News and Aggregate Demand Shocks

Guido Lorenzoni

Department of Economics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02142-1347, and NBER, Cambridge, Massachusetts 02138; email: glorenzo@mit.edu

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Abstract

In this review, I look at the recent literature on news as a source of economic fluctuations. The main question in this literature is: how does the aggregate economy respond to a shock that raises consumers' and firms' expectations about future productivity growth? I discuss how different papers have addressed this question, emphasizing the mechanisms at work under different specifications of preferences and technology, under different assumptions about nominal and real rigidities, and under different assumptions about the agents' information structure. I also briefly discuss some challenges faced by the empirical literature on the topic.

1. INTRODUCTION

In the search for the causes of aggregate economic fluctuations, changes in expectations offer an appealing narrative. Consumers and firms become more optimistic about future economic prospects, both start spending more, and consumption and investment increase, driving up aggregate activity. If the agents' optimism turns out to be justified, the economy converges to a higher long-run path; if it does not, the economy returns to its original trend.

From a partial equilibrium point of view, the behavior of consumers and firms just described is consistent with standard models of optimizing behavior: The permanent income hypothesis implies that future income expectations affect current consumption decisions; neoclassical investment theory implies that the expected marginal product of capital is a primary determinant of investment. It is also easy to formalize the idea of rational waves of optimism and pessimism in terms of imperfect information. For example, one can endow the agents with noisy signals about the future and let them solve the associated signal-extraction problem. Then shocks to the noise component will generate temporary fluctuations in expectations about future economic outcomes.

Once one turns to general equilibrium, however, things get more complicated. In particular, in a standard neoclassical environment, equilibrium in the labor market does not allow for an aggregate expansion driven by news about the future. Given the capital stock inherited from the past and given a fixed level of productivity, a joint increase in investment and consumption requires an increase in the labor input. However, a fixed capital stock and fixed productivity also mean that firms' labor demand is unchanged. Furthermore, as consumption is driven up by what is essentially a wealth effect, the same wealth effect must shift the labor supply curve to the left. A combination of a fixed labor demand curve and a labor supply shifting to the left yields a fall in labor input, not an increase.

This logic is confirmed by simulating a baseline real business cycle (RBC) model and looking at the effects of a news shock, i.e., a shock that increases expected future productivity without affecting current productivity. Let the preferences of the representative consumer be represented by the utility function

$$E\left[\sum_{t=0}^{\infty}\beta^t\left(\log C_t-\frac{\psi}{1+\eta}N_t^{1+\eta}\right)\right], \tag{1}$$

where C_t is consumption and N_t is labor effort. Suppose the technology is Cobb-Douglas with $Y_t=\exp\{a_t\}K_{t-1}^{\alpha}N_t^{1-\alpha}$, where K_t is the capital stock and a_t is an exogenous productivity level that follows the process

$$a_t=\rho a_{t-1}+\xi_t+\varepsilon_{t-4},$$

with $\rho\in(0,1)$, and ε_t and ξ_t are random independent and identically distributed (i.i.d.) shocks. The shock ξ_t is a standard shock to current productivity, and the shock ε_t is a news shock, which is observed at date t but only affects productivity a year later at $t+4$. Letting the time period be a quarter, set the parameters $\beta=0.99$, $\alpha=0.33$, $\eta=1/2$, and $\rho=0.95$ and let the depreciation rate of capital be $\delta=0.0125$. The impulse responses for output, consumption, investment, and labor supply to the anticipated technology shock are plotted in **Figure 1** (see color insert). The news shock yields an increase in consumption, a reduction in labor effort, and a decrease in investment. The representative consumer's optimal response is to smooth the consumption path by running down the current capital stock in the periods before higher productivity is realized. By choosing a utility function with a higher elasticity of intertemporal substitution, it is possible to get different implications; namely, we can obtain a fall in consumption after the news shock, accompanied by an increase in employment and investment. With a high elasticity of substitution, we have an increase in the real interest rate, which more than compensates for the positive wealth effect, yielding lower consumption and higher labor effort (through an intertemporal substitution channel). However, no combination of parameters can generate a joint increase in consumption, investment, and employment.

This property of neoclassical models of the business cycle was first recognized by Barro & King (1984) and then explored by Cochrane (1994) and Danthine et al. (1998) in different variants of the neoclassical growth model. More recently, Beaudry & Portier (2007) show that the result is general in one-sector models with time-separable preferences and basically relies on the assumption that consumption and leisure are both normal goods. To understand the generality of the result, it is easier to consider the social planner problem that corresponds to the competitive equilibrium analyzed. From the point of view of the social planner, for a given level of investment, the optimal allocation of consumption and labor effort comes from the solution of a static problem. An increase in investment with unchanged current productivity corresponds to a downward shift in the feasible consumption-leisure pairs for this static problem. It can then be shown that consumption must decrease if investment increases (see proposition 1 in Beaudry & Portier 2007).

At the same time, Beaudry & Portier have also been exploring the empirics of expectation-driven business cycles. Beaudry & Portier (2006) provide time-series evidence supporting the view that shocks to expectations about the future can give rise to standard business cycles characterized by a joint increase in consumption, investment, and labor supply. Below I discuss in more detail their empirical exercise.

The combination of the evidence in Beaudry & Portier (2006) with the theoretical result mentioned above has opened up a quest for models that can deliver a standard business cycle expansion in response to good news about the future, that is, environments in which expected technological improvements lead to a joint increase in consumption, investment, and employment. In richer, multisector environments, the broader problem is to generate enough comovement across sectors in response to a news shock. In this article, I review some of the recent literature on expectation-driven cycles. I begin in Sections 2–4 by discussing how the problem just described has been attacked from different directions: by changing preferences or technology in a neoclassical setup and by introducing various type of frictions, in particular, nominal rigidities, real wage rigidities, and financial frictions. In Section 5, I then discuss different ways of representing information and models that introduce news shocks in environments with dispersed information. Finally, in Section 6, I cover some empirical work in this area, discussing both structural vector autoregression (SVAR) evidence and structural estimation of dynamic stochastic general equilibrium (DSGE) models. In reviewing a rich and growing body of literature, I look for a few unifying themes rather than comprehensiveness.

2. CAN GOOD NEWS GENERATE AN EXPANSION IN A NEOCLASSICAL MODEL?

In the baseline RBC model, a reason why investment falls in anticipation of technological improvements is that capital can be costlessly turned into consumption goods and consumption goods into capital. This allows the representative consumer to decumulate capital in the anticipation phase and then accumulate it at a fast pace once the technological improvement is realized. A simple way to enrich the description of capital accumulation in the model is to introduce convex adjustment costs in investment. Indeed, by adding adjustment costs, it is possible to obtain an investment boom. However, with this modification alone, the model now delivers a drop in consumption following a news shock. The core problem remains the same: Without a shift in technology today, there is no motive for an increase in labor effort. The only way to get there is via a consumption fall that increases the marginal utility of consumption today and shifts the labor supply to the right. Therefore, to generate an expansion driven by news shocks in a neoclassical environment, we need either (*a*) preferences that can produce a positive shift in labor supply together with an increase in current consumption or (*b*) a mechanism leading to a positive shift in labor demand, for a given level of technology. Below I discuss how the literature has introduced ingredients that deliver both (*a*) and (*b*).[1]

Christiano et al. (2010) consider preferences with a habit-formation element, described by the utility function

$$E\left\{\sum_{t=0}^{\infty}\beta^t\left[\log(C_t - hC_{t-1}) - \frac{\psi}{1+\eta}N_t^{1+\eta}\right]\right\}, \tag{2}$$

where h is a parameter in [0, 1). Moreover, they assume that the capital accumulation equation takes the form

$$K_t = (1-\delta)K_{t-1} + \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right]K_{t-1}, \tag{3}$$

where I_t is investment and $S(x) \equiv (s/2)x^2$. That is, there are adjustment costs associated with changes in the rate of investment, rather than the more conventional adjustment costs associated with changes in the stock of capital.[2] These specifications of preferences and technology have been quite successful in empirical applications of DSGE models because they introduce a backward-looking element in the equations that determine consumption and investment. These backward-looking elements give the model more flexibility in capturing the empirical time-series behavior of these variables, e.g., in capturing their responses to monetary policy shocks.

