B\right] = 1$. Hence, when bad news arrives in period t, agents revise their forecast for semiannual productivity growth in $t+2$ downwards from 1.9% to 0%. This choice strikes a balance between having an adjustment that is sufficiently large and infrequent, and one that reasonably lies within the agents' belief set. In practice, $\mu_B = 0.985$ and the conditional probability that the bad state realizes given bad news is about 0.55. Given the choice for p_{GG}, the probability p_{BB} that the bad state persists the next period has only a small effect on $\mathrm{E}_t\left[g_{t+2} \mid g_t = \mu_G, n_t = \mu_B\right]$. Nevertheless, p_{BB} is an important parameter as the expected duration of the bad state has consequences for the agents' savings decision. In the benchmark calibration, I set p_{BB} to 0.25.[4]

Given the peso problem setup, three key parameters thus determine the dynamics of expectations following bad news: The bad state value μ_B, the news accuracy q, and the expected duration of the bad state, captured by p_{BB}. In the robustness section, I explore alternative values for these parameters, and therefore smaller and larger shocks to expectations. Although a switch to the bad technology state is extremely rare, a bad news shock is more frequent. Under the benchmark calibration, bad news arrives in the good state once every 23 years. Hence, roughly one out of two occurrences of the bad news shock will not be followed by an actual change in productivity growth. This property is consistent with the presumption that in the sample of observations for Korea the depression state has not occurred, whereas a Sudden Stop has.

[4]For comparison, Danthine and Donaldson (1999) set the persistence of their depression state to 0.20.

Model Parameters. I set the gross annual interest rate to 1.05, the average 3 month T-bill rate that prevailed in the years surrounding the crisis. The country risk premium in tranquil times is one percent, the approximate average value of the EMBI global spread for Korea in non-crisis years, and also the value at the onset of the crisis. Together, this choice yields an annual interest rate of 6%.

The labor elasticity of output α takes on the conventional value of 0.36, which implies a labor share in total factor earnings for Korea that is in between the value of 0.5 used by Gertler et al. (2003) and the value 0.7 calculated by Young (1995). The average productivity growth factor is $\mu = 1.019$ in order to match the average gross capital formation-to-GDP ratio of approximately 0.31 in 1980-2002 in a non-stochastic version of the model which excludes the bad state. The annual productivity growth rate is therefore 3.8%. The parameters δ and η normalize the rate of capacity utilization to one and generate an annual depreciation rate of 0.1 in the non-stochastic model. A difficult parameter to calibrate is ω, the elasticity of marginal depreciation with respect to capital utilization. Basu and Kimball (1997) obtain a point estimate for the US of unity, but their 95% confidence bounds are wide: $[-0.2, 2]$. Baxter et al. (2001) find in the context of an international two-country RBC model that lower values, $\omega = 0.05$ or 0.10, fit the data well. The benchmark calibration in this paper will take a value of 0.05, but the numerical analysis also considers higher values.

The value for ζ normalizes hours worked to one in the non-stochastic model. The wage elasticity of labor supply is 2.2 (or $\psi = 0.45$), as in Mendoza (1991). The elasticity of the discount factor $\xi = 0.061$ matches the average net foreign debt position-to-GDP ratio of 0.21 in Korea, which I obtain by averaging annual data from of Lane and Milesi-Ferretti (2006) for the period 1980 to 1997. The implied consumption-to-GDP ratio is 0.68, which is roughly in line with the value of 0.71 in the data. The parameters γ and ϕ are 2 and 2.5 respectively, well within the range of conventional values. Finally, I choose $\chi_2 = 0.76$

to match the 5% increase in the risk premium during the Korean Crisis episode. Table 2 summarizes all the values used for generating the results under the benchmark calibration.

Numerical Solution Technique. I obtain the approximate model solution to the system of Euler equations describing the equilibrium behavior of the various macroeconomic variables, given in the Appendix. The numerical method used is time iteration, as described by Coleman (1990). Time iteration is generally slow and therefore the iterative scheme is augmented by the application of the method of endogenous gridpoints, developed by Carrol (2006). This method reduces the number of nonlinear equations that need to be solved numerically in every iteration.

The model features two endogenous state variables, k_t and d_t (detrended), and five exogenous state variables: The current and previous period value of g_t, the news shock n_t and the two lags n_{t-1}, n_{t-2}. The additional lags of n_t and g_t are necessary to evaluate lagged expectations. All functions are approximated by a linear interpolation scheme based on a (11×11) grid of the (k_t, d_t) space, which means their continuous nature is preserved. As a result, each function is approximated over a total number of 3872 nodes. Further increasing the number of nodes does not lead to any noticeable changes in the results.

4 Quantitative Properties of the Model

4.1 Matching the Korean Crisis Episode

Figure 2 plots equilibrium paths of the key macroeconomic variables, together with their data equivalents for the years surrounding the Korean Crisis. The first row depicts the annualized growth rate of real GDP, consumption and investment. The second row plots hours worked (in percentage deviation from the 1996 value), the country risk premium and the net exports-to-GDP ratio. The equilibrium paths are for the following sequence of shocks: Prior to the second half of 1997 (1997:2), the model economy has been in high growth state μ_G for an arbitrarily long period with the news signal correctly predicting future states. In 1997:2, bad news arrives about productivity growth in 1998:2. The bad news persists in 1998:1 and when 1998:2 arrives, the signal returns to predicting μ_G. During the whole experiment, there is never any change in productivity growth. The transition probabilities in (11), which imply that the news shock displays persistence of 0.14, lead to the following expectation dynamics: In 1997:2, bad news shifts expectations, which are rationally adjusted downwards from 1.9% to 0% productivity growth for 1998:2. When 1998:1 brings bad news about 1999:1, agents incorporate this additional information into their forecasts and expected productivity growth in 1998:2 drops further to -1.3%. In 1998:2, the information that the initial news signal was false and the good news signal about 1999:2 both lead to an upward revision to 0.4% of the forecast for 1999:1. In 1999:1, agents return to anticipating 1.9% growth for the subsequent periods. The first column in Table 3 summarizes the dynamics of expected productivity growth in response to the news sequence.[5]

The model succeeds in capturing the key aspects of the Korean crisis experience. Consistent with the data, the news shock causes a rise in net exports and contractions in GDP, consumption, investment and hours. Quantitatively, the responses are of magnitudes associated with Sudden Stop episodes: Annual GDP growth plummets from 3.8% to -7.7%; hours worked decline by 12%; consumption falls by 6.2% and investment contracts with 31% on an annual basis. The net exports-to-GDP ratio shoots up from 0.3% to 11%. The model also closely matches the subsequent swift recovery after the crisis. As in the data, GDP, consumption and investment grow above trend in the year following the crisis.

