

Good News is Bad News: Leverage Cycles and Sudden Stops*

Ozge Akinci [†]

Board of Governors of the Federal Reserve

Ryan Chahrour[‡]

Boston College

Toulouse School of Economics

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Abstract

We show that a model with imperfectly forecastable changes in future productivity and an occasionally-binding collateral constraint can match a set of stylized facts about Sudden Stop events. “Good” news about future productivity raises leverage during times of expansions, increasing the probability that the constraint binds, and a Sudden Stop occurs, in future periods. During the Sudden Stop, the nonlinear effects of the constraint induce output, consumption and investment to fall substantially below trend, as they do in the data. Also consistent with data, the economy exhibits a boom period prior to the Sudden Stop, with output, consumption, and investment all above trend.

Keywords: News Shocks, Sudden Stops, Leverage, Boom-Bust Cycle

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[†]Federal Reserve Board of Governors, Washington DC. Email: ozge.akinci@frb.gov.

[‡]Department of Economics, Boston College, Chestnut Hill, MA, U.S.A. and Toulouse School of Economics, Toulouse, France Telephone: 617-552-0902. Email: ryan.chahrour@bc.edu.

1 Introduction

In this paper, we show that an RBC-style model augmented with an occasionally binding collateral constraint and a predictable component in productivity can match the patterns observed in the data surrounding Sudden Stop events in small open economies. The facts we seek to match have been characterized by a recent empirical literature using data from emerging market crises of recent decades. First, such episodes are low-probability events that occur amid regular business cycle fluctuations. Second, financial crises are associated with deep recessions which are different from regular recessions both in terms of duration and magnitude. Third, Sudden Stops are almost always preceded by a substantial buildup of leverage. Fourth, these episodes typically occur after a period of expansion, with output, consumption and investment above trend, the trade balance below trend, and high asset prices.¹

In our model, agents faced with improving growth prospects optimally choose to borrow against their future income, increasing their leverage in good times and bringing them closer to an occasionally binding constraint on their debt holdings. On average, the good news is realized, leading to higher long-run consumption and output for the household. However, because good news also brings households closer to the constraint on their leverage, it exposes them to a greater risk that an unfavorable future shock will eventually lead the constraint to bind, thereby leading *ex post* to a worse outcome than they might otherwise have realized had all shocks arrived as surprises. In this sense, good news leads agents to engage in optimistic behavior that is both rational, since it is validated on average, but also risky, since it reduces the agent's ability to respond to negative shocks that might arrive in the future.

In this paper, we show that a reasonably calibrated model, which is an otherwise standard RBC-style model of a small open economy, matches all of the basic facts laid out in the opening paragraph. In particular, it predicts substantial booms in output, consumption, investment, and rising leverage whenever available information indicates high future growth rates for consumption, i.e. after positive news shocks. In most cases, such expectations are validated *ex-post*, and the risks associated with increased leverage are incurred rationally by private agents. However, in the event of a sufficiently negative realization of actual productivity growth (or any other shock, in fact) the additional leverage taken on by agents during the period of optimism causes the leverage constraint to bind, or bind more strongly, leading to a debt-deflation spiral that

¹For more details on this empirical evidence, see Calvo et al. (2006), Gourinchas and Obstfeld (2012), Mendoza and Terrones (2012), Korinek and Mendoza (2014).

is strongly non-linear. Due to the non-linear effects of the the binding credit constraint, the model delivers quantitatively realistic crashes in the event of a crisis, including a simultaneous and deep fall in consumption and borrowing that would otherwise be difficult to deliver in an open economy with access international financial markets. In our economy, agents only partially internalize the risks generated by their own leverage choices so that such crisis, while rare, occur occasionally along an equilibrium path that in other ways resembles the standard small-open economy business cycle modeled in an extensive literature.

Existing models of open emerging economies, even those with credit market frictions, do not easily generate the set of facts cited above. These models typically require unusually large shocks to account for financial crises events and many are designed to study the financial crises in isolation.² Moreover, these models have a difficult time generating output and consumption booms in the period leading into the crisis. This is true because good times are usually associated with improved asset prices and, thus, improved net worth of the borrowers which relaxes borrowing constraints according to most common specifications. Thus financial crises in these models, if they occur, typically occur only after a series of bad realizations of shocks. News shocks address this challenge by introducing the possibility that borrowing and leverage rise in response to *good* shocks, and therefore increase during times of expansion. Crises in this case can be triggered by good news followed by a bad realization, and indeed even when no change in fundamental is finally observed, rather than following a sequence of purely negative shocks.

This paper is related to various strands of the literature. We draw our stylized facts from [Mendoza \(2010\)](#), who uses a similar model, augmented with shocks to imported intermediate inputs and a correlated shock structure, to deliver crisis of realistic magnitudes. Below we argue that news shocks have the potential to match the magnitude of Sudden Stop downturns as well as [Mendoza \(2010\)](#) and do a better job at capturing the pre-bust boom period. Another related paper is that of [Cao and L’Huillier \(2014\)](#). They use an linearized open economy framework to think about medium-term business cycles caused by innovations that lead to increased expectations of future productivity, which are not always realized *ex post*. However, they do not consider the role of financing constraints and the associated non-linearities. [Lorenzoni \(2008\)](#) and [Korinek \(2010\)](#) also study more theoretical contexts where borrowing is collateralized by assets whose price agents take as given. Other related papers include [Uribe and Yue \(2006\)](#), [Bianchi](#)

²See, among others, [Gertler et al. \(2007\)](#), [Gertler and Karadi \(2011\)](#), [Gertler and Kiyotaki \(2010\)](#).

and Mendoza (2010), Bianchi (2011); Benigno et al. (2012); Otrok et al. (2012), and Bianchi and Mendoza (2013).

This paper proceeds as follows. Section 2 lays out the basic model used in our analysis. Section 3 summarizes our calibration and the solution method used for the non-linear model. In section 4, we highlight our main results regarding the drivers of Sudden Stops in the model economy, and examine the model’s ability to match historical Sudden Stop experiences. Section 5 concludes.

2 Model

The model economy closely resembles the baseline RBC-style small open economy model of García-Cicco et al. (2010), with the addition of a collateral constraint as in Mendoza (2010). The economy is populated by a continuum of infinity-lived utility-maximizing consumer-workers.

The representative consumer-worker chooses per-period consumption, hours, investment (c_t, h_t, i_t respectively), the next-period capital stock, k_{t+1} , and the amount of debt, d_{t+1} , incurred in period t to be repaid in $t + 1$, to maximize the discounted expected future flow of utility

$$\max_{\{c_t, h_t, i_t, d_{t+1}, k_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, X_{t-1} h_t) \quad (1)$$

subject to the constraints

$$c_t + i_t = A_t F(k_t, X_t h_t) + \frac{d_{t+1}}{R_t} - d_t - k_t \phi(i_t/k_t) - \chi R_t w_t h_t - g_t \quad (2)$$

$$k_{t+1} = (1 - \delta)k_t + i_t \quad (3)$$

$$\kappa \geq \frac{\frac{d_{t+1}}{R_t} + \chi R_t w_t h_t}{q_t k_{t+1}} \quad (4)$$

Equation (2) is the household intertemporal budget constraint, which reflects that households must pay a cost of capital adjustment parameterized by the function $\phi(i/k)$ and also must finance a fraction χ of their wage bill with working capital. Unproductive government spending g_t is exogenous, and we assume it to be constant in the detrended model. Equation (3) represents a standard process for the evolution of capital.