To see the implication of these assumptions for our problem, let us keep the parameters chosen above and set the additional parameters $h = 0.6$ and $s = 15$ (in line with the parameterization in Christiano et al. 2010). The impulse response functions are plotted in **Figure 2** (see color insert). The anticipated technology shock generates an expansion in all four variables. In this model, labor demand is still pinned down by the current capital stock and technology level. Therefore, behind the effects in **Figure 2** there must be a shift in labor supply. What is driving up labor supply? The habit-formation specification implies that when the consumer anticipates higher consumption in the future, the marginal utility of consumption today increases, as it is equal to

[1]The large literature on increasing returns and multiple equilibria has broadly followed avenue (*b*), by focusing on endogenous movements in productivity. Although that literature shares many themes with the papers reviewed here, I do not cover it for reasons of space. Readers are referred to excellent reviews by Murphy et al. (1989) and Benhabib & Farmer (1999).

[2]Lucca (2007) shows that some time-to-build models are isomorphic to models with this form of adjustment costs.

$$\frac{1}{C_t - hC_{t-1}} - E_t \frac{\beta h}{C_{t+1} - hC_t}.$$

Therefore, the marginal benefit from working today increases. Notice that for this mechanism it is important to specify preferences in terms of a so-called internal habit, in which consumers internalize that higher consumption today affects the habit component tomorrow, rather than an external habit (which is, for example, assumed in Smets & Wouters 2007 and other DSGE models), in which the consumers do not internalize this effect.

Christiano et al. (2010) point out two weaknesses of this simple model. First, the model generates a large spike in the risk-free rate at the time when the productivity increase is actually realized. The discontinuity in the growth rate of consumption, which can be seen in **Figure 2**, is responsible for this spike. An unpleasant consequence of this spike in the interest rate is that asset prices fall in response to good news about the future. The conclusion that Christiano et al. (2010) draw is that we need to move in the direction of models with a more muted response of the real interest rate and that nominal rigidities can help in this direction. I return to nominal rigidities below.

The second weakness of the model is that, with the parameters given above, a standard current technology shock leads to a decline in hours worked. Jaimovich & Rebelo (2009) present more sophisticated preferences that avoid this problem. More generally, they provide the most thorough exercise in producing a news-driven business cycle in the context of a neoclassical, one-sector growth model. The preferences in Jaimovich & Rebelo (2009) take the following form:

$$E\left[\sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \psi X_t N_t^{\theta}\right)^{1-\sigma} - 1}{1-\sigma}\right], \tag{4}$$

where X_t is a state variable that shifts the disutility of labor effort. The law of motion of X_t is given by

$$X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}. \tag{5}$$

Notice that if X_t were a constant, these preferences would be quasilinear, as in Greenwood et al. (1988). However, given that X_t is endogenous and is driven by consumption dynamics, these preferences are in fact consistent with balanced growth. On a balanced-growth path, both the real wage rate and the state variable X_t grow at the same rate, which is consistent with a stationary level of labor supply N_t.

The model also features adjustment costs in investment, as in Equation 3, and variable capacity utilization, as it is commonly introduced in several DSGE exercises. As shown below, variable capacity utilization matters for its effects on labor demand. But let us focus first on the model implications for labor supply. Here the state variable X_t plays a crucial role. In the benchmark calibration, Jaimovich & Rebelo (2009) choose a very low parameter $\gamma = 0.001$. This implies that the state variable X_t moves very slowly. One could thus conjecture that the behavior of labor supply is similar to a quasilinear environment with a constant X_t. This intuition is incorrect. In a quasilinear environment, there is no shift in labor supply and an anticipated technology shock is contractionary, as in the baseline RBC model. In Jaimovich & Rebelo (2009), the representative consumer instead internalizes the future dynamics of X_t, and it is through this channel that a shift in labor supply is obtained.

Intuitively, increasing consumption today includes a forward-looking cost through Equation 5, as higher consumption today makes labor effort more costly tomorrow. The anticipation of a boom leads to a decline in this forward-looking cost, so the marginal benefit of consumption today increases, leading to an increase in labor effort today. The effect is subtle, and once more an external-habit specification—i.e., having consumers take X_t as given—would not work.

An unpleasant implication of the preference specification in Jaimovich & Rebelo (2009) is that it features a positive income effect on labor supply in the short run. That is, a consumer with preferences as in Equation 4, who receives an unexpected increase in nonlabor income, e.g., an unexpected capital gain, responds by working more in the short run, although eventually he will work less in the long run. Jaimovich & Rebelo (2009) recognize this property of their preferences and acknowledge that income effects in labor supply play a central role in their result (see, in particular, their discussion of figure 3 in the paper). The simple habit specification in Equation 3 does not suffer from this problem; that is, it can be shown that the income effect on labor supply is negative. This demonstrates that there are essentially two options to generate a positive response of labor supply: Either one is willing to accept a positive income effect or one needs to produce a large increase in interest rates and obtain a shift in labor supply via intertemporal substitution. The open challenge for this approach is to obtain a shift in labor supply using preferences that are consistent observed income effects and intertemporal responses in micro studies.[3]

Jaimovich & Rebelo's (2009) model also features a shift in labor demand. Here the mechanism works through capital utilization. Capital utilization can increase for two reasons: either because the price of labor falls and it is optimal to increase labor input or because the cost of the capital input falls. Clearly, the first mechanism cannot generate a shift in labor demand; it can only change its slope. Therefore, an increase in labor demand can only occur if the price of capital decreases as a result of the shock. This is where adjustment costs of the form in Equation 3 are crucial. With standard adjustment costs to capital, an increase in investment leads to an increase in the cost of capital. However, with adjustment costs in investment as in Equation 3, an increase in investment generates a drop in the cost of capital. This, together with variable capital utilization, can generate a positive shift in labor demand. The unpleasant side of this channel is that we can get a news-driven boom only with a drop in asset prices (which, by a q-theory argument, moves with the cost of capital). This is another way to look at the asset price problem pointed out by Christiano et al. (2010).

Summing up, it is possible to enrich preferences and technology in a neoclassical environment so as to obtain positive shifts in labor supply and labor demand following a news shock. However, going in this direction requires either accepting relatively implausible income effects on labor supply or producing large increases in the interest rate and an associated drop in asset prices.

3. THE ROLE OF NOMINAL AND REAL RIGIDITIES

As shown above, a major stumbling block in generating booms driven by anticipations is the response of the supply side. A basic Keynesian idea is that price rigidities allow one to build general equilibrium models in which short-run dynamics are dominated by

[3] For example, the evidence in Imbens et al. (2001) seems inconsistent with positive income effects at any horizon.

the demand side. This idea clearly applies to demand shocks driven by expectations.[4] To see this, consider a simple New Keynesian model with preferences given by Equation 1 as in the baseline RBC model (see Galí 2008, chapter 3, for a detailed treatment). Let consumption C_t be an aggregate of a continuum of goods produced by monopolistic producers, $C_t = \left(\int C_{j,t}^{1-1/\epsilon} dj\right)^{\epsilon/(\epsilon-1)}$, as in the usual Dixit-Stiglitz specification. Moreover, suppose firms are only allowed to change their price at random intervals, as in Calvo (1983). Assume that wages are flexible and determined on a competitive labor market. Assume also, for the moment, that the capital stock is fixed. Obviously, this prevents us from analyzing the response of investment, but I return to investment below.