In some respects, the model performs less well. Consumption falls more than GDP dur-

[5] An alternative experiment has the news signal switch back to μ_G in 1998:1. The results are qualitatively very similar to the experiment in which the bad news persists. Without persistent news, the recession is quantitatively smaller and lasts for one period only. The results are available on request.

ing the crisis, whereas the model yields the reverse. Because the model underpredicts the consumption drop, the increase in net exports is smaller than in the data. Also, the net exports-to-GDP ratio remains high after the crisis, but reverts in the model. Another issue is timing. According to the theory, investment leads GDP and consumption. In reality, the contraction and recovery of these variables is more simultaneous. Nevertheless, the experiment shows that the shock to expectations goes a long way in explaining the Sudden Stop, the associated economic crisis and the quick recovery experienced by South-Korea.

To understand the mechanics of the response to a news shock in period $t = 1997{:}2$, it is useful to see what drives the eventual reduction in real activity in $t+2 = 1998{:}1$. The output drop is primarily caused by a decrease in hours worked. The equilibrium in the labor market can be loosely summarized by the following equations:

$$
\begin{aligned}
0 =& \mathrm{E}_{t+1}\left[\lambda_{t+2}\left(R_{t+1}w_{t+2} - (1-\alpha)\Gamma_{t+2}^{1-\alpha}\left(\frac{u_{t+2}k_{t+2}}{h_{t+2}}\right)^{\alpha}\right)\right] , && \text{(Labor Demand)} \\
w_{t+2} =& \zeta l_{t+2}^{\psi}\Gamma_{t+1} , && \text{(Labor Supply)} \\
l_{t+2} =& h_{t+2} . && \text{(Labor Market Clearing)}
\end{aligned}
$$

The labor demand and supply equations follow from the firm's and households' optimality conditions. Three ingredients of the model are key for inducing a large decline in hours: Predetermined labor, the working capital constraint and the expectation-elastic country risk premium. Firms choose labor input for $t+2$ production before the realization of time $t+2$ uncertainty, and lower expected labor productivity induces them to demand less labor. Since the country's risk premium in $t+1$ increases with lower expected productivity, the interest rate R_{t+1} rises. Because firms need to finance the wage bill in advance by issuing bonds, the rise in R_{t+1} increases the cost of hiring labor in $t+2$, causing a further reduction in labor demand. In general equilibrium, both these effects dominate and hours drop through a decrease in the real wage. Because expectations for $t+3$ productivity growth are still relatively low in $t+2$, the cut in hours persists in $t+3$.

To assess the relative importance of predetermined labor and the financial propagation mechanism, Figure 3 plots the equilibrium paths for the same shock sequences in three models: The benchmark model, a version in which labor responds contemporaneously to productivity shocks ("Variable Labor"), and a version without financial propagation mechanism in which the elasticity of the risk premium χ_2 is zero ("R Fixed"). In the benchmark model, hours worked decline by 12%. Without financial propagation mechanism, hours fall by 6.4%, and with variable labor by 5.3%. Hence, both predetermined labor and the financial propagation stemming from the working capital constraint and the expectation-elastic risk premium are important for generating a large response of hours worked.

The decline in economic activity after the news shock is also due to reductions in the capital stock and in the rate of capacity utilization. In order to obtain a drop in investment that is comparable to the data, the expectation-elastic risk premium is the key model ingredient, at least under the benchmark calibration. Figure 3 shows how investment falls in all variants of the model, but only when the risk premium increases is the reaction similar in size to the data. To see why, note that the households' asset choice is determined by an arbitrage condition stating that the expected return in utils of buying one additional bond or investing one more unit should be equal,

$$\mathrm{E}_t\left[\lambda_{t+2}\right] R_{t+1} = \mathrm{E}_t\left[\lambda_{t+2}(1+r^k_{t+2})\right] , \qquad \text{(Arbitrage)}$$

where the return on capital investment r^k_{t+2} is given by

$$r^k_{t+2} = \frac{r_{t+2} + 1 - \delta - \eta \frac{u_{t+2}^{1+\omega}}{1+\omega} + \Phi\left(\frac{k_{t+3}}{k_{t+2}}\right)}{1+\phi\left(\frac{k_{t+2}}{k_{t+1}} - \mu\right)} - 1 , \qquad \text{(Return to Capital)}$$

where $\Phi\left(\frac{k_{t+3}}{k_{t+2}}\right) = \phi\left(\frac{k_{t+3}}{k_{t+2}} - \mu\right)\frac{k_{t+3}}{k_{t+2}} - \frac{\phi}{2}\left(\frac{k_{t+3}}{k_{t+2}} - \mu\right)^2$. In equilibrium, the rental rate of capital equals the marginal product of capital services,

$$r_{t+2} = \alpha u_{t+2}\left(\frac{u_{t+2}k_{t+2}}{\Gamma_{t+2}h_{t+2}}\right)^{\alpha-1}. \qquad \text{(Rental Rate of Capital)}$$

The households' optimality condition for capacity utilization is

$$\eta u_{t+2}^{\omega} = \alpha\left(\frac{u_{t+2}k_{t+2}}{\Gamma_{t+2}h_{t+2}}\right)^{\alpha-1}, \qquad \text{(Capacity Utilization)}$$

which states that the marginal benefit of higher utilization equals the marginal cost in terms of higher capital depreciation. Households expect the marginal product of capital to be lower in $t+2$ because of the decline in hours and because of lower expected productivity in period $t+2$. The decline in hours also causes a fall in capacity utilization in $t+2$, which has an additional negative effect on the marginal product of capital. On the other hand, lower utilization reduces capital depreciation, which raises the $t+2$ return to capital. Overall, the equalization of capital and bond returns requires a contraction of period $t+1$ investment. Evidently, if the bond rate rises after the shock to expectations, the required drop in investment is much larger. Because adjusting the capital is stock is costly, the households, who anticipate the course of events, start cutting investment in period t. Since hours do not react significantly until $t+2$, the resulting lower capital stock in $t+1$ yields a slight increase in capacity utilization before a significant decrease in $t+2$. In $t+2$, investment growth remains negative because of lower expectations for productivity growth in $t+3$. From $t+3$ onwards, investment growth picks up in order to catch up with the trend. Because of adjustment costs, the capital stock remains below trend for a longer period, resulting in high levels of capacity utilization during the recovery.

To understand the response of consumption, consider the households' Euler equation for bond holdings

$$\lambda_t = e^{-\beta(t)} R_t \mathrm{E}_t\left[\lambda_{t+1}\right] \qquad \text{(Euler eq. for Bonds)}$$

Given the choice of preferences, in equilibrium, $\lambda_t \approx (c_t/\Gamma_{t-1} - w_t h_t/(1+\psi))^{-\gamma}$, implying that consumption growth and changes in hours are positively related. Therefore all the elements of the model causing the decline in hours are also responsible for the drop in consumption in $t+2$. Consumption falls in period in t and $t+1$ because of lower anticipated future income. Of course, in the case of an expectation-elastic risk premium, there is the additional direct negative effect on consumption of a higher interest rate. Figure 3 shows how in all variants of the model consumption falls in response to the news shock. The reaction is the largest when all factors magnifying the decline in hours are present.