The key equation for the questions of this paper is the occasionally binding collateral constraint given by (4). The right hand side of equation (4) defines leverage in the

economy as the ratio of total borrowing (including working capital required to hire labor) divided by the agent's net worth given by total capital times its price, which is exogenous to the agent but in equilibrium is given by Tobin's Q. Similar constraints have been used by many authors, including [Kiyotaki and Moore \(1997\)](#) and [Mendoza \(2010\)](#). In the constraints (2) and (4), besides the price of installed capital, q_t , consumers take the real wage, w_t , and the interest rate on external borrowing, R_t , as given. In equilibrium, the real wage is given by $w_t = U_{h,t}/U_{c,t}$.

In order to induce stationarity of the model when the constraint does not bind, we assume R_t is related to the exogenous world interest rate, according to the functional-form suggested by [Schmitt-Grohé and Uribe \(2003\)](#):

$$\log(R_t) = \log(R_t^*) + \psi \left(e^{\bar{d}_t/y_t - \bar{d}/y} - 1 \right) \quad (5)$$

where the parameter ψ measures the elasticity of the borrowing rate to the current debt-to-GDP ratio.

We note immediately that the environment incorporates three distinct externalities. The first two externalities are pecuniary externalities of the type emphasized by [Bianchi \(2011\)](#), and driven by the presence of the prices w_t and q_t in the collateral constraint. [Mendoza and Smith \(2006\)](#) and [Mendoza \(2010\)](#) argue that the quantitative effects of these externalities under the specification of the collateral constraint used here are rather small, and solve their model using a method that ignores them; whether this remains the case in our environment is not immediately clear and our solution method takes them into account. The final externality comes from the fact that agents do not internalize the effect of their borrowing choice on the equilibrium interest rate which depends on aggregate debt. We calibrate the debt elasticity, and therefore this last externality, to be as small as is computationally feasible. The first order conditions of the household's problem are presented in the Appendix [A](#).

3 Calibration and Solution

The functional forms of preferences and technology are the following:

$$U(c_t, X_{t-1}h_t) = \frac{(c_t - \theta\omega^{-1}X_{t-1}h_t^\omega)^{1-\sigma} - 1}{1-\sigma} \quad (6)$$

and

$$F(k_t, X_t h_t) = k_t^\alpha (X_t h_t)^{1-\alpha}. \quad (7)$$

We calibrate the parameters of preferences and production to match the values used in [Mendoza \(2010\)](#). The adjustment cost function is parameterized as

$$\phi(i/k) = \frac{\exp(\phi(i/k + 1 - \gamma - \delta))}{\phi} - (i/k + 1 - \gamma - \delta) - \frac{1}{\phi}.$$

The non-standard formulation of the adjustment cost is locally equivalent to the standard quadratic specification (it has the same level and slope) but ensures that, globally, Tobin's Q is never negative, a concern in some relatively unlikely regions of the state space.

We assume that the exogenous processes for the productivity shocks and the interest rate are given by

$$\log(A_{t+1}) = \rho_a \log(A_t) + \epsilon_{A,t+1} \tag{8}$$

$$\log(\gamma_{t+1}/\gamma) = \rho_x \log(\gamma_t/\gamma) + \epsilon_{\gamma,t-1}^2 + \epsilon_{\gamma,t+1}^0 \tag{9}$$

$$\log(R_{t+1}^*/\bar{R}^*) = \rho_r \log(R_t^*/\bar{R}^*) + \epsilon_{R,t+1} \tag{10}$$

where $\gamma_t \equiv \frac{X_t}{X_{t-1}}$, long-run gross productivity growth is given by the parameter γ , \bar{R}^* is long-run world interest rate, and all ϵ shock terms are *iid*.

We calibrate the parameters ρ_a , ρ_x , and ρ_r to 0.6, 0.35, 0.5 respectively, which are roughly in the middle range of standard values for these parameters in the small open economy context. There is little agreement on the relative importance versus permanent for stationary shocks in in the open economy; our initial calibration puts relatively high weight (around 80 percent) on non-stationary shocks. For the permanent component in productivity, we assume that one half is driven by news which is consistent with the findings of [Schmitt-Grohé and Uribe \(2012\)](#) of the news component of permanent productivity shocks. Finally, we choose κ , the key parameter in the collateral constraint. as well the parameter ϕ , governing investment adjustment costs, in order to match the roughly 2.0% frequency of Sudden Stops in the data, along with the average eight percent drop in consumption that is typical of these events. Our parameter choices are summarized in tables [1](#) and [2](#).

In order to solve the model, we first stationarize the economy by dividing all trending variables by X_{t-1} . The resulting stationary first order conditions and corresponding balanced growth path are described the [Appendix B](#). We then solve the model using a policy function iteration approach, approximating the policy functions with linear finite element basis functions in the seven-dimensional state space $x_t = [b_t, \log(k_t), \epsilon_{\gamma,t-2}^2, \epsilon_{\gamma,t-1}^2, \log(\gamma_t), \log(A_t), R_t]$. The solution procedure delivers piecewise

linear policy functions $c(x_t)$, $h(x_t)$, and $k(x_t)$ denoting optimal consumption, hours, and capital which minimize mean-squared residuals to equations (11) - (16) as well as the constraints given in (2) - (4) over a finite grid.

4 Results

In this section, we first consider some features of an approximate version of the model in which the constraint never binds and the model is linearized around its non-stochastic steady-state. Much of the intuition for the results regarding the model with the constraint can be garnered by examining the correlations of consumption, investment, and leverage induced by the four shocks of the model. After showing in the unconstrained model that news shocks are a promising candidate for driving leverage and leverage-based crisis, we then turn towards a study of the non-linear model, showing that news shocks are indeed a key driver of Sudden Stop events in the model.

4.1 Model without the Leverage Constraint

Figure 1 plots impulse responses for a variety of variables to a one-standard deviation innovation for each shock in the unconstrained linearized model. The blue line represents the “news shock,” which is the key shock for our results. Given our preferences, labor supply in the unconstrained economy responds only to the marginal product of labor in the current period. Since capital is predetermined, output therefore cannot move on impact to the news shock. Yet, consumption-smoothing agents foresee high future consumption, and therefore increase consumption today. High consumption today, in turn, can be financed only by either increasing debt or by negative investment. The latter force, however, is countered by the desire to increase investment today in order to take advantage of the forecast future high productivity. Thus the current increase in consumption must be financed to some degree by an increase in debt. While the increase in debt is generic, the consequence for leverage is not. Since the measure of leverage also contains the price of installed capital, which rises on impact whenever investment adjustment costs are substantial, it is a matter of calibration as to whether the effect in the numerator or denominator dominates. According to our baseline calibration, however, the good news shock leads to a substantial increase in leverage, thus tends to bring the economy closer to leverage levels that would bind if the constraint were imposed.

The responses to the news shock contrast sharply with the responses to both the

contemporaneous productivity growth shock and the temporary TFP shock. The productivity growth shock has a near-zero impact effect on leverage, followed by a positive but muted increase in leverage over subsequent periods. This persistent impact on leverage is driven primarily by the autocorrelation in the growth shocks, which causes even the surprise growth shock to contain a degree of news about future productivity. Contrasting even more starkly, the temporary TFP shocks in fact leads to both a high level of investment and an overall fall in leverage, a pattern that is not consistent either with the facts surrounding developing economies business cycles or the patterns surrounding Sudden Stop episodes. Finally, higher interest rates leads to relatively small changes in leverage, as investment, debt and Tobin's Q all decrease simultaneously.