Following standard steps, the optimality conditions and the market-clearing conditions can be log-linearized and transformed to obtain two stochastic difference equations that characterize the joint behavior of output and inflation in equilibrium. In particular, the consumer's Euler equation and goods' market clearing give the relation (omitting constant terms)

$$y_t = E_t[y_{t+1}] - i_t + E_t[\pi_{t+1}], \tag{6}$$

where y_t is output (in logs), i_t is the nominal interest rate, and π_t is inflation. The firm's optimal pricing condition can be manipulated so as to obtain (again omitting constant terms)

$$\pi_t = \lambda(w_t - p_t - a_t) + \beta E_t[\pi_{t+1}], \tag{7}$$

where w_t are nominal wages, p_t is the price level, a_t is the productivity level, and λ is a parameter that depends (positively) on the frequency of price adjustment and on the parameters α and ϵ. Substituting the consumer's optimality condition for labor supply, which in log-linear terms takes the form $w_t - p_t - y_t = \eta n_t$, we end up with the following condition:

$$\pi_t = \kappa(y_t - a_t) + \beta E_t[\pi_{t+1}], \tag{8}$$

where $\kappa \equiv \lambda(1+\eta)/(1-\alpha)$. To close the model, we need to specify the behavior of the central bank, and we assume that it follows a simple interest rate rule that depends only on current inflation:

$$i_t = \phi\pi_t.$$

The flexible-price limit of this model arises when we let the probability of price adjustment go to 1, which implies that $\kappa \to \infty$. In this case, the model simply delivers $y_t = a_t$, and output is determined only by the current level of technology. So, clearly, in the flexible-price version of this model, there is little room for anticipations to affect current activity. These anticipations only affect the real interest rate r_t, which is

$$r_t = E_t[a_{t+1}] - a_t. \tag{9}$$

When consumers expect future productivity to increase, the interest rate adjusts so as to keep current output constant.

Going back to the sticky-price model, suppose productivity follows the unit root process

$$a_t = a_{t-1} + \xi_t + \varepsilon_{t-1}, \tag{10}$$

[4]In the recent literature, the first contributions to independently pursue this idea were Lorenzoni (2009) and Christiano et al. (2010) in the context of different information structures.

where the news shock ε_t affects productivity with a one-year lag. One can show that in this case expected future inflation is zero in equilibrium, $E_t[\pi_{t+1}] = 0$, and expected future output is equal to expected future productivity, $E_t[y_{t+1}] = E_t[a_{t+1}]$. Then the consumer's Euler equation becomes

$$y_t = E_t[a_{t+1}] - i_t.$$

Now, if the current nominal interest rate i_t is not responsive enough, future productivity has the potential to affect current output through consumer expectations. In particular, with the interest rate rule assumed, one can show that equilibrium output is given by

$$y_t = \frac{\phi\kappa}{1+\phi\kappa}a_t + \frac{1}{1+\phi\kappa}E_t[a_{t+1}] = a_t + \frac{1}{1+\phi\kappa}\varepsilon_t; \tag{11}$$

that is, output is a weighted average between current productivity and future productivity expectations, with weights depending on the policy parameter ϕ. As long as ϕ is finite, anticipated productivity shocks are expansionary.

In a New Keynesian environment, the effect of a news shock—as with any shock—depends on the monetary policy rule. In particular, as ϕ goes to infinity, the equilibrium converges to the equilibrium of a flexible-price economy irrespective of the value of κ. In that case, the central bank adjusts the nominal interest rate so as to mimic the movements in the real rate in the flexible-price benchmark (Equation 9). Moreover, $\phi \to \infty$ is the optimal monetary policy in this environment, as it delivers both zero inflation and a zero output gap. Therefore, the expansionary effect of news shocks is the symptom of a suboptimal policy rule. Extending the model, there are a number of reasons why monetary policy may not be able to mimic the flexible-price benchmark in this type of environment. For example, one could introduce markup shocks, affecting the pricing equation, and assume that the monetary authority can only observe y_t and π_t and not the shocks directly. In this case, the monetary authority would not be able to identify the values of a_t and $E_t a_{t+1}$, which are needed to compute the natural interest rate (Equation 9) and would have to base its actions on its best estimates of these variables. This discussion shows that in models with nominal rigidities, there is a natural connection between models of expectation-driven cycles and the problem of designing monetary policy with imperfect information. This link is even more apparent when we turn to signal-extraction models in the next section. I return to optimal monetary policy in that context.

3.1. Adding Investment

For simplicity, above I omit investment, by fixing the capital stock. But endogenous investment can be easily added to this environment, and the news shock ε_t can then generate a common expansion in consumption, investment, and hours. To be specific, we can take the baseline RBC environment of Section 1, with the only addition of sticky prices à la Calvo, and obtain expansionary news shocks. To understand the mechanics, let me maintain the assumption of a random walk for productivity, with anticipated shocks, as in Equation 10, but focus on a limit case with an extreme form of nominal rigidity, that is, the case in which firms adjust prices infrequently so that $\lambda \to 0$ in the

Phillips curve relation (Equation 7).[5] In this case, the log-linearized model can be solved to obtain the following expressions for consumption, investment, and hours:[6]

$$c_t = \frac{1}{1-\alpha} E_t[a_{t+1}] = \frac{1}{1-\alpha}(a_t + \varepsilon_t), \tag{12}$$

$$i_t = \frac{1}{\delta}\frac{1}{1-\alpha} E_t[a_{t+1}] - \frac{1-\delta}{\delta} k_{t-1}, \tag{13}$$

$$n_t = \frac{1}{1-\alpha}\left[\frac{1}{1-\alpha}\left(\frac{C}{Y} + \frac{1}{\delta}\frac{I}{Y}\right)a_{t+1} - a_t - \left(\alpha + \frac{I}{Y}\frac{1-\delta}{\delta}\right)k_{t-1}\right], \tag{14}$$

where C/Y and I/Y are the consumption-to-output ratio and investment-to-output ratio in the nonstochastic steady state, respectively. It is easy to see that consumption satisfies the Euler equation (Equation 6) (with c_t replacing y_t), as the expected value of productivity in two periods is equal to the expected value of productivity in one period. The expression for investment comes from the forward-looking optimality condition for the capital stock K_t. In particular, consumers choose to accumulate capital up to the point at which the expected future rental rate on capital equals the risk-adjusted real interest rate net of depreciation. A shock to future productivity raises the expected future rental rate. Moreover, our extreme form of price stickiness implies that the real interest rate does not respond. Therefore, the capital stock reaches immediately the level $E_t[a_{t+1}]/(1-\alpha)$—which is its new steady-state level—leading to the expression in Equation 13. Finally, labor supply adjusts mechanically so that output equals the sum of consumption and investment. Basically, this model builds on the partial equilibrium intuitions from which we started in Section 1 and combines them with a passive supply side to obtain news-driven business cycles. In particular, the anticipated shock ε_t leads to a permanent increase in consumption of $[1/(1-\alpha)]\varepsilon_t$; investment on impact has a spike of $[1/\delta(1-\alpha)]\varepsilon_t$, and from the second period on it plateaus at the lower level $[1/(1-\alpha)]\varepsilon_t$; labor supply increases to $\left([C/Y + (1/\delta)I/Y]/(1-\alpha)^2\right)\varepsilon_t$ and then goes back to its stationary level.