The response of net exports is positive as savings increase and investment falls. Figure 3 shows that this is true with and without expectation-elastic risk premium and with and without predetermined labor. However, only in the version of the model with the expectation-elastic risk premium and the associated large negative effect on investment is the magnitude of the reaction roughly of the same order as in the data.

Figure 4 allows to assess the role of variable capacity utilization as an amplification mechanism by plotting the model response for different values of the elasticity of depreciation with respect to capital utilization ω. In order to maintain the calibrated depreciation and utilization rate, I adjust the parameters δ and η correspondingly. The main effect of higher values for ω is to dampen movements in the marginal product of labor and therefore in hours worked, GDP and consumption. At the same time, higher values for ω make investment react more. The reason is that the effect on depreciation dominates the one on the marginal product of capital. Overall, the return of capital tends to decrease more with higher ω and a larger adjustment of investment is necessary to equalize returns on capital and bonds.

To summarize, in a small open economy model it is relatively easy to generate a response to bad news about future productivity growth that is characterized by reductions in real activity, employment, consumption and investment, together with an increase in net exports. However, to obtain fluctuations of similar magnitude as during the Korean crisis, all model features are important. Predetermined labor, the working capital constraint and the expectation-elastic risk premium all contribute to obtaining large declines in hours, consumption and real activity after the shock to expectations. For investment and net exports, the expectation-elastic risk premium is the most important element of the model under the present calibration. What value of the elasticity of marginal depreciation ω is better suited to match the Korean experience is ambiguous. On the one hand, a lower ω contributes to explaining the large decline in real activity, as well as the measured Solow residual during Sudden Stops (Aguiar and Gopinath, 2007). On the other hand, a lower ω increases the reliance on other factors to rationalize the observed fluctuations in investment and net exports.

4.2 Changing the Shock to Expectations

This section explores how the model response to bad news is affected when the expectations dynamics are different from the benchmark calibration. Recall that three parameters are key in determining the expectation dynamics: Productivity in the bad state μ_B, the probability that the bad state persists p_{BB}, and the news precision q.
Figure 5 plots the response for the benchmark value of $\mu_B = 0.985$, together with those for $\mu_B = \{0.97, 1\}$. The second and third column in Table 3 give the dynamics of expected productivity growth for the new values. Lower values of μ_B imply larger drops in expected productivity growth. The probabilities of the bad state are unchanged. For each value of

μ_B, I change the elasticity of the risk premium χ_2 to keep the response of the risk premium in $t+1$ identical. The resulting values are $\chi_2 = \{0.53, 1.4\}$ respectively. The main effect of lowering μ_B is to enlarge the negative response of hours. The reason is that, since labor is predetermined, lower expected productivity causes larger reductions in labor demand. As a consequence, the reactions of output and consumption are also larger for lower values for μ_B. The response of investment and net exports does not change dramatically, because the reaction of the interest rate is unchanged.

Figure 6 plots the equilibrium paths when $p_{BB} = \{0.5, 0.75\}$, together with the benchmark case of $p_{BB} = 0.25$. The fourth and fifth column in Table 3 give the dynamics of expected productivity growth for these values. The parameter p_{BB} has only a negligible effect on expected productivity in $t+2$, both in period t and period $t+1$. However, period $t+2$ expectations about growth in $t+3$ are higher for larger p_{BB}. The higher the persistence of the bad technology state, the more the incorrect first news signal and the arrival of a good signal about $t+4$ reduce the probability of the bad regime in $t+3$. Again, I adjust the values for χ_2 to obtain an identical response of the risk premium in $t+1$ (to 0.73 and 0.72 respectively). The main change induced by an increase in the expected duration of the bad state is in the reaction of investment and net exports. The response of hours and GDP is only significantly affected in $t+2$ because of differences in the risk premium. The reason is that, although labor is predetermined, adjusting the labor stock is not costly. Therefore the firm's optimal choice of labor input depends on the expectation of next period productivity. Adjustments of the capital stock, however, are costly, and the change in investment is affected by expected productivity beyond the next period, and therefore by the expected duration of the bad state. As a result, the response of investment in t and $t+1$ is magnified by higher values of p_{BB}. There is also an effect on consumption. When the bad state persistence is higher, expected future income is lower. Therefore consumption falls more in period t and $t+1$ for higher p_{BB}. Larger reductions in investment and consumption also cause bigger increases in net exports. This result establishes a second element of the model that can explain the large reaction of investment and net exports during the Korean Crisis besides the rise in the risk premium: If the bad state is more persistent, the fluctuations in investment and net exports are considerably larger.

Finally, Figure 7 plots the response for two alternative values of the precision parameter, $q = \{0.95, 1-\varepsilon\}$, where ε is an arbitrarily small number. The sixth and seventh column in Table 3 provide the dynamics of expected productivity growth for these values. The main effect of altering the value of q is a change in the probability of the bad technology state. Higher values of q therefore lower expected productivity growth. Once more, I adjust the values for χ_2 to obtain the same response of the risk premium in $t+1$ (to 1.51 and 0.70 respectively). Higher precision q magnifies the decline in hours, GDP and consumption in $t+2$. When the news signal is more precise, expectations in $t+2$ about growth in $t+3$ rely more on the $t+1$ news signal and less on the state of technology or news in $t+2$. That is why the decline in expected productivity growth and the drop in economic activity are more persistent in $t+3$ for higher q. There is also a more subtle effect on the period t response of consumption and investment. When the bad news shock arrives in period t, agents put higher probability weight on the bad state occurring beyond $t+2$ if q is higher. If the news signal is more precise and the bad state is persistent, the arrival of bad news about $t+2$ also increases the probability of bad news in $t+1$ and of the bad technology state in $t+3$. For instance, the period t probability of additional bad news in $t+1$ is 0.10 when $q = 0.95$, 0.14 when $q = 0.99$ and arbitrarily close to p_{BB} when $q = 1-\varepsilon$. Because of capital adjustment costs, the period t contraction in investment is larger when the precision is higher.

5 Conclusion

In their analysis of equilibrium models of Sudden Stops, Chari et al. (2005) challenge future research to explore an alternative approach, in which: *[...] private agents see events that lead them to predict future drops in a country's output, and as a result, these agents pull their capital from the country. [...] anticipated output drops drive the Sudden Stops, rather than the reverse.* But *[...], whether quantitative evidence can be found to support it is an open issue.* This paper provides quantitative evidence that an adverse shift in expectations about future productivity growth can trigger a Sudden Stop and output drop. In a small open economy that faces a peso problem in productivity growth states, a news shock announcing a switch to a bad regime generates an increase in net exports and decreases in economic activity, consumption and investment. To quantitatively match the 1998 Korean Crisis with reasonable shifts in expectations, the model relies on several amplification mechanisms. Predetermined labor input, variable capacity utilization and financial frictions contribute most to explaining the large declines in hours, GDP and consumption for a given adjustment in expectations. The financial friction and a larger expected duration of the bad regime are the most important elements for generating large fluctuations in investment and net exports.