The different responses of leverage in the linear-unconstrained model are suggestive of our ultimate results in the leverage-constrained economy: since news shocks are the key driver of fluctuations in leverage, in the constrained economy they will also be key force determining the risk of leverage-based crises. It is precisely the features of news shocks described above - that they tend to drive large pro-cyclical fluctuations in leverage - that make us view them as promising candidates for the type of shock driving the boom-bust cycles associated with Sudden Stop events.

Table 3 confirms that, unconditionally, leverage in the unconstrained linearized economy is driven primarily by the news shocks and, to a lesser extent, by the surprise temporary and permanent shocks. This table also shows that, despite being temporary, the transient shock to TFP explains a sizable share of the variance in GDP growth rates. This is driven largely by the fact that, despite the autocorrelation in the growth process, shocks to the growth rate behave essentially like random walk shocks, leading to a large but then permanent change in the level of GDP.

4.2 Model with Leverage Constraint

Having made a set preliminary observations about the effects of news shocks in an unconstrained environment, we now turn to examining the non-linear model. Panels (a) and (b) of figure 2 display policy functions for debt accumulation and investment respectively.³ Each panel contains three lines, which differentiate between policy functions at low, average, and high realization of the current news shocks, as well as corresponding lines (in light green) for the same object computed in the unconstrained, linearized

³Note that these are not the same objects solved for directly by the numerical procedure, and instead are derived as implications of the policy functions for consumption, hours, and capital. For numerical reasons, it is desirable to parameterize the most linear policies, while for exposition of course it informative to see the policies which exhibit the strongest non-linearities.

economy. The figures show that, for many regions of the state space, the policy functions delivered by the global and local solution procedures are quite similar. However, when debt is unusually high or capital unusually low, these functions also demonstrate strong non-linearities. In the first panel of both figures, in cases of extremely high debt, previously parallel lines in fact cross, suggesting that agents take advantage of high current productivity to do a larger degree of deleveraging than they would have otherwise done with lower current productivity growth.

Although some areas of the state-space clearly demonstrate strong non-linearities, in equilibrium these areas of the state-space may be visited infrequently. To assess the average effects of the constraint, table 4 compares the non-stochastic steady-state of the economy with the long-run average values in the full non-linear economy. The table shows that, in terms of unconditional means, the non-linear stochastic model looks very much like the non-stochastic steady-state, in which the constraint does not bind. Output, hours, and consumption are just slightly higher, a difference generated by precautionary motives that lead agents to have somewhat higher average holdings of capital. Correspondingly, long run debt-to-GDP and leverage are both reduced to a substantial degree by the presence of the constraint. Overall, *unconditional* long-run average *flows* in the economy are largely unaffected by the non-linearity in the economy, while *stock* variables such a capital and debt move in the expected direction given the cautionary motives of agents.

Tables 5 and 6 show unconditional second moments for the economy when the constraint does not and does bind respectively. Here, the constraint leads to small differences in in the variance of output and somewhat larger increase in the variance of consumption. The constrained economy also displays a much larger difference in the standard deviation of investment, which is increased by roughly half by the presence of the constraint. While consumption growth is substantially less volatile than output in the unconstrained model, it's variance increases once the constraint is imposed by around 0.6 percent, such that consumption variance surpasses output variance by a small amount. This finding echoes those of [Basu and Macchiavelli \(2014\)](#), who show an always-binding collateral constraint can explain the excess volatility puzzle of consumption in developing economies and find cross-sectional empirical support for the mechanism.

In contrast, the standard deviation of leverage in the model with the binding constraint is roughly one-third of its value in the unconstrained model. With the addition of the constraint, the volatility of leverage declines for direct reasons, because the con-

straint truncates the support of admissible values, and because precautionary motives lead to smaller leverage movements away from the constraint.

Figure 3 compares the shape of the equilibrium distributions of debt, investment, consumption and output growth for the constrained and unconstrained economies. The figures show that, with the imposition of the constraint, investment growth and consumption growth display fat-tailed distributions, with excess kurtosis of 13.4 and 0.7 respectively. The presence of fat tails in these distributions are strong indicators that the non-linearity created by the constraint plays an important role along the equilibrium path of the economy. Given the one-sided nature of the constraint it is perhaps surprising that these distributions remains roughly symmetric. We provide some intuition for this finding in the following paragraphs.

Figure 4 offers a preliminary look at the dynamic effects of the constraint on the economy. For this figure and for figure 5, we simulate the economy for 100,000 periods and then identify all periods which satisfy the event criteria; in the case of figure 4, merely that the constraint binds in the current period. According to our baseline calibration, the constraint binds around 19 percent of time, although we will see later this includes many instances when the constraint binds in a relatively benign fashion. We then look at median values for various quantities in the five-year window before and after the event.

Qualitatively, figure 4 shows the set of patterns anticipated by the impulse responses of the unconstrained model. First, output, consumption, investment and hours are all above trend prior to the constraint binding event, and all fall substantially once it binds. In the event period, the trade-balance shows a modest reversal, and leverage is seen to rise prior to the event, and then fall afterwards. The final row of the figure shows that economy has experienced, on average, a sequence of good news shocks leading up to the crisis and that, indeed, the level of permanent productivity growth in the economy is elevated. In short, good news is predicting future constraint-binding episodes. The rate of permanent productivity growth falls sharply in the period of the constraint binding, indicating on average, a negative contemporaneous growth shock offsetting the previous positive news shocks. Finally, notice that overall stationary TFP is low going into the crisis period, then rises back to to its long-run level in subsequent periods. This is also unsurprising, given our observation in the linearized model that negative temporary TFP shocks lead to increased leverage.

The qualitative features of this simple event study demonstrate some of the patterns associated with Sudden Stop events but, at least on average, are not quantitatively

consistent with the findings of [Mendoza \(2010\)](#) and others cited earlier. This is easiest to see from the response of Tobin’s Q which, though it falls, remains quite close to its long-run level. Similarly, while stationary TFP is low initially, non-stationary productivity growth is relatively high throughout the period, dropping only slightly below average in the crisis period. This suggests that a good proportion of binding events are relatively benign cases where a long series of good news is momentarily reversed, but not so far as to fully offset the “stock” of good news in the economy.

Figure 5 seeks to focus attention on recognizable Sudden Stop episodes, and constitutes the main results of our paper. The figure plots the median path of different variables five years before and after Sudden Stop events, identified in the model-simulated data exactly as in [Mendoza \(2010\)](#). The figure shows that, in the 5 years prior to the crisis, the economy experiences a concurrent boom in output, consumption, investment, and hours, consistent with the facts he reports. Output falls just slightly in the period prior the Sudden Stop, then declines further to around four percent below trend in the event period. The total fall of output, from peak-to-trough, is just over five percent, slightly below what it is in the data. As a contrast, Mendoza’s calibrated model delivers a smaller initial boom and an overall peak-to-trough change of just slightly over four percent. For consumption, the peak-to-trough fall is over seven percent, which is very close to what is shown in the [Mendoza \(2010\)](#) data, and is substantially larger than the fall implied by his model. The model also delivers a quantitatively realistic investment boom prior to the Sudden Stop event, which is greater than thirty percent in both the model and the data. Finally, the trade balance shows a strong reversal as in the data, although the initial level prior to the Sudden Stop is not as far below trend as Mendoza’s data show.

