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## Pain of Paying in a Business Cycle Model

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Baptiste Massenot

# Pain of Paying in a Business Cycle Model

SAFE Working Paper No. 194

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# Pain of Paying in a Business Cycle Model

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## Abstract

Motivated by the consumer behavior literature, this paper presents a new business cycle model in which consumers incur a pain of paying and neglect the opportunity costs of consumption. The model has a unique equilibrium and can be easily solved in closed form. Although consumers maximize their utility and have perfect foresight, there is no Euler equation. Several New Keynesian puzzles disappear as a result: negative supply shocks do not stimulate the economy, lower interest rates are not deflationary, and forward guidance is not overly powerful.

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# 1 Introduction

Is lower productivity contractionary? Are lower interest rates inflationary? While most economists would instinctively answer these fundamental macroeconomic questions positively, the state-of-the-art business cycle theory, the New Keynesian model, answers them negatively if certain conditions related to equilibrium selection and monetary policy are met. According to this theory, lower productivity can be expansionary because it decreases the opportunity cost of spending now by increasing future prices. A lower interest rate can be deflationary because it decreases the opportunity costs of spending now by decreasing the return on savings, which may lower consumption growth. In both cases, the justification for these puzzling answers relies on the opportunity costs of consumption.

This paper explores the business cycle implications of relaxing the assumption that consumers consider the opportunity costs of their consumption decisions. The consumer behavior literature offers compelling reasons for such an exploration by reporting evidence consistent with opportunity cost neglect (Thaler, 1980; Knutson et al., 2007; Frederick et al., 2009). Introspection indeed suggests that it may be difficult in practice, if not impossible, to assess the opportunity costs of consumption, as illustrated by the following quote from Richard Thaler:

*“ The cost of going to the game is what you could do with that \$1,000. You should only go to the game if that is the best possible way you could use that money. Is it better than one hundred movies at \$10 each? Better than an upgrade to your shabby wardrobe? Better than saving the money for a rainy day or a sunny weekend? [...] Thinking like that is a right and proper normative theory of consumer choice. It’s what Econs do, and in principle we should all strive to think this way most of the time. Still, anyone who tried to make every decision in this manner would be paralyzed. How can I possibly know which of the nearly infinite ways to use \$1,000 will make me happiest? The problem is too complex for anyone to solve, and it is unrealistic to think that the typical consumer engages in this type of thinking. Few people think*

*in a way that even approximates this type of analysis.”* (Thaler, 2015)

This paper proposes a new business cycle model in which the pain of paying, instead of the opportunity costs, guides consumption decisions (Prelec and Loewenstein, 1998). When consumers think about buying a coffee, for example, they consider the disutility associated with paying for the coffee but they do not consider what they could instead buy with this money. Consumers are more likely to buy the coffee if paying is less painful, perhaps because of preferences, a lower price, or a bigger consumption budget (Thaler, 1985; Morewedge et al., 2007; Soster et al., 2014).

Besides opportunity cost neglect, the model otherwise shares many elements with standard New Keynesian models (Woodford, 2003; Galí, 2015). Consumers maximize their objective function and have perfect foresight. Because the pain of paying depends on the consumption budget, it is related to preferences that depend on money or wealth (Sidrauski, 1967; ?). Finally, a Phillips curve and passive monetary policy close the model.

The resulting model is very simple. The equilibrium is unique and can easily be solved in closed form.

Furthermore, several New Keynesian puzzles disappear. Although consumers maximize their objective function and have perfect foresight, there is no Euler equation. As a result, negative supply shocks are not expansionary (Eggertsson, 2010, 2012; Eggertsson et al., 2014), a lower interest rate is not deflationary (García-Schmidt and Woodford, 2019; Cochrane, 2018), and forward guidance is not overly powerful (Carlstrom et al., 2015; Del Negro et al., 2015; McKay et al., 2016).

The literature has offered alternative solutions to some of these puzzles by relying on inattention (Gabaix, 2019, 2017), limited foresight (García-Schmidt and Woodford, 2019; Woodford, 2019), level-k thinking (Farhi and Werning, 2019), heterogeneous agents (McKay et al., 2016; Hagedorn et al., 2019; Bilbiie, 2019), incomplete information (Wiederholt, 2015; Angeletos and Lian, 2018), the fiscal theory of the price level (Cochrane, 2018), or wealth in the utility function (Michaillat and Saez, 2019), among others. The present paper contributes to this literature by proposing an analytically

simpler model motivated by the consumer behavior literature.

## 2 Consumption

The self-employed representative agent lives for an infinity of periods indexed by  $t$  and is endowed with money  $m_t$ .