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Appendix: The Equilibrium Conditions

Define $\hat{x}_t = \frac{x_t}{\Gamma_{t-1}}$. The solution of the model is obtained by finding approximations for $\hat{c}_t$, h_t, $\hat{y}_t$, $\hat{V}_t$, λ_t, u_t, $\hat{k}_{t+1}$, $\hat{d}_{t+1}$ and $\hat{x}_t$ as functions of the model's state variables that solve the following system of equations:

$$\lambda_t = U_c(t) - \beta_c(t) e^{-\beta(t)} \hat{V}_t \tag{14}$$

$$\hat{V}_t = g_t E_t \left[\left(\hat{U}(t+1) + e^{-\beta(t+1)} \hat{V}_{t+1} \right) \right] \tag{15}$$

$$0 = \mathrm{E}_{t-1} \left[\lambda_t \left(\zeta h_t^{\psi} R_{t-1} - g_t (1-\alpha) \left(\frac{u_t \hat{k}_t}{g_t h_t} \right)^{\alpha} \right) \right] \tag{16}$$

$$\eta u_t^{\omega} = \alpha \left(\frac{u_t \hat{k}_t}{g_t h_t} \right)^{\alpha - 1} \tag{B.4}$$

$$\lambda_t = e^{-\beta(t)} R_t \mathrm{E}_t \left[\lambda_{t+1} \right] \tag{17}$$

$$\lambda_t \left(1 + \phi \left(g_t \frac{\hat{k}_{t+1}}{\hat{k}_t} - \mu \right) \right) = e^{-\beta(t)} \mathrm{E}_t \left[\lambda_{t+1} \left(\alpha u_{t+1} \left(\frac{u_{t+1} \hat{k}_{t+1}}{g_{t+1} h_{t+1}} \right)^{\alpha-1} + 1 - \delta - \eta \frac{u_{t+1}^{1+\omega}}{1+\omega} + \Phi \left(\frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} \right) \right) \right] \tag{18}$$

$$g_t \hat{k}_{t+1} = \hat{x}_t + \left(1 - \delta - \eta \frac{u_t^{1+\omega}}{1+\omega} \right) \hat{k}_t - \frac{\phi}{2} \left(g_t \frac{\hat{k}_{t+1}}{\hat{k}_t} - \mu \right)^2 \hat{k}_t \tag{19}$$

$$R_{t-1} \hat{d}_t + \hat{c}_t + \hat{x}_t = \alpha \hat{y}_t + \frac{(1-\alpha)}{R_{t-1}} \hat{y}_t + g_t \hat{d}_{t+1} \tag{20}$$

$$\hat{y}_t = (u_t \hat{k}_t)^{\alpha} (g_t h_t)^{1-\alpha} \tag{21}$$

where

$$\hat{U}(t) = \frac{\left(\hat{c}_t - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{1-\gamma}}{1-\gamma}, \quad U_c(t) = \left(\hat{c}_t - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{-\gamma}, \quad R_t = \rho \chi_1 \left(1 + \mathrm{E}_t \left[g_{t+1} \right] - \mu \right)^{-\chi_2}$$

$$\beta_c(t) = \xi \left(1 + \hat{c}_t - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{-1}, \quad \Phi \left(\frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} \right) = \phi \left(g_{t+1} \frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} - \mu \right) g_{t+1} \frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} - \frac{\phi}{2} \left(g_{t+1} \frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} - \mu \right)^2 .$$

Tables and Figures

Table 1: Timing of Events in the Model

$(t-1)^+$	
t^-	shocks are revealed;
	firms rent capital and issue bonds at rate R_{t-1}
t^+	firms produce and decide on period $t+1$ labor input;
	bonds issued in $(t-1)^+$ and t^- mature;
	households consume, invest and trade bonds at rate R_t
$(t+1)^-$	

Table 2: Benchmark Parameter Values

Technology		
α	0.36	Labor input elasticity of output
δ	-0.026	Capital depreciation parameter
η	0.078	Capital depreciation parameter
ω	0.05	Utilization elasticity of marginal depreciation
ϕ	2.5	Capital adjustment cost parameter
μ	1.019	Semiannual productivity growth factor
Household Preferences		
ψ	0.45	Inverse wage elasticity of labor supply
ξ	0.061	Elasticity of discount factor
γ	2	Coefficient of relative risk aversion
Interest Rate		
ρ	$1.05^{0.5}$	World riskless interest rate
χ_1	$1.01^{0.5}$	Country risk premium parameter
χ_2	0.76	Elasticity of country risk premium