While the model succeeds in matching the pre-crisis boom and the depth of Sudden Stop crashes, it substantially misses the rate of recovery in these variable post-crash. In particular, the model delivers a return of consumption, output and investment to pre-crisis levels in the year following the Sudden Stop, which is counter-factual. This observation is closely related to the earlier result that the fat-tails in consumptions and investment remained surprisingly symmetrical in the constrained model. We come back to this issue momentarily.

The final row of figure 5 sheds some light on the constellation of shocks leading up to sudden-stop events. The figure shows that news about future productivity is very positive in the period just prior to the Sudden Stop, but is in fact slightly negative in the two periods just prior to the event. In contrast, the level of productivity growth remains

elevated in all periods before and after the event. This pattern can be explained upon realizing that, with several periods of delay, both good news and good surprise shocks to growth lead to increased leverage in the unconstrained model. After a sequence of such shocks, a combination of bad surprise shocks and muted news shocks is needed to deliver the below average productivity growth that is required to trigger a true overall contraction in the economy, rather than a fast “correction” of the endogenous variables from elevated levels towards their long-run values. Although we have not reported it here, filtering Sudden Stop events using growth rates, rather than deviations from long-run trends, delivers the more intuitive result that news shocks are, on average, positive in the periods leading up to the event.

The process for TFP and the growth rate shock also shed light on the reasons for the quick recovery following the Sudden Stop. The figure show that Sudden Stops tend occur in the economy when the stock of news, which is to be realized at future dates, is high. Since we have assumed a two period lag for news, there exists only one period during which the stock of unrealized news may remain high, and this news *must* be realized in the period following the Sudden Stop, leading to pattern of high productivity growth that systematically follows Sudden Stop events. Moreover, since the temporary TFP shock tends to be low in these periods, and is mean reverting, it also contributes to a fast increase in output and hours over the periods following the Sudden Stop.

Figure 6 plots the probability that an Sudden Stop occurs one period forward as a function of the current news shock hitting the economy. The function is clearly upward sloping, with probability of a Sudden Stop well below one-percent when the “stock” of news is bad, reaching nearly percent when news is very good. In terms of the risk of Sudden Stops, good news is indeed bad news. The hump-shaped probability figure in figure 7 shows that, in the moment two periods before the shock (when news first arrives) Sudden Stops are in fact more likely to occur if the news shock is close to its average. Again, this is explained by the observation that, if the stock of news is too high, it becomes nearly impossible to generate the negative productivity growth needed to generate a contraction of output and consumption *below trend*. In such cases, large negative *growth rates* remain more likely; good news increases the likelihood of a strong reversal of these variables but many such episodes are ignored by the filter that focuses on periods where output is well below its trend level.

The panels in figure 8 show that Sudden Stop risk, and risk to consumption growth, are not perfectly correlated. Panel (a) shows the median and 99 percent confident bands

of one-period ahead consumption growth conditional on the percentile of the current news shock. The figure shows that risk two consumption growth increases monotonically with “better” news, with the width of the bands rising from around 17 to 25 percent going from the first decile of the distribution to the the last. The result in this panel is consistent with the finding that good news increases Sudden Stop risk, since such events are associated with large moments in consumption. Panel (b) shows the same average and 99 percent confidence bands for two-period ahead consumption. Since news affects productivity two periods ahead, average consumption growth clearly increases with higher news shocks as this horizon. Yet, the width the of the distributions also increases with news, going from 17 to around 23 percent. Good news increases the probability of the constraint binding, and thus the dispersion of future consumption growth, at this horizon as well, even if it is not directly associated with the risk of a Sudden Stop.

5 Conclusions

This paper has shown that shocks to expectations about future productivity growth are a good candidate for explaining the observed patterns in developing economies of concurrent growth and leverage expansion followed by occasional reversals in both leverage and real quantities. The presence of an occasionally binding collateral constraint amplifies these reversals substantially, yielding the characteristic features of Sudden Stops. The stylized model presented here does a remarkably good job at matching the stylized facts about suddens stops both qualitatively and, for many variables, quantitatively. Moreover, the arrival of good news leads to a high-probability of “tail” outcomes, including large decreases in consumption. The presence of externalities in this context, and consequently the insufficiently strong precautionary motives faced by agents, suggests the possibility that the information contained in news shocks could, in fact, be detrimental to welfare. We plan to examine this possibility in future work.

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A Household's Optimality Conditions

Let the multipliers on the constraints in equation (2) through (4) be given by λ_t , $\lambda_t q_t$, and $\lambda_t \mu_t$ respectively. Then the first order conditions of the household problem are

$$U_{c,t} = \lambda_t \tag{11}$$

$$-\frac{U_{c,t}}{U_{h,t}} = A_t F_{h,t} - \chi(R_t - 1)w_t - \mu_t \chi R_t w_t \tag{12}$$

$$q_t = 1 + \phi' \left(\frac{i_{t+1}}{k_{t+1}} \right) \tag{13}$$

$$q_t(1 - \mu_t \kappa) = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(A_t F_{k,t+1} + q_{t+1}(1 - \delta) + \phi' \left(\frac{i_{t+1}}{k_{t+1}} \right) \left(\frac{i_{t+1}}{k_{t+1}} \right) - \phi \left(\frac{i_{t+1}}{k_{t+1}} \right) \right) \right] \tag{14}$$

$$(1 - \mu_t) = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} R_t \right], \tag{15}$$

the constraints in equations (2) - (4), as well as the complementary slackness conditions $\mu_t \geq 0$ and

$$\mu_t \left(\kappa - \frac{\frac{d_{t+1}}{R_t} + \chi R_t (w_t h_t)}{q_t k_{t+1}} \right) = 0. \tag{16}$$

B Stationary Equilibrium and Model Steady-state

Let $\tilde{z}_t \equiv z_t/x_{t-1}$, for $z_t \in \{c_t, k_t, w_t, b_t\}$, and let $\tilde{\lambda}_t \equiv \frac{\lambda_t}{x_{t-1}^\sigma}$. Then, given the functional forms provided above, the stationary first order conditions of the economy are given as follows.

$$\tilde{\lambda}_t = \left(\tilde{c}_t - \theta \frac{h_t^\omega}{\omega} \right)^{-\sigma} \quad (17)$$

$$\theta h_t^{\omega-1} = A_t(1-\alpha)\tilde{k}_t^\alpha h_t^{-\alpha} \gamma_t^{1-\alpha} - \chi(R_t - 1)\tilde{w}_t - \mu_t \chi R_t \tilde{w}_t \quad (18)$$

$$q_t = 1 + \phi \left(\frac{\tilde{i}_t}{\tilde{k}_t} + 1 - \gamma - \delta \right) \quad (19)$$

$$q_t(1 - \mu_t \kappa) = \beta E_t \left[\frac{\tilde{\lambda}_{t+1}}{\tilde{\lambda}_t} \gamma_t^{-\sigma} \left(A_{t+1} \alpha \tilde{k}_{t+1}^{\alpha-1} (\gamma_{t+1} h_{t+1})^{1-\alpha} + q_{t+1}(1 - \delta) + \dots \right. \right. \\ \left. \left. \phi' \left(\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}} \right) \left(\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}} \right) - \phi \left(\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}} \right) \right) \right] \quad (20)$$