3.2. Wage Rigidities

Richer responses can be obtained by combining nominal rigidities with some of the ingredients introduced in Section 2. In particular, Christiano et al. (2010) build on the model with habits and adjustment costs discussed above, adding staggered adjustment à la Calvo (1983) both in prices and in wages, following the approach of Erceg et al. (2000). They show that an estimated DSGE model with these features can generate a large expansion in response to a news shock, with a boom in output, consumption, hours, and investment. The responses are quantitatively much larger—by a factor of three—than in the corresponding flexible-price economy. Moreover, with nominal wage rigidities, the interest rate response is more muted, and asset prices increase in anticipation of a technological improvement. However, as in the simple New Keynesian model described above, this large

[5] As I take the limit for $\lambda \to 0$, I keep all other parameters, including ϕ, fixed.

[6] Given the nonstationary process for a_t, some care has to be taken when log-linearizing to normalize Y_t, C_t, K_t, and I_t and the real wages, dividing them by $\exp\{a_t/(1-\alpha)\}$. The variables N_t, the interest rate, and the rental rate on capital are stationary and do not need to be normalized. For ease of exposition, I present results for the logs of the original variables (not normalized), omitting constant terms.

expansion is a symptom of a suboptimal monetary policy rule. The model dynamics under an optimal monetary policy are very close to the flexible-price benchmark.

It is useful to discuss further the role of wage rigidities, as they have important consequences for the model's predictions about inflation. In the baseline New Keynesian model (with fixed capital stock), the effect of news shocks is tightly linked to inflation. In particular, inflation is given by

$$\pi_t = \frac{\kappa}{1 + \phi\kappa}\varepsilon_t,$$

so news shocks have an expansionary effect if and only if they raise current inflation. However, this link is broken once we add wage rigidities. In particular, if the real wage adjusts sluggishly, Equation 7 suggests that inflation can fall in anticipation of a productivity increase, as firms anticipate low marginal costs. This is precisely what happens in the calibrated model of Christiano et al. (2010). Moreover, in this environment the inflation-targeting behavior of the central bank acts as an amplification mechanism, rather than as a dampener (as it does in the baseline New Keynesian model in which increasing ϕ reduces the impact of demand shocks). This happens because the deflationary effect of an anticipated productivity increase leads the central bank to lower the nominal interest rate exactly at the time at which the natural interest rate is increasing.

The channel from real wage rigidities, to low inflation, to a low nominal rate is not the only channel by which real wage rigidities can amplify the response of the economy to a news shock. Den Haan & Kaltenbrunner (2009) and Den Haan & Lozej (2010) explore expectation-driven cycles in search and matching models of the labor market. In that environment, the crucial question is whether an anticipated increase in productivity can lead to a current increase in the number of posted vacancies and thus to a current increase in employment and real activity. Vacancy creation can be seen as a form of investment; therefore, in this class of models a problem arises that is somewhat similar to problems seen in the basic RBC model. In particular, if we let the social planner choose the socially optimal level of vacancy creation, we can have an increase in vacancy creation in anticipation of a future productivity increase, but not an increase in current consumption, given that the costs of vacancy creation more than offset the current increase in output.[7] This is similar to what happens in a standard RBC model with sufficiently large adjustment costs in capital. Investment can increase in anticipation of higher productivity, but then consumption falls. However, in a search and matching model of the labor market, there is no guarantee that decentralized bargaining over wages is going to yield the efficient allocation that the planner would choose.[8] Den Haan & Kaltenbrunner (2009) look at what happens when they calibrate their model under a form of bargaining that allows for partial real wage rigidities. Under their parameters, the economy is in a situation of chronic undercreation of vacancies. Therefore, when good news about the future arrives, the output gains from increased vacancy creation more than offset the creation costs, and it is possible to have a boom in vacancies, employment, consumption, and output.

[7]The online appendix of Den Haan & Kaltenbrunner (2009) provides the analytical argument behind this discussion, in a simplified version of their model.

[8]This only happens if some version of the so-called Hosios (1990) condition is satisfied.

3.3. Financial Frictions

A branch of the literature has explored the role of credit market frictions in news-driven business cycles. In particular, the idea is that an increase in asset prices, reflecting good news about the future, can help relax borrowing constraints at the firm level. In particular, this can happen if the borrowing constraints take the form of collateral constraints, in which borrowing limits are affected by the market value of the firm's assets. Then the boom dynamics are driven by the relaxation of the borrowing constraints. We can distinguish different channels that can lead to an expansion.

First, the relaxation of borrowing constraints can simply lead to an increase in the demand for investment goods. As seen above, this channel would be at work also in the absence of financial frictions, but it may be stronger in the presence of collateral constraints. Because this channel operates on the demand side, it must be combined with some form of nominal rigidity to explain the passive response on the supply side (see Walentin 2009). Second, the relaxation of borrowing constraints may also impact the supply side. In particular, Kobayashi et al. (2007) consider environments in which financial constraints affect the ability of a firm to hire variable inputs, via a constraint on working capital. This implies that a relaxation of the borrowing constraint leads to an increase in labor demand and thus to an expansion in output. Third, if borrowing constraints are less binding, we can have an efficient reallocation of inputs to the most-productive firms. This is the channel explored in a calibrated model by Jermann & Quadrini (2007), who show that this reallocation effect can generate an increase in current aggregate total factor productivity (TFP), which then produces an expansion through a traditional RBC channel.

4. MULTISECTOR MODELS

Models with many sectors clearly allow more flexibility and so open new channels for the transmission of news shocks. At the same time, multisector models also pose new challenges, as the problem arises whether these models can replicate the high degree of sectoral comovement that characterizes aggregate fluctuations.

Consider the following three-sector specification of technology, proposed by Beaudry & Portier (2004). There is a sector producing consumption goods using intermediates X_t and capital K_{t-1}, with a constant elasticity of substitution technology:

$$C_t = \left(X_t^{\nu} + K_{t-1}^{\nu}\right)^{\frac{1}{\nu}}.$$

Intermediates are produced using only labor with the technology $X_t = e^{a_t}\left(N_{X,t}\right)^{\alpha_X}$, where $N_{X,t}$ is labor employed in the intermediate-goods sector. Also investment is produced using only labor with the technology $I_t = \left(N_{I,t}\right)^{\alpha_K}$, where $N_{I,t}$ is labor employed in the intermediate-goods sector. Capital accumulates following the usual law of motion $K_t = (1-\delta)K_t + I_t$. Total labor supply is given by $N_t = N_{X,t} + N_{I,t}$.

Beaudry & Portier (2004) combine this technology with the standard preferences in Equation 1, assuming linear disutility of labor effort, $\eta = 0$, and estimating the remaining parameters with a method of moments approach. A crucial parameter is the elasticity of substitution in the production of consumption goods. In their estimates, ν is negative, implying a relatively high degree of complementarity between the two inputs. They then show that this model can generate an expansion in anticipation of an increase in a_t. Notice that a_t is an intermediate-specific technology shock that does not affect the production of investment goods. Therefore, the intuition is that when the shock materializes, it does not allow the economy to accumulate capital at a faster rate, as in the baseline RBC model. Agents then need to begin accumulating capital in anticipation of an increase in a_t. Because investment is produced with labor alone, this requires an increase in labor input $N_{I,t}$. On impact, the incentive to produce intermediates and consumption goods is unaffected by the news shock. However, as capital accumulates, the productivity of the tradable input in the consumption-goods sector increases, and the production of both intermediates and consumption goods adjusts upward.

It is useful to recognize the role that relative prices have in this mechanism. The complementarity in the consumption-goods sector implies that the rental price of capital will increase when the shock a_t is realized. Therefore, increased production in the investment-goods sector is driven by this expected increase in the relative price of the capital input in the long run. Alternatively, in the short run, the increased supply of capital, before a_t actually increases, makes capital relatively abundant. Therefore, the increased production in the intermediate-goods sector is driven by the current fall in the relative price of the capital input. The role of relative prices (and of expected relative prices) in generating comovement is a theme I return to when I consider dispersed-information models below.