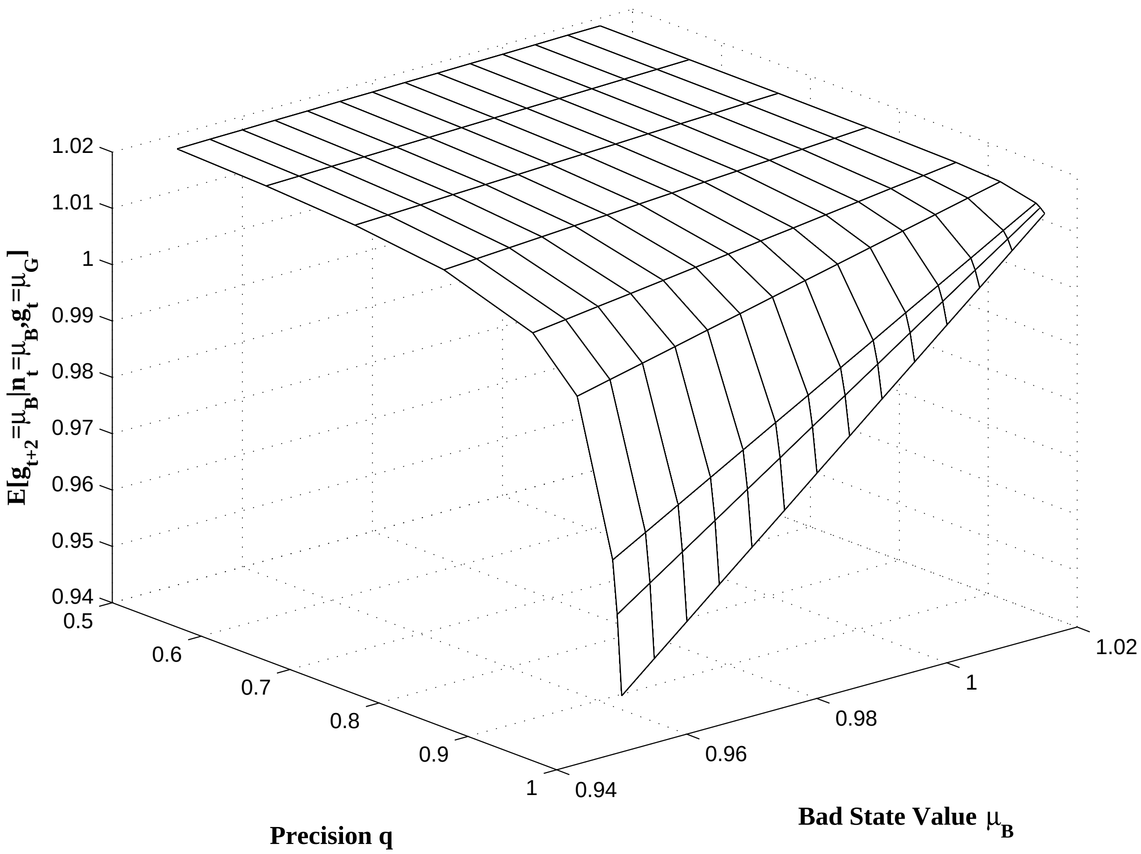

Figure 1: Expected Productivity in $t+2$ Conditional on time t Bad News and Good Technology State

Table 3: Expectation Dynamics

Period	Expected	Benchmark	$\mu_B = 0.97$	$\mu_B = 1$	$p_{BB} = 0.5$	$p_{BB} = 0.75$	$q = 0.95$	$q = 1 - \varepsilon$
$t = 1997{:}2$	$\ln g_{t+1}$	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
	$\ln g_{t+2}$	0.0%	−0.9%	0.8%	0.0%	0.0%	1.2%	−1.5%
$t + 1 = 1998{:}1$	$\ln g_{t+2}$	−1.3%	−2.6%	0.1%	−1.4%	−1.4%	0.3%	−1.5%
	$\ln g_{t+3}$	0.0%	−0.9%	0.8%	0.0%	0.0%	1.2%	−1.5%
$t + 2 = 1998{:}2$	$\ln g_{t+3}$	0.4%	−0.2%	1.1%	0.7%	1.2%	1.4%	−1.5%
	$\ln g_{t+4}$	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%

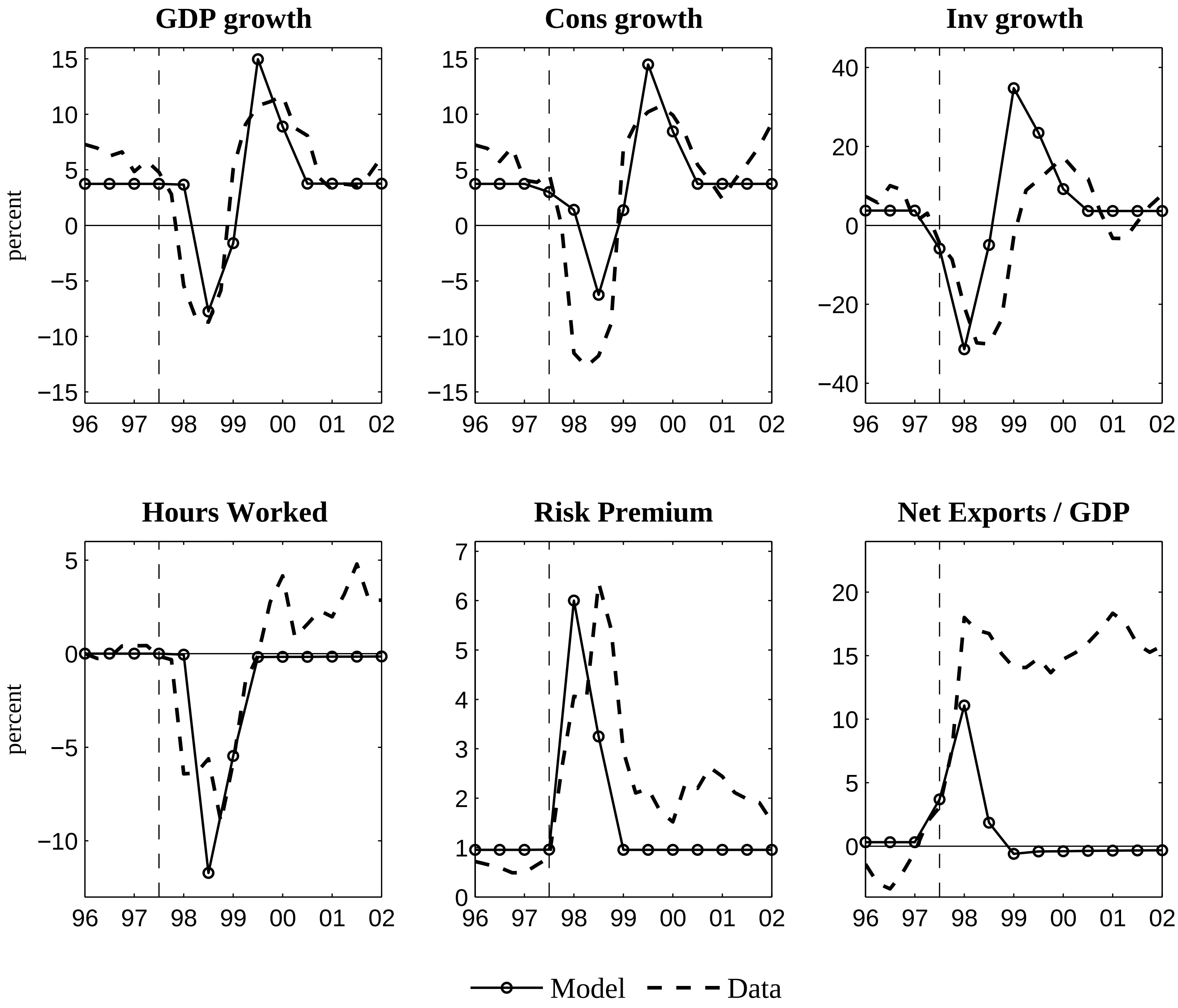

Figure 2: The Korean Crisis and the Model Response to News Shock in 1997:2. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked is in percentage deviations from the 1996:1 value. Data Sources: **GDP**: Gross domestic product at constant prices, quarterly levels, OECD ; **Investment**: Gross Fixed Capital Formation, quarterly levels, OECD ; **Consumption**: Private plus Government Final Consumption Expenditure at constant prices , quarterly levels, OECD ; **Hours Worked**: Total Employment Multiplied by Weekly Hours per Employee in Non-Agricultural Activities, ILO; **Risk Premium**: EMBI Global Spread Korea, JP Morgan, obtained from Neumeyer et al. (2005); **Net Exports/GDP**: obtained from Neumeyer et al. (2005). All variables are seasonally adjusted by the publishing agency, except for weekly hours and employment, which I seasonally adjusted using the Census Bureau's X12 method.