$$(1 - \mu_t) = \beta E_t \left[\frac{\tilde{\lambda}_{t+1}}{\tilde{\lambda}_t} R_t \right] \quad (21)$$

$$\tilde{k}_{t+1} \gamma_t = (1 - \delta) \tilde{k}_t + \tilde{i} \quad (22)$$

$$\tilde{c}_t = A_t \tilde{k}_t^\alpha (h_t \gamma_t)^{1-\alpha} - \tilde{d}_t + \tilde{d}_{t+1} \gamma_t / R_t - \chi(R_t - 1)\tilde{w}_t - \tilde{i}_t - \tilde{k}_t \phi \left(\frac{\tilde{i}_t}{\tilde{k}_t} \right) \quad (23)$$

$$\log(R_t) = \log(R_t^*) + \psi \left(e^{\tilde{d}_t/y_t - \overline{d}/y} - 1 \right) \quad (24)$$

as well as the complementary slackness conditions $\mu_t \geq 0$ and

$$\mu_t \left(\kappa - \frac{\tilde{d}_{t+1}}{R_t} + \frac{\chi R_t \tilde{w}_t \tilde{h}_t}{q_t \tilde{k}_{t+1}} \right) = 0, \quad (25)$$

and the equilibrium definition $\tilde{w}_t = \theta h_t^{\omega-1}$.

Linearization requires that we solve for non-stochastic steady state of the economy. To do this, we assume values for \bar{h} and \overline{d}/y , and then find the values of θ and long-run debt that are consistent with our assumptions. Rearranging equation (20) and imposing steady-state implies that

$$\frac{k}{h} = \left[\frac{\frac{\gamma^\sigma}{\beta} - 1 + \delta}{\alpha} \right]^{\frac{1}{\alpha-1}} \quad (26)$$

Given our assumption for \bar{h} , the long run capital level follows immediately. From there, the resource constraint and the production function can be used to determine consumption, and equation (17) can be solved for θ .

Table 1: Baseline parameterization of the model.

Parameter	Concept	Value
σ	Risk Aversion	2.001
ω	Labor Elasticity	1.900
\bar{R}	Long Run Interest Rate	1.040
α	Capital Share in Gross Output	0.306
δ	Capital Depreciation Rate	0.088
θ	Disutility of Labor	4.337
$\frac{g}{y}$	Government Exp.-to-GDP in unconstrained steady-state	0.110
$\frac{d}{y}$	Debt-to-GDP in unconstrained steady-state	0.650
γ	Long run productivity growth	1.010
ϕ	Capital Adjustment Cost	2.400
κ	Collateral Constraint	0.300
χ	Share of Working Capital	0.258
ψ	Interest Rate Elasticity	0.100

Table 2: Baseline parameterization of the model - exogenous processes.

Parameter	Concept	Value
σ_a	Std. Dev. of TFP shock	0.010
σ_x^{news}	Std. Dev. of Trend News shock	0.020
σ_x^{surp}	Std. Dev. of Trend Surprise shock	0.020
σ_r	Std. Dev. of Interest Rate shock	0.015
ρ_a	AR coeff. of TFP shock	0.600
ρ_x	AR coeff. of Trend shock	0.350
ρ_r	AR coeff. of Interest Rate	0.500

Table 3: Variance decomposition for linearized model.

	ΔY	ΔC	ΔI	Q	Leverage	TB/GDP
X_{news}	0.41	0.22	0.05	0.18	0.56	0.24
X_{surp}	0.36	0.49	0.19	0.32	0.25	0.10
A	0.22	0.18	0.05	0.06	0.14	0.01
R	0.01	0.11	0.72	0.44	0.04	0.65

Table 4: Long-run values for unconstrained and constrained model.

Object	Non-binding Steady-State	Ergodic Mean
Output	0.297	0.304
Hours	0.200	0.202
Consumption	0.187	0.193
Capital	0.709	0.745
$\frac{d}{y}$	0.650	0.542
leverage	0.338	0.289

Table 5: Unconditional moments for unconstrained model.

	ΔY	ΔC	ΔI	Q	Leverage	TB/GDP
Std. Dev.	3.71	3.26	12.37	3.27	3.24	3.21
Std. Dev./Std. Dev. (ΔY)	1.00	0.88	3.34	0.88	0.87	0.87
Auto-Correlation	1.00	1.00	1.00	1.00	1.00	1.00
Corr. with ΔY	1.00	1.00	1.00	1.00	1.00	1.00

Table 6: Unconditional moments for constrained model.

	ΔY	ΔC	ΔI	Q	Leverage	TB/GDP
Std. Dev.	3.82	3.85	17.45	3.35	1.17	3.10
Std. Dev./Std. Dev. (ΔY)	1.00	1.01	4.57	0.88	0.31	0.81
Auto-Correlation	-0.13	-0.23	-0.42	0.35	0.88	0.00
Corr. with ΔY	1.00	0.88	0.43	0.51	0.02	-0.16