The assumption of a linear disutility of labor effort is important to produce a generalized expansion in this model. It is that assumption that shuts down any feedback from the increase in labor supply in the investment-goods sector to labor supply in the intermediate-goods sector. With $\eta > 0$, an expansion in the former sector would increase the marginal disutility of labor, leading to a contraction in the production of intermediate goods and consumption on impact. In that case, the shock brings about a reallocation of effort from the intermediate sector to the investment-goods sector. Alternatively, one can think of a representative household with two workers working in the two sectors, and thus of a preference specification of the type

$$\ln C_{X,t} + \ln C_{I,t} - \frac{1}{1+\eta} N_{X,t}^{1+\eta} - \frac{1}{1+\eta} N_{I,t}^{1+\eta}.$$

With this specification, it is possible to obtain a generalized expansion also with positive values of η.

In observed expansions that seem to have an expectation-driven component, there are typically asymmetries, with some sectors growing especially fast (e.g., the U.S. expansion in the late 1990s). Therefore, it seems fruitful to look at these episodes through the lens of a multisector environment. Whether the multisector structure per se is sufficient to generate a realistic degree of comovement is an open quantitative question. A conjecture based on the discussion above is that it may be fruitful to explore multisector models in the context of economies with heterogeneous agents, in which one can trace the responses of workers and consumers in the different sectors to shocks and relative price changes.

5. NEWS AND NOISE

Above I distinguish between shocks that affect current productivity and perfectly anticipated shocks that affect future productivity. This way of representing the agents' information in the model has some drawbacks. In particular, it requires the modeler to specify exactly how many periods in advance information is received about future shocks. Moreover, to describe an anticipated shock that eventually is not realized, one has to look at the combined response of the economy to two shocks: a news shock (ε_t) realized at some time $t-k$, followed, at time t, by a current shock (ξ_t) that exactly offsets the first one.[9] An alternative way of describing how agents receive news about the future is to assume that productivity is driven by the evolution of an unobservable state variable and that agents only receive noisy signals about the state. The presence of noise in the agents' signals then immediately yields shocks that lead agents' expectations to change temporarily and then gradually revert back to their initial level. An additional advantage of this signal-extraction approach is that it extends naturally to environments with dispersed information, which I discuss below.

5.1. Common Information

A simple information structure that allows a fair amount of flexibility is the following. Productivity is the sum of a long-run component x_t and a transitory component z_t,

$$a_t = x_t + z_t, \tag{15}$$

where x_t is stationary in growth rates and follows the process

$$\Delta x_t = \rho_x \Delta x_{t-1} + \epsilon_t, \tag{16}$$

and z_t is stationary in levels and follows the process

$$z_t = \rho_z z_{t-1} + \eta_t, \tag{17}$$

and ϵ_t and η_t are i.i.d. shocks. The agents in the model do not observe the state vector (x_t, z_t) but only observe current productivity a_t and a signal about the long-run component

$$s_t = x_t + v_t,$$

where v_t is an i.i.d. shock.

Lorenzoni (2009) considers the special case in which $\rho_x = \rho_z = 0$ (that is, the long-run component x_t is a random walk and z_t is a purely temporary shock) and uses it to study news-driven demand shocks in a simple New Keynesian environment similar to the one in Section 3. In particular, I focus on the economy's response to the noise shock v_t, which temporarily raises consumer expectations about the long-run level of productivity x_t. Applying the Kalman filter, the consumers' current expectations about x_t, denoted by $x_{t|t}$, follow the law of motion

$$x_{t|t} = \mu x_{t-1|t-1} + (1-\mu)\left[\xi s_t + (1-\xi)a_t\right], \tag{18}$$

where μ and ξ are scalars in $(0, 1)$ that depend on the variances of ε_t, η_t, and v_t. When a noise shock hits, agents' expectations about future productivity $E_t[a_{t+j}]$ increase equally for all $j = 1,2,3, \ldots$. At the same time, current productivity a_t is not affected. Therefore, at time t, a noise shock is similar to the anticipated productivity shock studied in the previous sections. However, as agents accumulate information in the following periods, they realize their mistake, and their productivity expectations revert to the initial value. Formally, equilibrium output is given by

[9]This is the approach followed, for example, by Christiano et al. (2010) to generate a boom-bust episode.

$$y_t = \frac{\phi\kappa}{1+\phi\kappa} a_t + \frac{1}{1+\phi\kappa} E_t[a_{t+1}] = \frac{\phi\kappa}{1+\phi\kappa} a_t + \frac{1}{1+\phi\kappa} x_{t|t}.$$

The expression in the middle is identical to Equation 11 derived above and shows the common structure shared by models with anticipated shocks and signal-extraction models. However, the information structure adopted here yields smoother dynamics of $E_t[a_{t+1}]$ because $E_t[a_{t+1}]$ is equal to $x_{t|t}$ and thus follows Equation 18. In particular, output, employment, and inflation increase on impact following a noise shock and then revert gradually to their initial levels, at a speed given by the parameter μ.

From an empirical point of view, a model with $\rho_x = \rho_z = 0$ is not appealing because in the data the univariate process for a_t—both if interpreted as labor productivity or as TFP—is not too far from a random walk. If $\rho_x = \rho_z = 0$, this implies that the shocks η_t are small, so there is little room for the agents to be confused between permanent and transitory shocks. But then there is little scope for noise shocks, given that agents' expectations converge fast to the truth. In other words, when the variance of η_t is small relative to the variance of ε_t, the coefficients μ and ξ in the Kalman filter (Equation 18) are close to 1 and 0, respectively, leaving little room for the signal s_t to affect the model's dynamics.

Blanchard et al. (2010) consider the specification in Equations 15–17 and show that there is a region of the parameter space for $\rho_x, \rho_z, \sigma_\eta^2$, and σ_ε^2 in which the univariate process for a_t is close to a random walk (actually, there is a one-dimensional set of parameters that yields an exact random walk). Therefore, the specification in Equations 15–17 allows us to build a simple representative-agent New Keynesian model with news and noise that can be confronted with the data, as discussed further in Section 6.

5.2. Dispersed Information

Signal-extraction models of news have been used to explore economies in which heterogeneous agents have different sources of information. Recently, there has been a large literature on macroeconomic models in which agents base their decisions on different information sets due to various types of informational frictions (e.g., Hellwig 2002, Mankiw & Reis 2002, Sims 2003, Woodford 2003, Collard & Dellas 2004, Kawamoto 2004, Moscarini 2004, Milani 2007, Maćkowiak & Wiederholt 2009). Here I focus on the intersection between that literature and the literature on news on productivity as a source of business cycles. Lorenzoni (2009) extends the baseline New Keynesian model discussed above to allow for dispersed information, proposing a decentralized information structure in which agents are better informed about productivity shocks in the sector in which they work. Before discussing that model, it is useful to go over the model in Angeletos & La'O (2010), who consider the same decentralized information structure in the context of a baseline RBC environment without nominal rigidities.