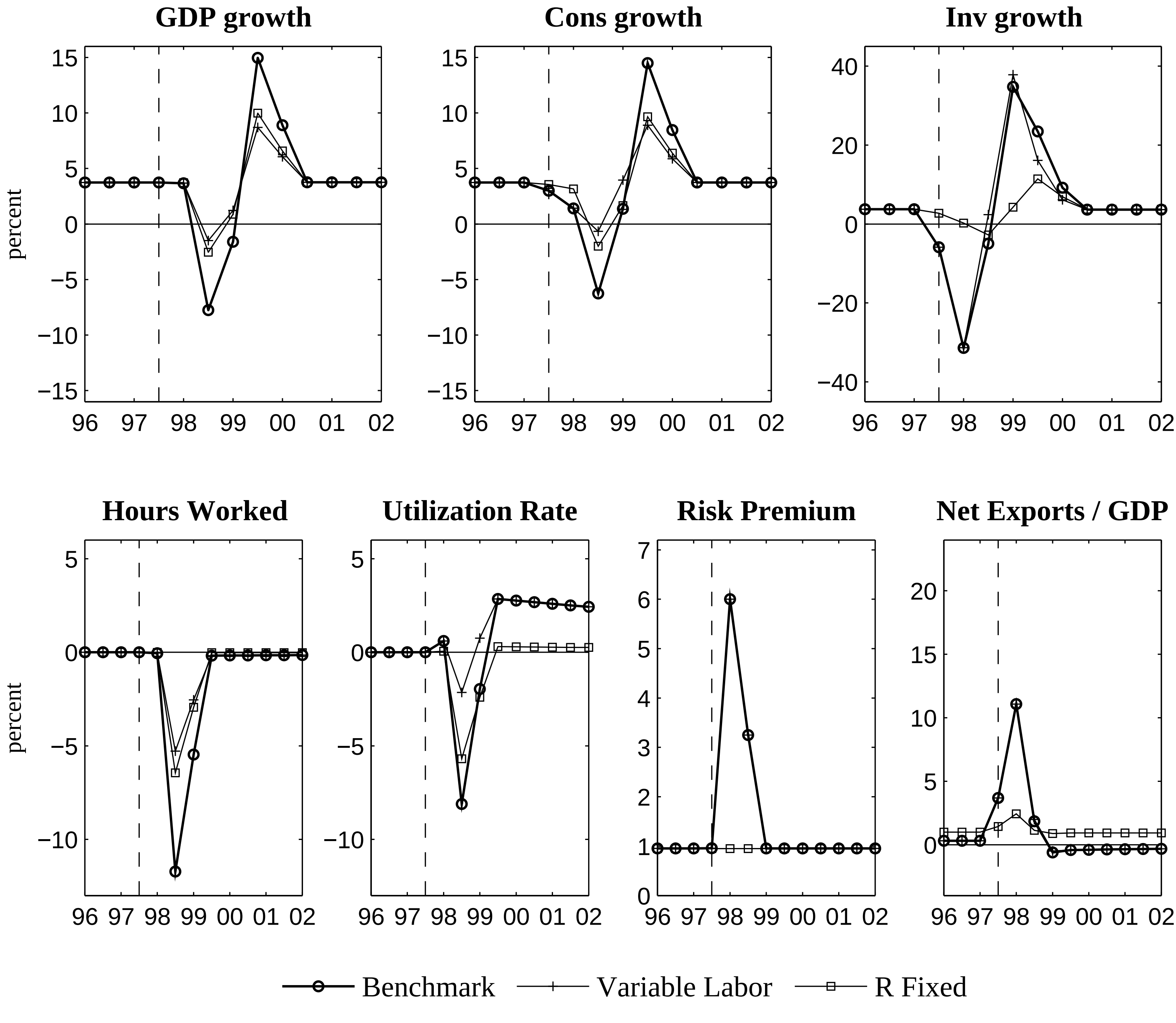

Figure 3: Response to News Shock in Different Models. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked and the rate of capacity utilization are in percentage deviations from the 1996:1 value.