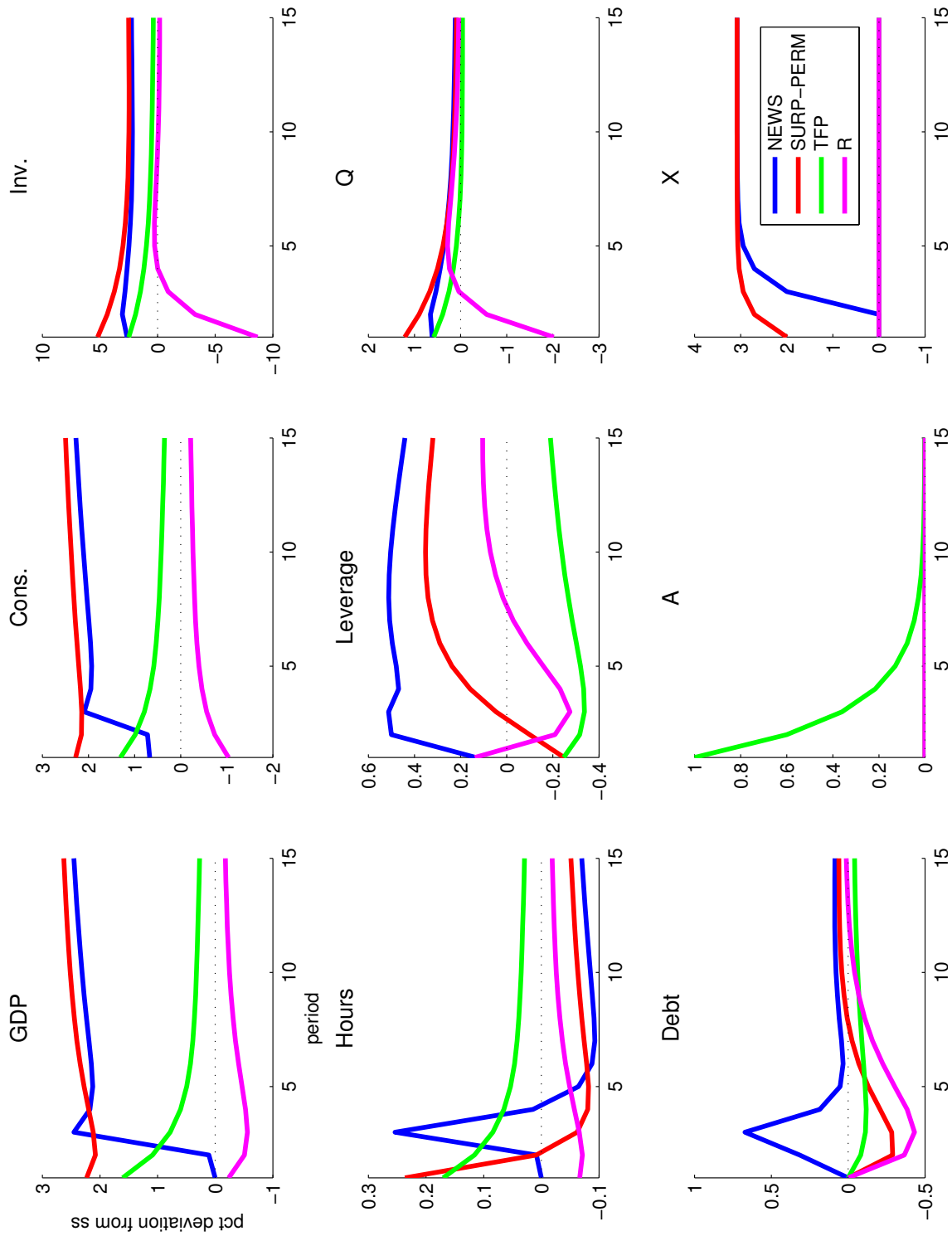
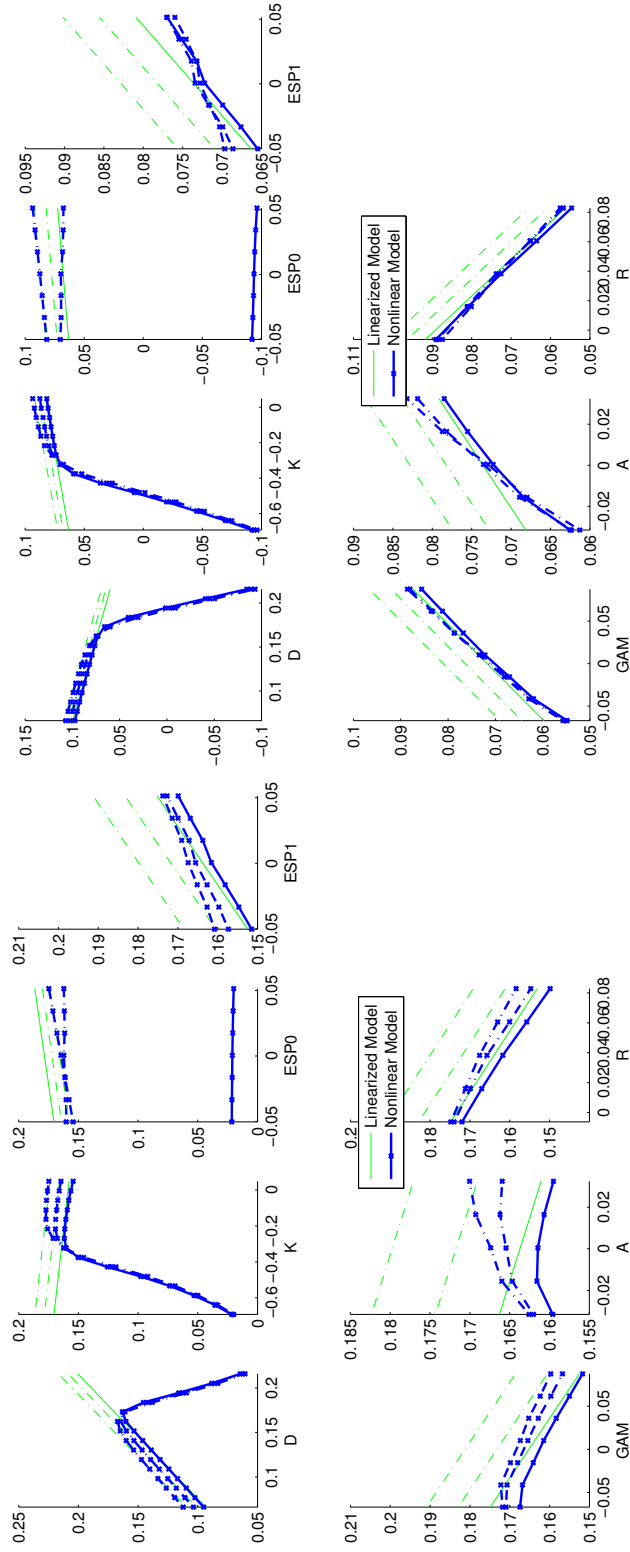


Figure 1: Impulse responses to all four shocks in the economy linearized around the non-binding steady-state.



(a) Debt Policy

(b) Investment Policy

Figure 2: Non-linear policy functions for debt and investment. Lines represent policy as function of the x-axis state, taking as given one of three different levels (high, average, low) of the current “news” innovation, with all other states fixed at their unconditional means. In the third panel of each figure, while plots policy as a function of the news shock, the three lines condition on different levels of the current capital stock.

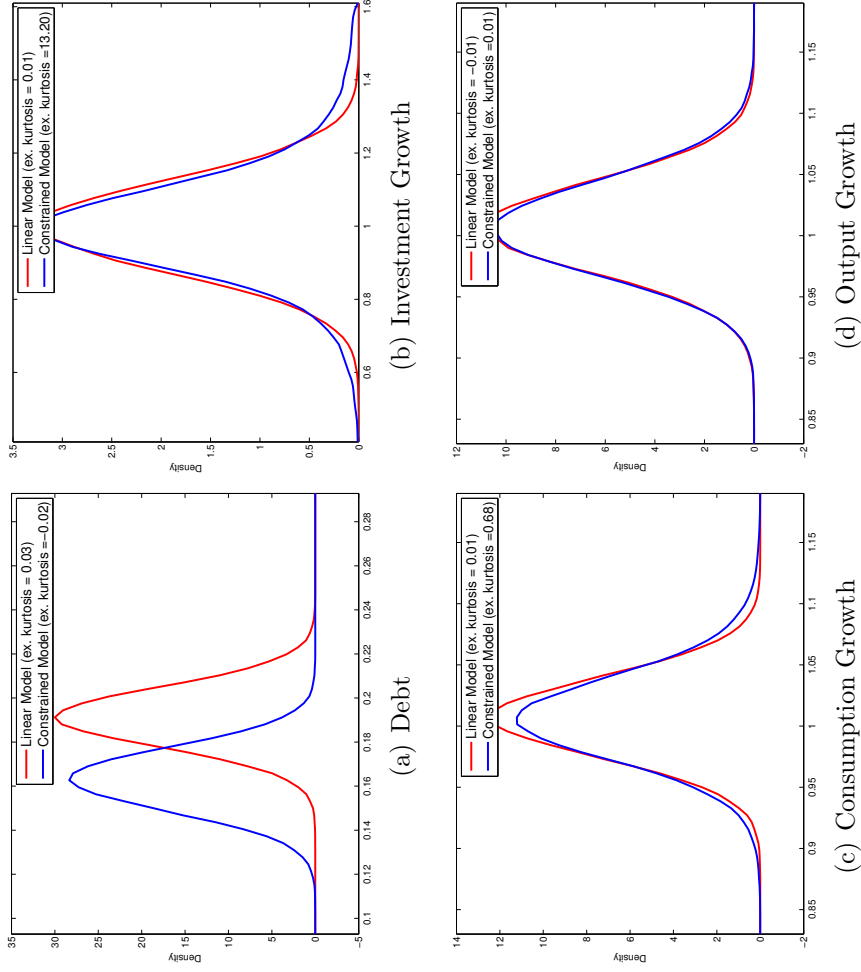


Figure 3: Ergodic distributions for the unconstrained and constrained economies. The distributions of debt is shifted downwards, while the growth rates of investment and consumption demonstrate substantially fatter tails (excess kurtosis) after the imposition of the constraint. The distribution of output growth is only slight changed, and demonstrates no corresponding excess kurtosis.