Angeletos & La'O (2010) consider a model with agents working in a continuum of ex ante symmetric sectors. Sectors are hit both by aggregate and by idiosyncratic productivity shocks. In the simplest static version of the model, each sector has a linear technology

$$Y_i = A_i N_i,$$

and $a_i = \log A = a + \varepsilon_i$, where a is an aggregate shock, and ε is an idiosyncratic shock. The representative agent in sector i has preferences represented by the utility function

$$\left(\int_0^1 C_{i,j}^{1-1/\epsilon} dj\right)^{\frac{\epsilon}{\epsilon-1}} - \frac{1}{2}N_i^2,$$

with $\epsilon > 0$.[10] The timing of the model is as follows: Agents in sector i produce output Y_i based solely on their observation of a_i and of a public signal $s = a + v$; then agents from all sectors meet in a centralized Walrasian market and trade their output. The crucial thing is that the relative price of good i will depend on the output produced by all other sectors. Therefore, at the production stage, agents have to forecast the output of other firms to choose their optimal output. After some manipulation, exploiting the normality of the shocks and the preference structure, one obtains the following expression for the output decision of agents in sector i (omitting constant terms for simplicity):

$$y_i = \frac{\epsilon}{\epsilon + 1} 2a_i + \frac{1}{\epsilon + 1} E[y|\, a_i, s]. \tag{19}$$

This expression looks like the best response in a game with strategic complementarity and linear strategies, such as the games analyzed by Morris & Shin (2002). The structure of these games and their welfare properties have been thoroughly analyzed by Angeletos & Pavan (2007). A basic insight about these games is that as agents' actions (output here) are more responsive to the public signal s, the stronger is the degree of strategic complementarity. Here this degree of strategic complementarity is $1/(\epsilon + 1)$ and is determined by the demand elasticity ϵ. When ϵ is lower, there is stronger complementarity between the goods, and the output decisions of the different sectors are more strongly correlated. In this case, the shock v to the common signal has a relatively larger effect on output.

Let us write equilibrium output as

$$y = \psi_a a + \psi_v v.$$

The coefficients ψ_a and ψ_v come from solving Equation 19 together with $y = \int y_i di$. The literature has focused on decomposing the variance of output in the variance due to changes in aggregate productivity a and the variance due to changes in the noise shock v. A stronger degree of complementarity, i.e., a lower value of ϵ, implies that a larger fraction of output fluctuations results from the noise shock v.

In this model, dispersed information only affects decisions on the supply side. However, related mechanisms arise in models in which the demand side plays a more active role. In particular, Lorenzoni (2009) considers a dynamic model in which consumption decisions are driven by expectations about future productivity through the consumer's Euler equation. In that environment, dispersed information plays two main roles. First, that agents can only observe productivity in their own sector adds noise to their current productivity observations. I note above that the empirical process for aggregate labor productivity does not display a large temporary component. However, in a model with dispersed information, we can assume that agents do not observe aggregate productivity in real time and only base their decisions on noisy signals about it. This slows down their learning process relative to a simple representative-agent setup, yielding possibly more realistic responses to news and noise shocks. Second, dispersed information changes the behavior of price setters. This has been known at least since Lucas's (1972) island model. Price setters adjust prices in response to their expectations about movements in future demand for their

[10]In this model, in each sector there are many firms, so there is not monopolistic competition.

products. Dispersed information means that they do not know if demand will increase jointly with their productivity, in which case their relative prices should remain unchanged, or whether it will increase faster, in which case they should try to increase their prices. This uncertainty makes the price response more sluggish, allowing for demand shocks to have a stronger effect on output.

It is interesting to contrast the effect of a positive noise shock in Angeletos & La'O (2010) and in Lorenzoni (2009). In the first environment, after the fact, producers are disappointed because they produced too much. In the second environment, both consumers and producers are disappointed after the fact: consumers because they consumed too much and price setters because they increased their relative price too little. However, the two approaches may have different implications for the role of some parameters. For example, lowering the parameter ϵ, governing the degree of elasticity of substitution across sectors, magnifies the effects of noise shocks in the RBC model, while it reduces strategic complementarity in price setting in a New Keynesian environment, leading to stronger price responses and thus to a more muted effect of noise shocks on output.[11]

In the standard New Keynesian environment, consumers essentially satisfy the permanent income hypothesis. Therefore, there is little role for strategic complementarities on the demand side driven by a reasoning of the following type: If other agents are spending more because of their high productivity expectations, then I expect higher income and I also want to spend more. This type of feedback is present, however, when some form of borrowing constraint is introduced. Guerrieri & Lorenzoni (2009) explore this feedback, studying a model in which the only frictions are a limited ability to borrow and a limited supply of liquid assets (and so without nominal rigidities).

In this review I concentrate on models in which the information structure is given. However, a number of important issues arise when one endogenizes the production of information. There is a growing literature analyzing information production in environments with dispersed information (e.g., Veldkamp 2011 offers an excellent survey of the field). Veldkamp & Wolfers (2007) study a multisector economy in which production decisions in each sector are driven by both sectoral and aggregate signals on productivity. However, they allow some agents to produce better (but not perfect) information both at the sectoral and at the aggregate level and to sell it to the producers of final goods. Because signals about aggregate productivity have a larger market, the equilibrium outcome is that more information is produced on these common shocks. Therefore, the presence of information markets works to increase the degree of sectoral comovement.

Although the focus is on positive issues in this review, models of dispersed information raise important questions about the optimal conduct of monetary and fiscal policy in the presence of noise shocks (e.g., see Angeletos & La'O 2008, Lorenzoni 2010). One point is worth mentioning here. When demand shocks are driven purely by news about the future, a common result is that the optimal monetary policy response is to raise interest rates and neutralize the effects of the shock. Recall that this was the case in the simple New Keynesian model in Section 3. Why does monetary policy not systematically neutralize all demand shocks of this type? A natural answer is to assume that the central bank may lack the information to distinguish a purely noise-driven expansion from an expansion driven by an

[11]Angeletos & La'O (2010) introduce two layers of good differentiation, across sectors and across goods within sectors. With this distinction, there are two parameters playing different roles, depending on the assumptions made on price setting.

actual change in productivity.[12] However, this approach seems much more appealing in the context of a model in which no single agent in the private sector can distinguish the two shocks, that is, in a model with information dispersion.

Overall, it seems that models with dispersed information offer an appealing way to think about news about the future evolution of fundamentals. Existing models have only begun to explore the role of dispersed information in generating sluggish adjustment in prices and quantities and in producing different forms of noise-driven fluctuations. Progress in this direction will clearly benefit from the development of new techniques to study equilibria in which many agents solve signal-extraction problems and in which prices and quantities provide endogenous sources of information. Recent developments in this direction include Rondina & Walker (2009) and Nimark (2010).

6. SOME EMPIRICAL WORK

Empirical work to uncover the role of news and noise in business cycles clearly faces tough problems of identification. The literature has pursued different approaches: SVAR with minimal identifying restrictions; a more structural approach, starting from a fully specified model and estimating it by maximum likelihood or Bayesian methods; and a reduced-form approach to capture the effect of well-identified shocks for which time series are available.

As mentioned in Section 1, Beaudry & Portier (2006) played an important role in sparking attention toward news-driven business cycles. They use time series for stock market prices to elicit the private sector's information about future productivity developments. In particular, they look at a vector autoregressive (VAR) model that includes a measure of TFP and the quarterly S&P 500 index. Using this bivariate VAR, they experiment with two identifying restrictions: First, they impose the restriction that one shock has no long-run effects on TFP and label the orthogonal shock as the news shock; second, they impose the restriction that one shock has zero short-run effect and label that shock as the news shock. As it turns out, the two restrictions lead to similar results. They then look at the effect of the two shocks on standard macroeconomic aggregates, including consumption, investment, and employment. They find that the identified news shock leads to positive conditional comovement among macroeconomic aggregates on impact, that aggregate variables strongly anticipate movements in technology, and that news shocks account for a large fraction of the variance of aggregate variables at business cycle frequencies. Further work by Beaudry & Lucke (2010) and Beaudry et al. (2011) has confirmed these findings. Beaudry et al. (2011) look at non-U.S. international data, and Beaudry & Lucke (2010) consider a richer identification strategy in a five-variable SVAR, allowing for several shocks, including both neutral and investment-specific technology shocks, and monetary and preference shocks, along with their news shock.