Within a period, the agent receives a continuum 1 of consumption opportunities. Each consumption opportunity gives the choice between consuming 1 unit and not consuming. Consuming yields utility  $u$  while not consuming yields utility 0.

The pain of paying the price  $p_t$  is measured by  $\Lambda(w_t)p_t$ , where  $w_t \geq 0$  is the intertemporal consumption budget. I assume that the pain of paying is decreasing and convex in the budget, that is,  $\Lambda' < 0$  and  $\Lambda'' > 0$ . Intuitively, richer agents have a lower pain of paying because their budget decreases relatively less when they buy something. Furthermore, the pain of paying of poorer agents is more sensitive to changes in the budget. This assumption is related to utility functions that are increasing and concave in money or wealth (Sidrauski, 1967; Michaillat and Saez, 2019) and is consistent with studies of consumer behavior that document a negative relationship between the pain of paying and the budget (Morewedge et al., 2007; Soster et al., 2014).

The consumption budget  $w_t$  is equal to the sum of money holdings  $m_t$ , all future income from self-employed production  $p_\tau y_\tau$  minus consumption spending  $p_\tau c_\tau$ :

$$w_t = m_t + \sum_{\tau=t}^{\infty} \delta_{\tau-t} [p_\tau (y_\tau - c_\tau)],$$

where  $0 \leq \delta_{\tau-t} \leq 1$  is a myopia parameter that depends on the horizon  $\tau - t$ .

Consumers thus set a single consumption budget and have perfect foresight. In practice, consumers may set budgets for different categories such as food, entertainment, or gas (Thaler, 1985; Heath and Soll, 1996; Hastings and Shapiro, 2013). Assuming a single budget, however, is natural in a setup with a representative good. Furthermore, consumers are unlikely to consider all future income and spending before every purchase. I capture this possibility parsimoniously by introducing a myopia parameter that discounts

future income and spending flows. Note that the budget will reduce to the simple form  $w_t = m_t$  in equilibrium because, with a representative agent, overall spending and income will be equal in all future periods. This implies that, in equilibrium, the model with perfect foresight corresponds to a model with perfect myopia. This implication, however, may not hold in richer models, for example, with heterogeneous agents.

We can now study the consumption decision. The overall value attached to consuming is  $u - \Lambda_t p_t$  while the value attached to not consuming is 0. Consumers choose the option that yields the highest value. They decide to consume if  $u - \Lambda_t p_t > \epsilon_t$ , where  $\epsilon_t$  is an i.i.d. random variable with mean 0 drawn from the cumulative distribution function  $F$ . As a result, consumption decisions are stochastic.<sup>1</sup> The probability of consumption is  $F(u - \Lambda_t p_t)$ . To simplify the analysis and to obtain closed-form solutions, I assume that  $F$  is uniform with support  $[-a, a]$ , where  $a$  is sufficiently large to ensure an interior solution.

Since there is a continuum 1 of consumption opportunities in a period, the total consumption  $c_t$  in a period is equal to the probability of consumption

$$c_t = \mu - \lambda_t p_t,$$

where  $\mu = (u - a)/2a$  and  $\lambda_t = \Lambda_t/2a$ .

Consumption decreases with prices and with the pain of paying. Furthermore, a bigger budget increases consumption because it decreases the pain of paying ( $\lambda'_t < 0$ ). The more responsive the pain of paying is to changes in the budget (a lower  $\lambda'_t$ ), the more agents increase their consumption. The model can thus predict a high marginal propensity to consume (MPC) even though consumers so far do not suffer from liquidity problems, which is in line with the empirical evidence (Jappelli and Pistaferri, 2014; Fagereng et al., 2018; Fuster et al., 2018). By contrast, the strong smoothing motive in standard models forces the consumption response to stay close to 0.

A bigger budget could result from a change in future income  $y_\tau$ , with  $\tau > t$ . More

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<sup>1</sup>Stochastic choice can also be found in applied microeconomics (McFadden, 1973), game theory (McKelvey and Palfrey, 1995), risky choice (Hey and Orme, 1994), neuroeconomics (Fehr and Rangel, 2011), etc.

myopic consumers (a smaller  $\delta$ ) would respond less to these shocks. Several empirical studies find small anticipatory effects of expected future income shocks on consumer spending (Olafsson and Pagel, 2018; Kueng, 2018; Ganong and Noel, 2019), which would be consistent with  $\delta < 1$ .