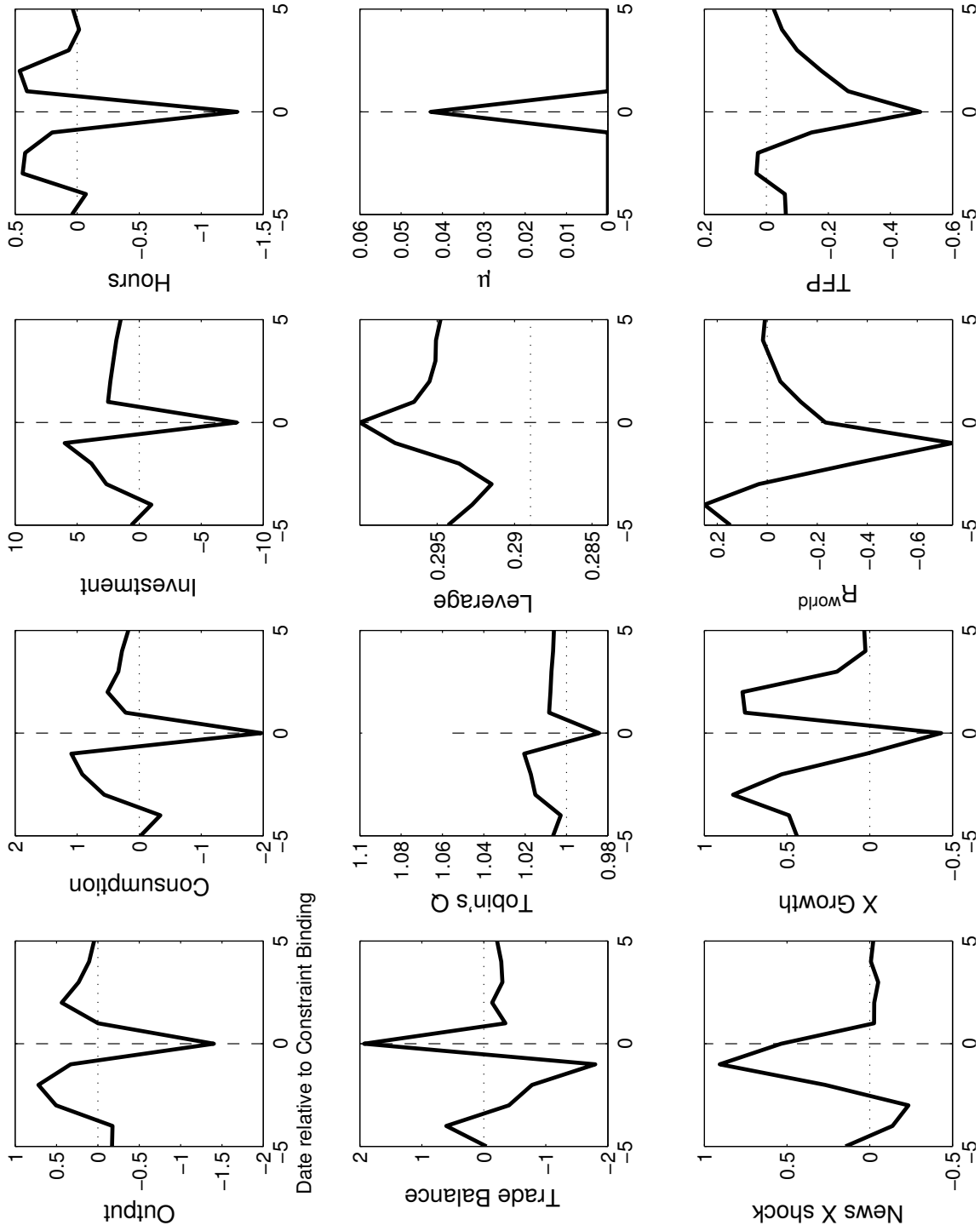


Figure 4: Constraint-binds event study. Panels show deviations from long-run level for each variable in the periods before and after the constraint binds. Output, consumption, investment, and the trade balance plot median deviations from an HP trend, while all others variables plot deviations from their ergodic means. The unconditional probability of the constraint binding is 19 percent.