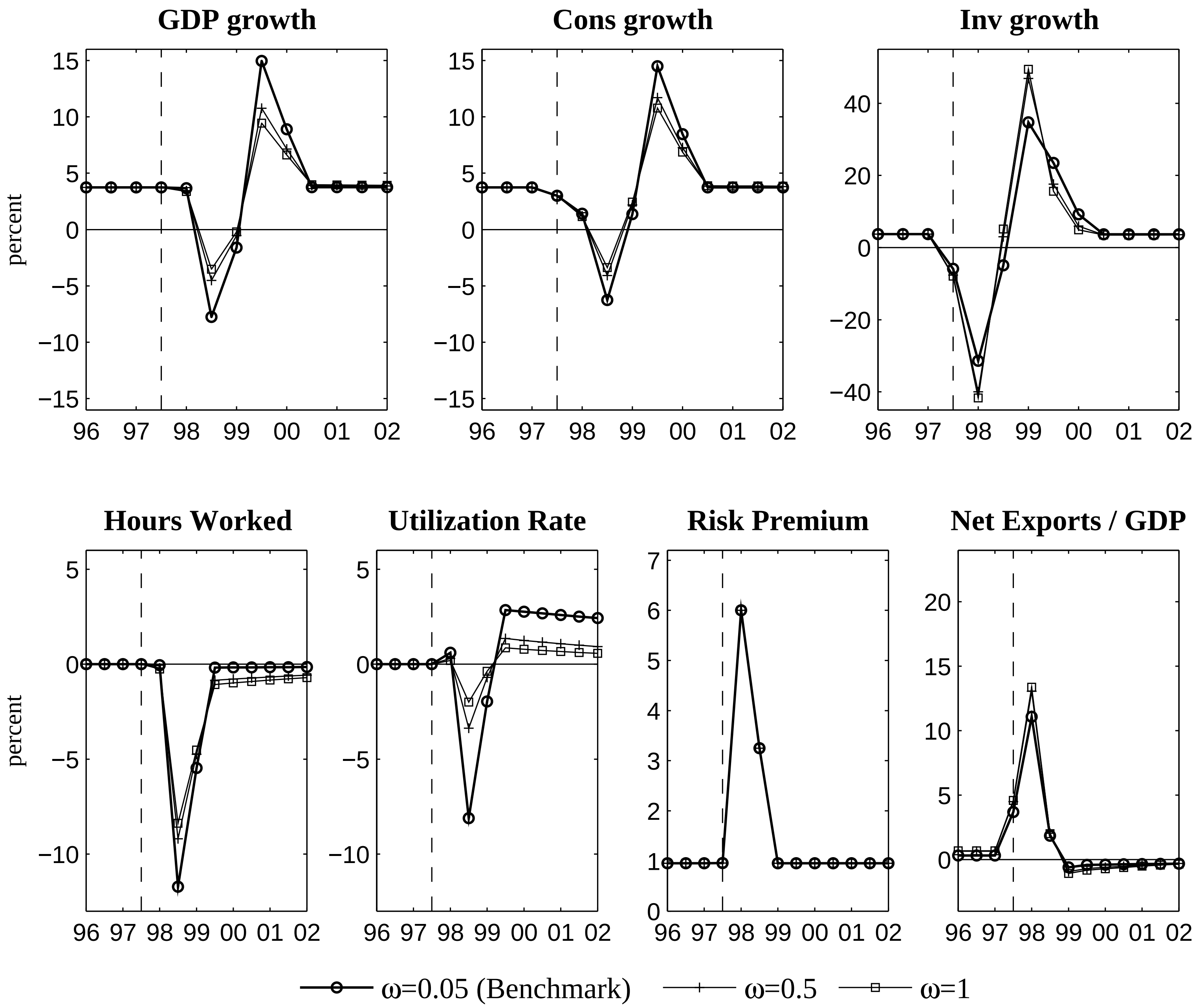

Figure 4: Model Response to News Shock: Different Values for ω. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked and the rate of capacity utilization are in percentage deviations from the 1996:1 value.

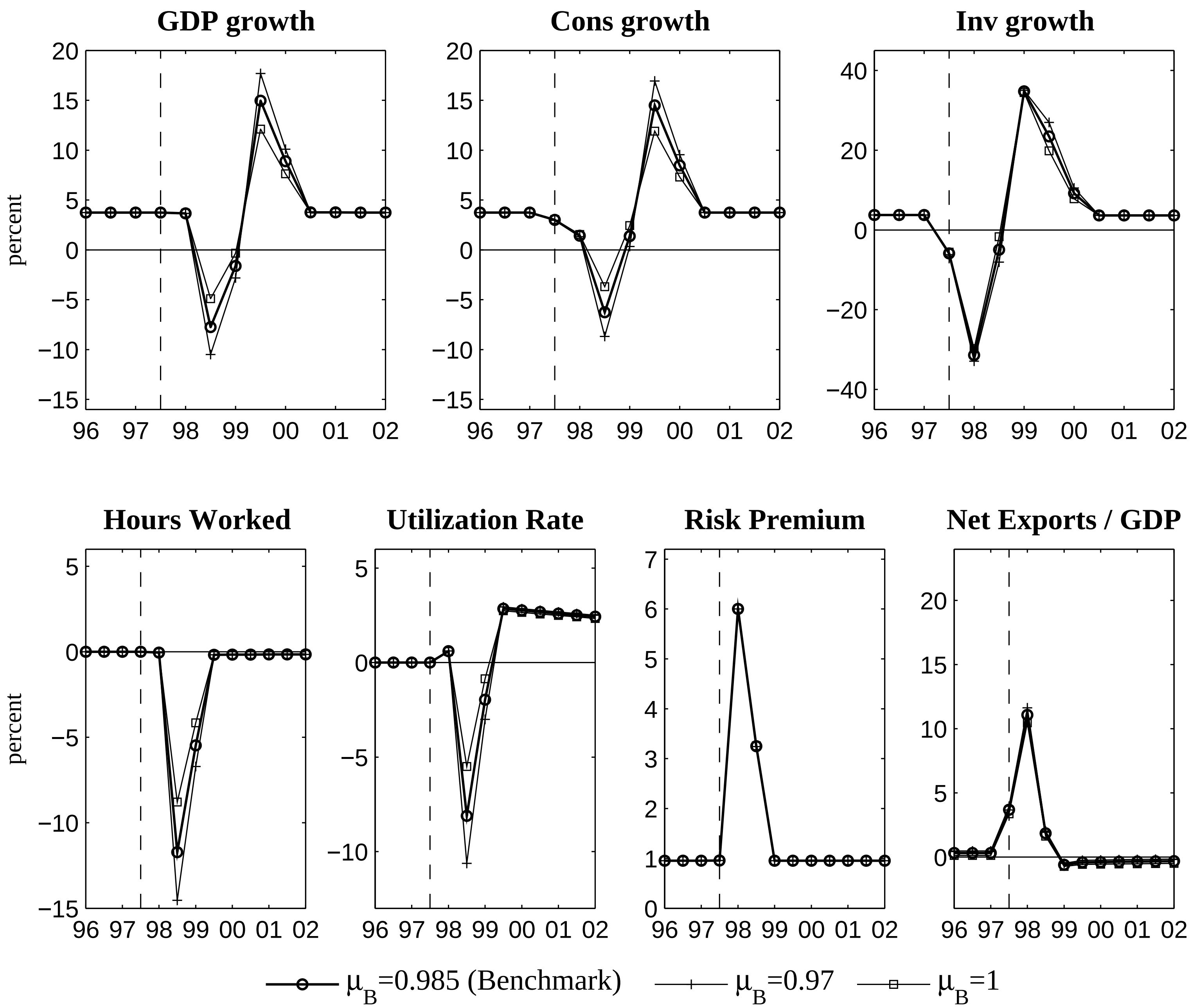

Figure 5: Model Response to News Shock: Different Values for μ_B. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked and the rate of capacity utilization are in percentage deviations from the 1996:1 value.