Consumption is a concave function of the budget since  $d^2c_t/dw_t^2 = -p_t\lambda_t'' < 0$  (where  $\lambda'' > 0$  by assumption). As a result, the bigger the budget, the smaller the consumption response to a change in the budget. Intuitively, the consumption of richer agents is less sensitive to changes in their budget. Relatedly, a decline in the budget will trigger a stronger consumption response than an increase. These predictions are broadly consistent with the empirical evidence. The studies cited above generally report a lower MPC for richer consumers and other studies report a stronger response for income declines than for income increases (Christelis et al., 2017; Bunn et al., 2018; Fuster et al., 2018).

Future prices have an ambiguous effect on the budget and thus on consumption. The effect of future prices is positive if agents are savers ( $y_\tau > c_\tau$ ) and negative otherwise ( $y_\tau < c_\tau$ ). Future prices only affect consumption through the income effect and, unlike standard models, not through the intertemporal substitution effect. This ambiguous prediction reflects the empirical evidence, which reports inconsistent correlations between expected inflation and consumer spending (Burke and Ozdagli, 2013; Bachmann et al., 2015; Crump et al., 2015; Ichiue and Nishiguchi, 2015; D'Acunto et al., 2018).

To summarize, this model shares many properties with standard models but there are also a few differences. There is no Euler equation and no intertemporal substitution effect. Finally, a distinct prediction is the potentially high MPC for liquid consumers.

### 3 Credit

To study the role of interest rates (and monetary policy) in this model, I now introduce a simple borrowing motive. The supply of credit is provided in a competitive frictionless credit market by consumers, who then earn the interest rate  $i_t$  on the amount lent.

For each consumption opportunity, consumers want to use credit with probability  $\gamma$ .



The reasons for using credit are left unspecified and may arise, for example, because of insufficient cash (perhaps due to a timing mismatch between income and spending) or a preference for keeping a cash buffer. The consumer then borrows  $b_t = p_t$  at the interest rate  $i_t$ . To keep things simple, I assume that consumers pay back all their debt at the end of the period and never default.

The budget of consumers now depends on present and future interest payments ( $b < 0$ ) or returns ( $b > 0$ ):

$$w_t = m_t + \sum_{\tau=t}^{\infty} \delta_{\tau-t} [p_{\tau}(y_{\tau} - c_{\tau}) + i_{\tau}b_{\tau}].$$

For each consumption opportunity, the consumer then has to pay the price  $p_t$  with probability  $1 - \gamma$  and  $p_t(1 + i_t)$  with probability  $\gamma$ . The following equation gives the resulting overall consumption in a period and will be referred to as the Demand function in the rest of the paper:

$$c_t = \mu - \lambda_t p_t (1 + \gamma i_t). \quad (\text{Demand})$$

A higher interest rate  $i_t$  decreases consumption because it increases the cost of borrowing. Consumption also decreases with illiquidity  $\gamma$ . Consistent with this prediction, the empirical studies cited above report that more illiquid consumers have a higher MPC.

Changes in future interest rates also have an ambiguous effect on the budget and on consumption. Higher future interest rates increase consumption if agents are lenders ( $b_t > 0$ ) and decreases it if they are borrowers ( $b_t < 0$ ). Like future prices, future interest rates only affect consumption through the income effect and not through the intertemporal substitution effect.

## 4 Equilibrium

The economy starts from an initial price  $p_0$  and money  $m_0$ . Monetary policy is passive, that is, the nominal interest rate is pegged to  $i_t$ . In each period  $t \geq 1$ , the equilibrium price  $p_t$  and output  $y_t$  satisfy market clearing ( $y_t = c_t$ ), the Demand equation, and the Phillips equation

$$\pi_t = \kappa x_t, \quad (\text{Phillips})$$

where  $\pi_t = p_t - p_{t-1}$  is inflation,  $\kappa$  is a parameter that depends on the degree of price rigidity, and  $x_t = y_t - \bar{y}_t$  is the output gap, with  $\bar{y}_t$  the natural level of output that would prevail under flexible prices.

This Phillips equation captures the supply side of the economy and introduces a trade-off between inflation and output in the short run. To simplify the analysis, it does not have an expected inflation term, unlike standard New Keynesian models. The Appendix shows that the properties of the model are qualitatively similar, whether one uses this simple Phillips curve or the more standard one with expected inflation.

Market clearing in all periods implies that the budget of the consumer is simply equal to money, that is,  $w_t = m_t$ . This implies that, in equilibrium, the pain of paying only depends on current money holdings and does not depend on the future.