Blanchard et al. (2009) show that the use of structural identification assumptions in a VAR setting is sensitive to the informational assumptions made. In particular, if one starts from a signal-extraction model (such as the one presented in Section 5), then no identification assumption can recover the original economic shocks ε_t, η_t, and v_t. The reason for this

[12]Models in which the central bank has limited information have been studied by Svensson & Woodford (2003, 2005) and Aoki (2003), among others. Amato et al. (2002) and Adam (2007) also analyze monetary policy in models with dispersed information.

problem is intuitive. An SVAR identification scheme requires that it be possible to recover the value of the current shocks from past and current values of the observables. This is typically not possible in signal-extraction problems, in which the consumer's problem is precisely to infer what shocks hit the economy. This does not mean that the model is not identified, i.e., that the model parameters cannot be recovered from the data. Actually, the authors show, in a simple specification, how time series on consumption and employment can be used to recover the model parameters by maximum likelihood. Even though ε_t, η_t, and v_t cannot be identified exactly, their variances (and the other model parameters) are. Obviously, with this approach, identification rests much more on the model structure. In particular, in Blanchard et al. (2009), identification relies on the validity of the consumer Euler equation. With this approach, it is then possible to obtain a variance decomposition, which suggests a potentially relevant role of noise shocks for short-run fluctuations. The results in Blanchard et al. (2009) point to the following trade-off: If we limit attention to models in which consumers can perfectly anticipate future shocks, then SVAR can be used; if we want to allow for more general information structures, then identification has to rely more on the model structure.

A recent contribution that takes a fully structural route is Schmitt-Grohé & Uribe (2010). They present a full-blown estimation exercise on a variant of the flexible-price model of Jaimovich & Rebelo (2006), in which agents receive anticipated news about technology and government spending. These anticipations concern shocks that will take place with a four- and with eight-quarter lag, respectively. They find a large fraction (about half) of output volatility at business cycle frequency to be associated with news shocks.

Barsky & Sims (2010) follow the SVAR approach of Beaudry & Portier (2006) but challenge their results using different identification assumptions. Even when restricting attention to models with perfectly anticipated shocks, an SVAR approach faces an important identification problem: If there are more than two variables, there are typically many disturbances that have no effect on TFP in the short run and anticipate future changes in TFP. In other words, there are different linear combinations of past observable variables that are orthogonal to current TFP innovations and help to forecast future TFP. The problem is then which of these should we treat as our news shock? Barsky & Sims (2010) choose their news shock as the shock orthogonal to the current TFP innovation that has the most predictive power in explaining future TFP. That is, they apply a principal-components approach to choose their news shock, choosing the one that maximizes the sum of contributions to the TFP's forecast error variance over a finite horizon. The results of this exercise are in striking contrast with those of Beaudry & Portier (2006). While consumption increases following a news shock, output, investment, and hours fall slightly, in line with the predictions of the standard neoclassical model discussed in Section 1. According to this evidence, the data show no puzzling comovement of consumption, investment, and hours following a news shock. News shocks play an important role in medium-frequency output fluctuations, but the economy's response to them is roughly consistent with a neoclassical benchmark. It is not clear, on theoretical grounds, why the identification approach of Barsky & Sims (2010) is superior to others. In particular, the objective of identification should be to find linear combinations of innovations that are less likely to be affected by other shocks, rather than linear combinations of innovations with the best forecasting properties. Nonetheless, this evidence is provocative, as it shows that different orthogonalizations can lead to quite different results and points to the need for better identification.

Where does one look for well-identified pure news/noise shocks in the data? A small literature has looked at the effect of data revisions as a source of noise in private-sector forecasts. Early releases of economic data are riddled with measurement error that is partially eliminated in later releases. As long as the private sector looks at these data to form expectations, the measurement error in early releases can be treated as a well-identified source of noise. Oh & Waldman (1990) focus on measurement error in early releases of leading economic indicators and show that shocks to this error term have sizeable positive effects on aggregate activity. Rodriguez Mora & Schulstad (2007) show that aggregate consumption responds more to early public announcements regarding aggregate GDP than to actual movements in GDP, as measured by the revised GDP series. Using this identification strategy may produce interesting evidence on the comovement of consumption, investment, and hours following noise shocks.

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LITERATURE CITED

Adam K. 2007. Optimal monetary policy with imperfect common knowledge. *J. Monet. Econ.* 54:267–301

Amato J, Morris S, Shin HS. 2002. Communication and monetary policy. *Oxf. Rev. Econ. Policy* 18:495–503

Angeletos G-M, La'O J. 2008. *Dispersed information over the business cycle: optimal fiscal and monetary policy.* Unpublished manuscript, Mass. Inst. Technol.

Angeletos G-M, La'O J. 2010. Noisy business cycles. In *NBER Macroeconomics Annual 2009*, ed. D Acemoglu, K Rogoff, M Woodford, pp. 319–78. Cambridge, MA: NBER

Angeletos G-M, Pavan A. 2007. Efficient use of information and social value of information. *Econometrica* 75:1103–42

Aoki K. 2003. On the optimal monetary policy response to noisy indicators. *J. Monet. Econ.* 50:501–23

Barro R, King RG. 1984. Time separable preferences and international substitution models of business cycles. *Q. J. Econ.* 99:817–39

Barsky RB, Sims ER. 2010. *Information shocks, animal spirits, and the meaning of innovations in consumer confidence*. Unpublished manuscript, Univ. Michigan

Beaudry P, Dupaigne M, Portier F. 2011. Modeling news-driven international business cycles. *Rev. Econ. Dyn.* 14:72–91

Beaudry P, Lucke B. 2010. Letting different views about business cycles compete. In *NBER Macroeconomics Annual 2009*, ed. D Acemoglu, K Rogoff, M Woodford, pp. 413–55. Cambridge, MA: NBER

Beaudry P, Portier F. 2004. Exploring Pigou's theory of cycles. *J. Monet. Econ.* 51:1183–216

Beaudry P, Portier F. 2006. Stock prices, news and economic fluctutations. *Am. Econ. Rev.* 96:1293–307

Beaudry P, Portier F. 2007. When can changes in expectations cause business cycle fluctuations in neo-classical settings? *J. Econ. Theory* 135:458–77

Benhabib J, Farmer REA. 1999. Indeterminacy and sunspots in macroeconomics. In *Handbook of Macroeconomics*, Vol. 1A, ed. JB Taylor, M Woodford, pp. 387–448. Amsterdam: North-Holland

Blanchard OJ, L'Huillier J-P, Lorenzoni G. 2010. *News, noise, and fluctuations: an empirical exploration*. Unpublished manuscript, Mass. Inst. Technol.

Calvo G. 1983. Staggered prices and in a utility-maximizing framework. *J. Monet. Econ.* 12:383–98

Christiano L, Ilut CL, Motto R, Rostagno M. 2010. *Monetary policy and stock market booms*. NBER Work. Pap. 16402

Cochrane JH. 1994. *Shocks. Carnegie-Rochester Conf. Ser. Public Policy* 41:295–364

Collard F, Dellas H. 2004. *The new Keynesian model with imperfect information and learning*. IDEI-Toulouse Work. Pap. 273

Danthine J-P, Donaldson J, Johnsen T. 1998. Productivity growth, consumer confidence, and the business cycle. *Eur. Econ. Rev.* 42:1113–40

Den Haan W, Kaltenbrunner G. 2009. Anticipated growth and business cycles in matching models. *J. Monet. Econ.* 56:309–27

Den Haan W, Lozej M. 2010. *Pigou cycles in closed and open economies with matching frictions*. Unpublished document, Univ. Amsterdam

Erceg CJ, Henderson DW, Levin AT. 2000. Optimal monetary policy with staggered wage and price contracts. *J. Monet. Econ.* 46:281–313

Galí J. 2008. *Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton, NJ: Princeton Univ. Press

Greenwood J, Hercowitz Z, Huffman GW. 1988. Investment, capacity utilization, and the real business cycle. *Am. Econ. Rev.* 78:402–17

Guerrieri V, Lorenzoni G. 2009. Liquidity and trading dynamics. *Econometrica* 77:1751–90

Hellwig C. 2002. *Public announcements, adjustments delays and the business cycle*. Unpublished manuscript, Univ. Calif., Los Angeles

Hosios AJ. 1990. On the efficiency of matching and related models of search and unemployment. *Rev. Econ. Stud.* 57:279–98

Imbens GW, Rubin DB, Sacerdote BI. 2001. Estimating the effect of unearned income on labor earnings, savings, and consumption: evidence from a survey of lottery players. *Am. Econ. Rev.* 91:778–94

Jaimovich N, Rebelo S. 2009. Can news about the future drive the business cycle? *Am. Econ. Rev.* 99:1097–118

Jermann U, Quadrini V. 2007. Stock market boom and the productivity gains of the 1990s. *J. Monet. Econ.* 54:413–32

Kawamoto T. 2004. Technology shocks and the role of monetary policy in the beauty contest monetarist model. *Discuss. Pap. 2004-E-10*, Bank Jpn.