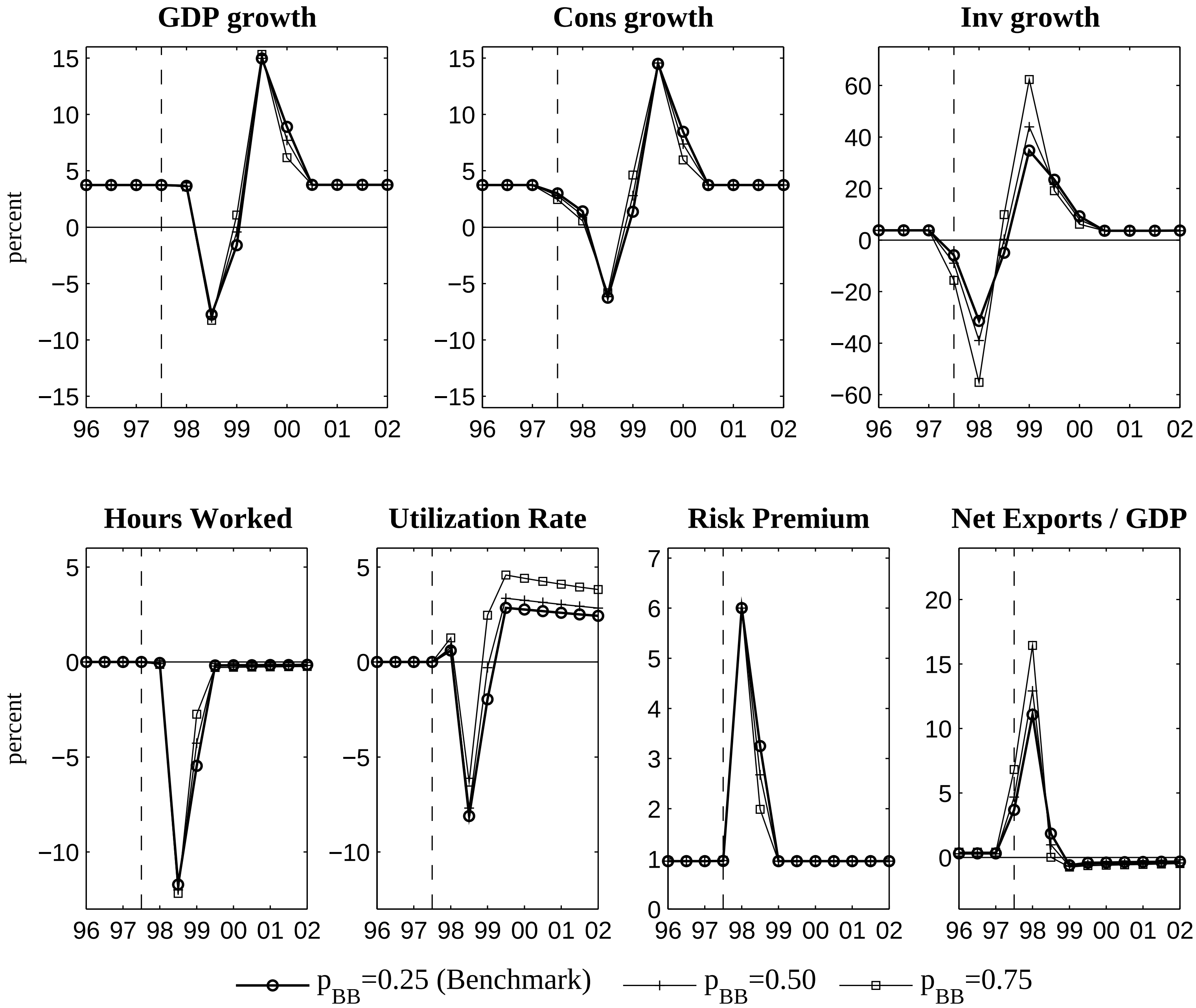

Figure 6: Model Response to News Shock: Different Values for p_{BB}. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked and the rate of capacity utilization are in percentage deviations from the 1996:1 value.

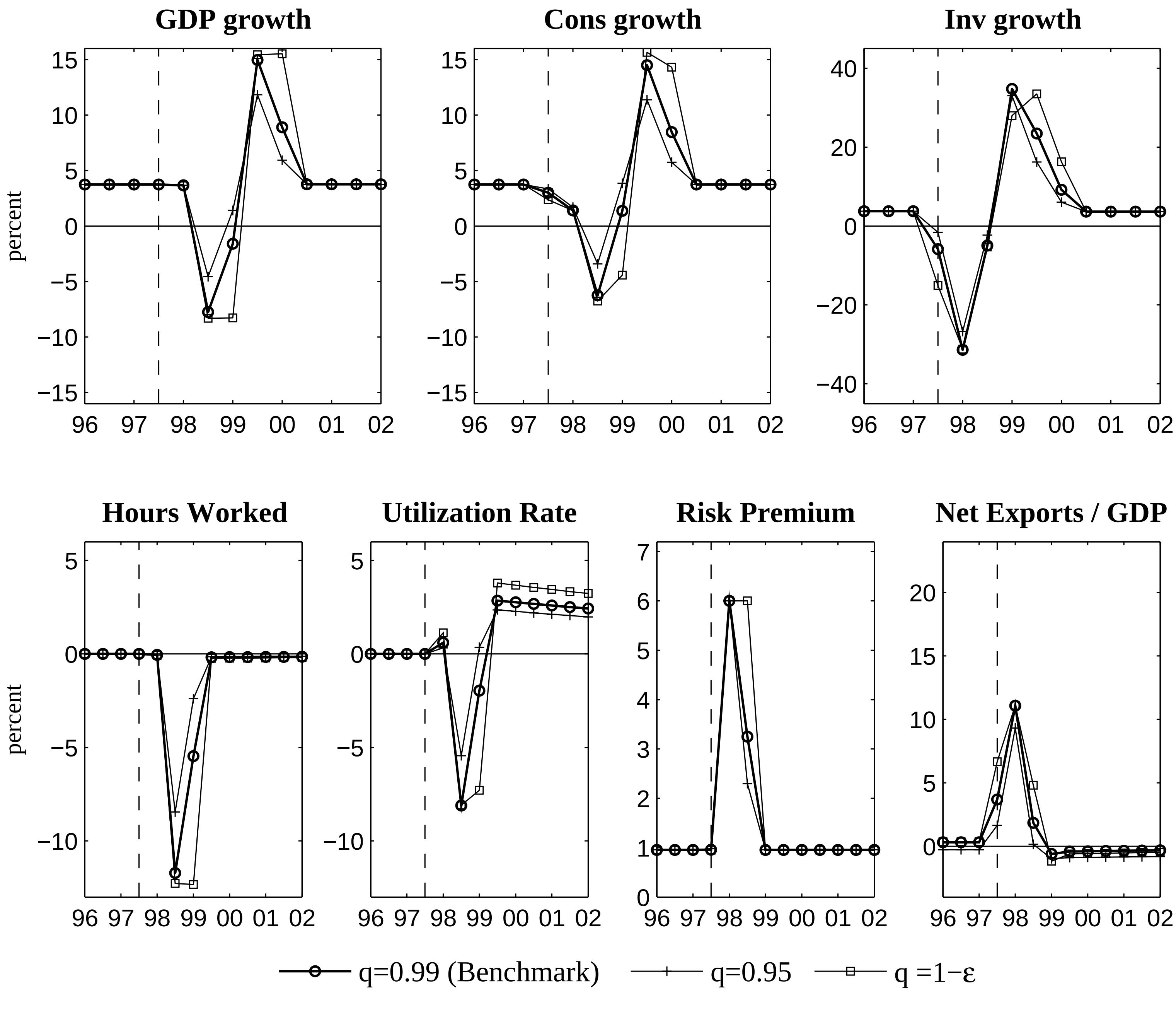

Figure 7: Model Response to News Shock: Different Values for q. The Vertical Line Marks the Period of the Shock.

GDP, consumption and investment are year on year growth rates. Hours worked and the rate of capacity utilization are in percentage deviations from the 1996:1 value.