Furthermore, money holdings  $m_t$  are equal to past money holdings  $m_{t-1}$  plus self-employed income  $p_t y_t$  minus consumer spending  $p_t c_t$  plus returns on bonds for lenders or interest payments on bonds for borrowers  $i_t b_t$ :

$$m_{t+1} = m_t + p_t(y_t - c_t) + i_t b_t.$$

In the absence of changes to the money supply, the money held by consumers remains constant  $m_t = m_0$  because market clearing implies that the representative consumer earns as much as he spends in every period. This also implies that  $\lambda_t$  is a constant and will thus be denoted by  $\lambda$ .

Using market clearing and the Demand equation, we can replace  $y_t$  in the Phillips equation. This yields the equilibrium price:

$$p_t = \frac{p_{t-1} + \kappa(\mu - \bar{y}_t)}{1 + \kappa\lambda(1 + \gamma i_t)}. \quad (1)$$

Replacing this equilibrium price in the Phillips equation yields the equilibrium production:

$$y_t = \frac{p_t - p_{t-1}}{\kappa} + \bar{y}_t = \frac{\mu + \lambda(1 + \gamma i_t)(\kappa \bar{y}_t - p_{t-1})}{1 + \kappa\lambda(1 + \gamma i_t)}. \quad (2)$$

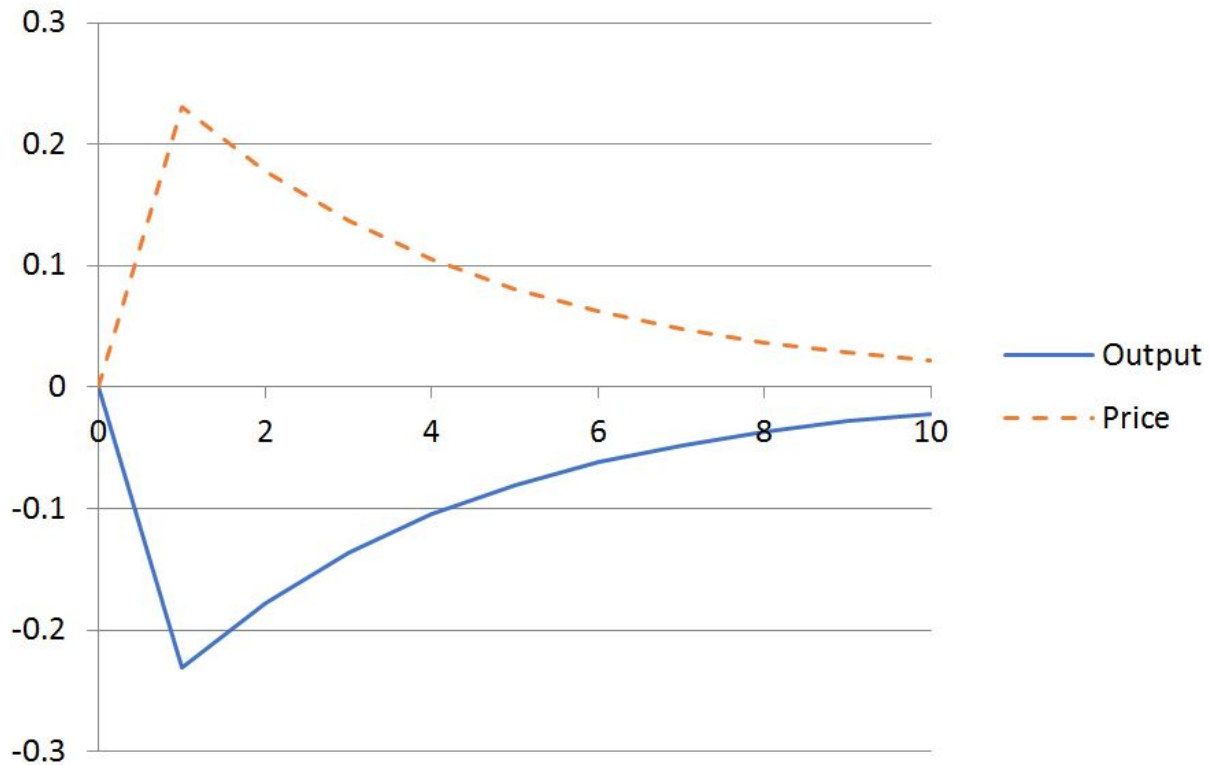


Figure 1: Effect of lower supply on output and price (in percent deviation from steady state). The parameter values are  $\bar{y}_t = 1, t \neq 1, \bar{y}_1 = 0.99, p_0 = 1, i_t = 0, \kappa = 0.3, u = 2.5, \lambda = 1, \gamma = 0.5, a = 0.5$ .