Kobayashi K, Nakajima T, Inaba M. 2007. Collateral constraint and news-driven cycles. *RIETI Discuss. Pap. Ser. 07-E-013*, Jpn.

Lorenzoni G. 2009. A theory of demand shocks. *Am. Econ. Rev.* 99:2050–84

Lorenzoni G. 2010. Optimal monetary policy with uncertain fundamentals and dispersed information. *Rev. Econ. Stud.* 77:305–38

Lucas RE Jr. 1972. Expectations and the neutrality of money. *J. Econ. Theory* 4(2):103–24

Lucca D. 2007. *Resuscitating time-to-build*. Unpublished manuscript, Fed. Reserve Bank, New York

Maćkowiak B, Wiederholt M. 2009. Optimal sticky prices under rational inattention. *Am. Econ. Rev.* 99:769–803

Mankiw NG, Reis R. 2002. Sticky information versus sticky prices: a proposal to replace the new Keynesian Phillips curve. *Q. J. Econ.* 117:1295–328

Milani F. 2007. Expectations, learning and macroeconomic persistence. *J. Monet. Econ.* 54:2065–82

Morris S, Shin HS. 2002. The social value of public information. *Am. Econ. Rev.* 92:1521–34

Moscarini G. 2004. Limited information capacity as a source of inertia. *J. Econ. Dyn. Control* 28:2003–35

Murphy K, Shleifer A, Vishny R. 1989. Building blocks of market clearing business cycle models. In *NBER Macroeconomics Annual 1989*, ed. O Blanchard, S Fischer, pp. 247–87. Cambridge, MA: NBER

Nimark KP. 2010. *Dynamic higher order expectations*. Unpublished manuscript, CREI, Barcelona

Oh S, Waldman M. 1990. The macroeconomic effects of false announcements. *Q. J. Econ.* 105:1017–34

Rodriguez Mora JV, Schulstad P. 2007. The effect of GNP announcements on fluctuations of GNP growth. *Eur. Econ. Rev.* 51:1922–40

Rondina G, Walker TB. 2009. *Information equilibria in dynamic economies*. Unpublished document, Univ. Calif., San Diego

Schmitt-Grohé S, Uribe M. 2010. *What's news in business cycles*. Unpublished document, Columbia Univ.

Sims CA. 2003. Implications of rational inattention. *J. Monet. Econ.* 50:665–90

Smets F, Wouters R. 2007. Shocks and frictions in US business cycles: a Bayesian DSGE approach. *Am. Econ. Rev.* 97:586–606

Svensson LEO, Woodford M. 2003. Indicator variables for optimal policy. *J. Monet. Econ.* 50:691–720

Svensson LEO, Woodford M. 2005. Indicator variables for optimal policy under asymmetric information. *J. Econ. Dyn. Control* 28(4):661–90

Veldkamp L. 2011. *Information Choice in Macroeconomics and Finance*. Princeton, NJ: Princeton Univ. Press

Veldkamp L, Wolfers J. 2007. Aggregate shocks or aggregate information? Costly information and business cycle comovement. *J. Monet. Econ.* 54:37–55

Walentin K. 2009. *Expectation driven business cycles with limited enforcement*. Sver. Riksbank Work. Pap. 229, Stockholm

Woodford M. 2003. Imperfect common knowledge and the effects of monetary policy. In *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*, ed. P Aghion, R Frydman, J Stiglitz, M Woodford, pp. 25–58. Princeton, NJ: Princeton Univ. Press

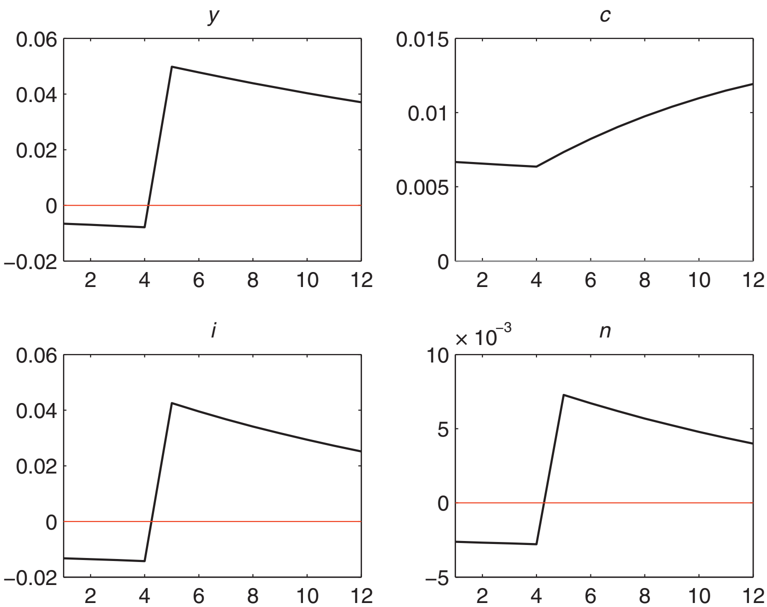

Figure 1

Responses to an anticipated technology shock in a baseline real business cycle model.

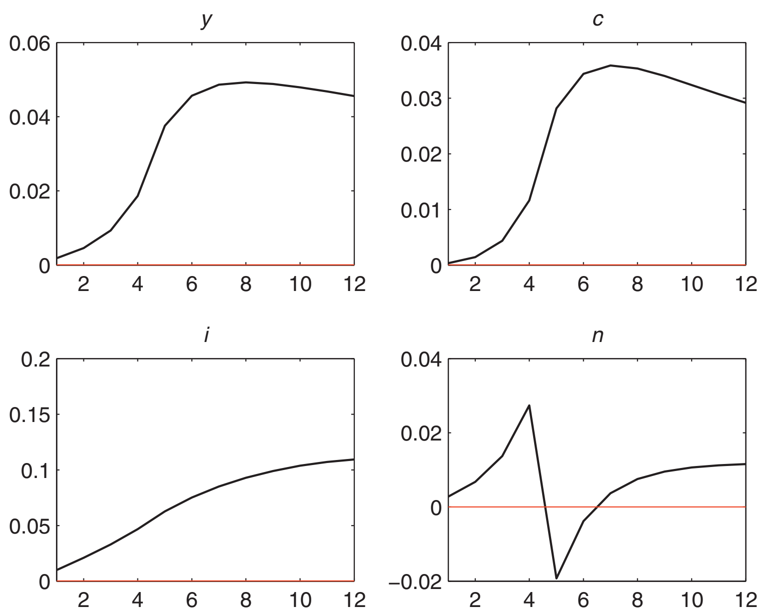

Figure 2

Responses to an anticipated technology shock in a model with habit formation and investment adjustment costs.

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Errata

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