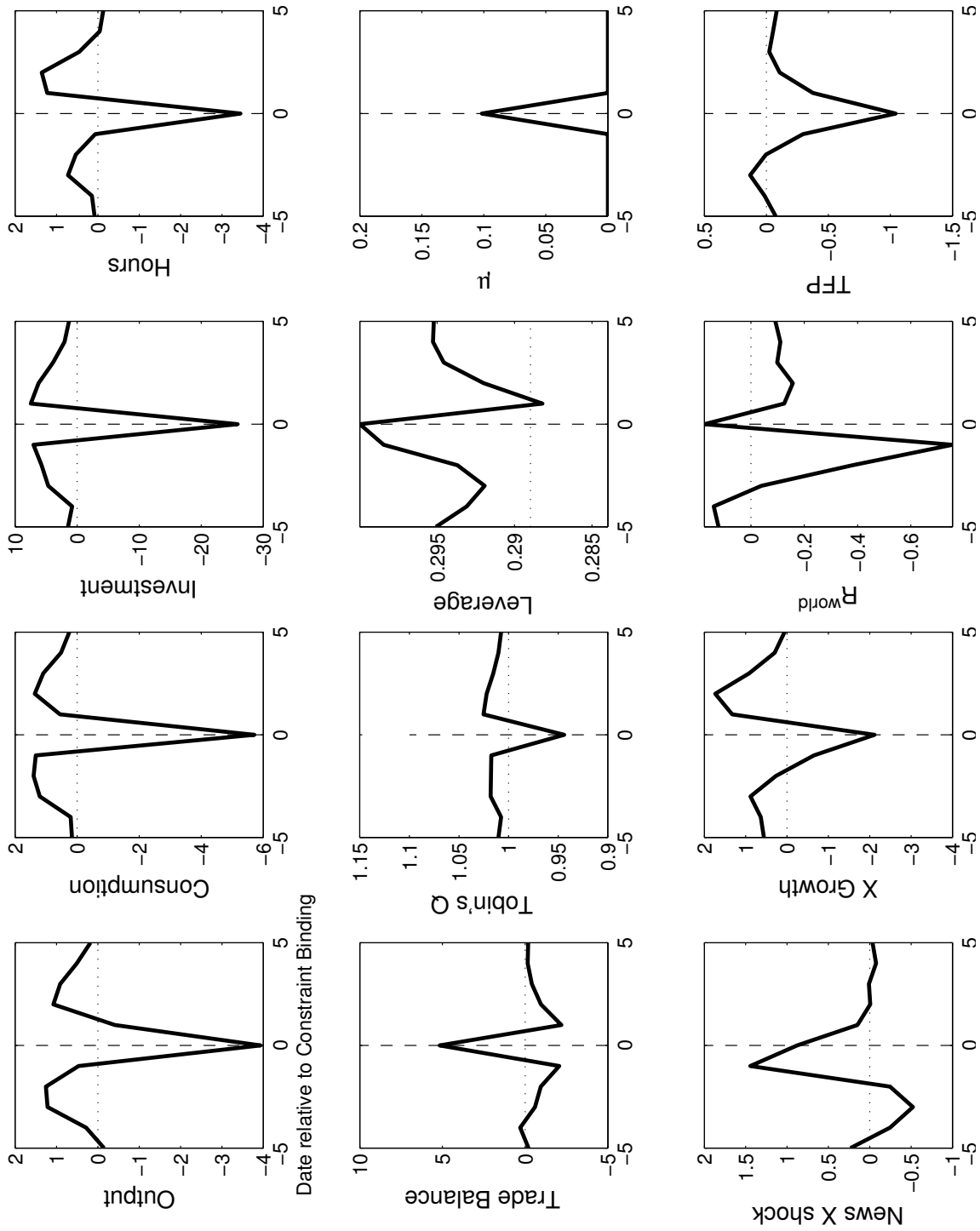


Figure 5: Sudden stop event study. Figure shows median deviations from long-run level in the periods before and after a sudden stop event, identified as in [Mendoza \(2010\)](#) as periods in which the leverage constraint binds, output is at least one standard deviation below trend, and the trade balance is one standard deviation above trend. Output, consumption, investment, and the trade balance plot median deviations from an HP trend, while all others variables plot deviations from their ergodic means. For consecutive periods that fit this criterion, we plot based on the initial period. The unconditional probability of a sudden stop event in the model is 2.0 percent.

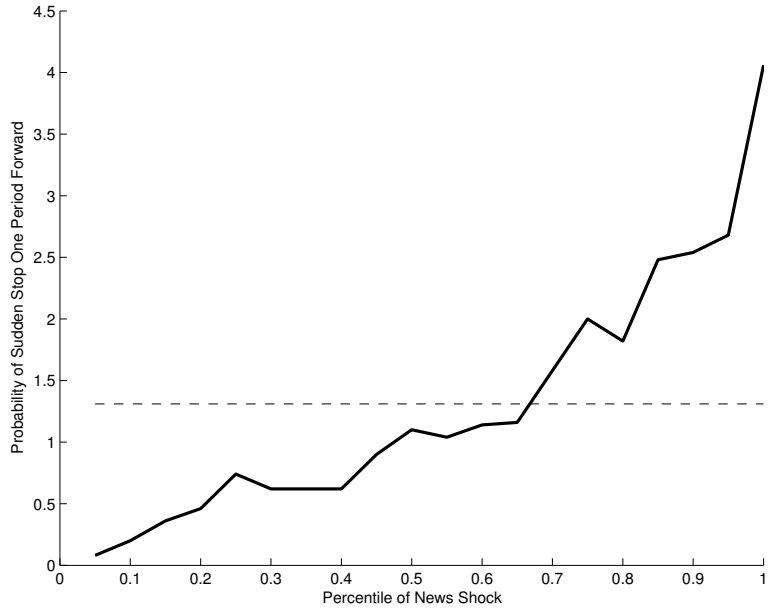


Figure 6: Good news increases the probability of a sudden stop. The figure plots the probability of a sudden stop event occurring one period hence conditional on the level of the trend news shock today. “Good news” about future growth also increases the probability of a future sudden stop event.

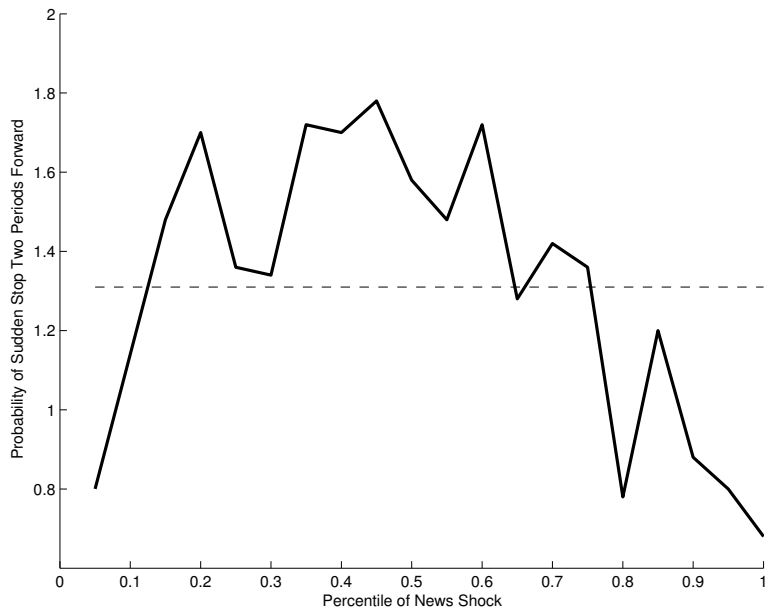


Figure 7: The figure plots the probability of a sudden stop event occurring two periods hence conditional on the level of the trend news shock today. “Good news” about future growth is not associated with Sudden Stop events at exactly the news horizon of two periods.

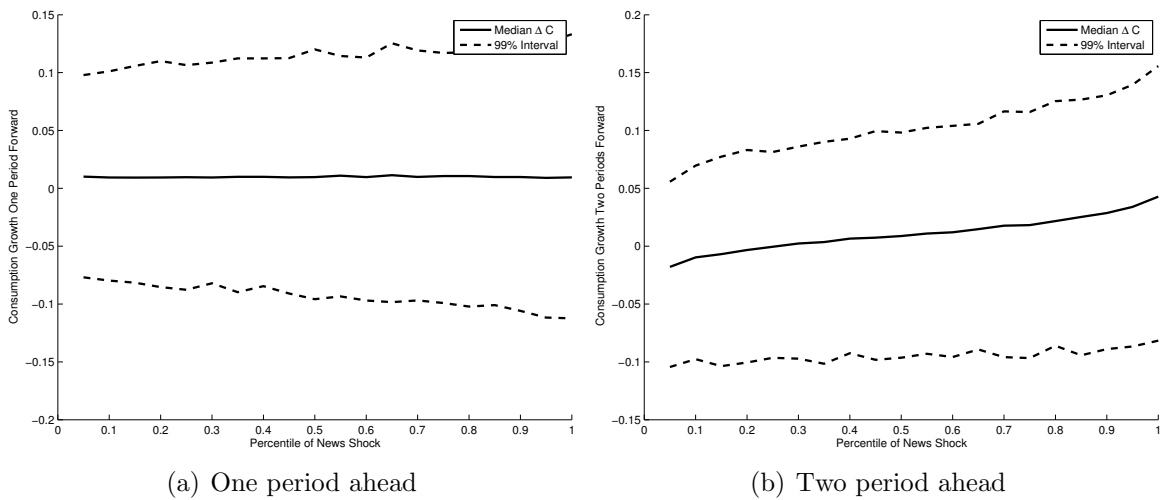


Figure 8: Good news leads to greater tail risk in later periods. The figure plots the conditional 99 percent confidence bands of consumption growth subsequent to different levels of the current realization of the news shock. News today leads to higher consumption growth variance in the following period. Two periods ahead, goods news lead to high average growth, but again a larger distribution of possible growth outcomes.