**Supply Shock** The equilibrium conditions show that a negative supply shock, implemented by a lower level of natural output, decreases output and increases prices. To illustrate the dynamic properties of the model, I simulate the effect of a drop in the natural output  $\bar{y}_t$ . In period  $t = 1$ , the natural output drops by one percent and then comes back to its initial value. Figure 1 shows the response of output and prices (expressed in percent deviations from steady-state). The negative supply shock depresses output and increases prices. Both output and prices slowly return to their initial values. Less price rigidity (a higher  $\kappa$ ) amplifies the price response and thus dampens the output response.

**Monetary Policy** The equilibrium conditions also show that a negative demand shock, implemented by a higher interest rate, decreases both prices and output. To illustrate the dynamic properties of the model, I simulate the effect of a higher interest rate  $i_t$ . In period  $t = 1$ , the interest rate increases by one percent and then comes back to its initial value. Figure 2 shows the response of output and prices (expressed in percent deviations

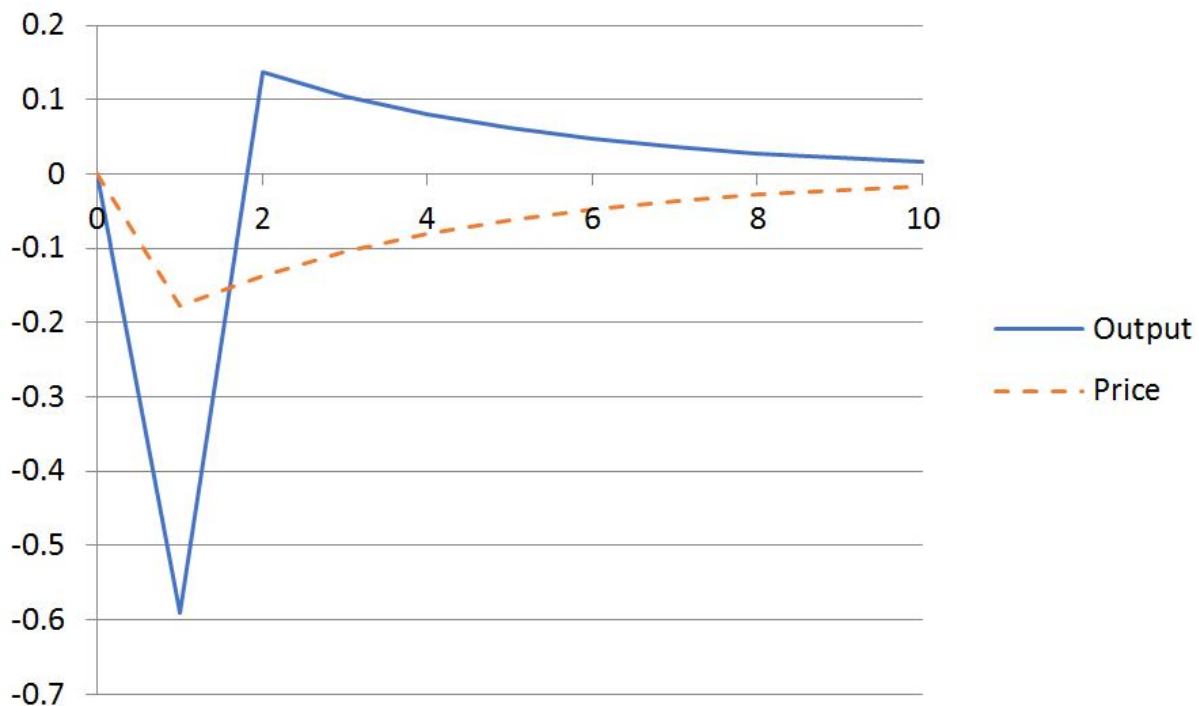


Figure 2: Effect of a higher interest rate on output and price (in percent deviation from steady state). The parameter values are  $i_t = 0, t \neq 1$ ,  $i_1 = 0.01$ ,  $p_0 = 1$ ,  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ .

from steady-state). The higher interest rate depresses both output and prices. This response can be explained by the lower demand of consumers when they face a higher interest rate. Prices gradually return to their initial value. Output first declines but then increases above its initial value because the interest rate is now back to its initial value (which increases demand) but prices did not have time to return to their initial value (which further increases demand). The response of the economy to an interest rate shock more generally captures the response to different demand shocks

**Government Spending** Finally, I study the effect of government spending  $g_t$ . To balance its budget, the government levies lump-sum taxes  $T_t = p_t g_t$ . The budget of consumers is unaffected by these taxes since they also get an increase in income equal to the government spending. The equilibrium is still characterized by the Demand and Phillips equations but the market-clearing condition becomes  $y_t = c_t + g_t$ . The equilibrium

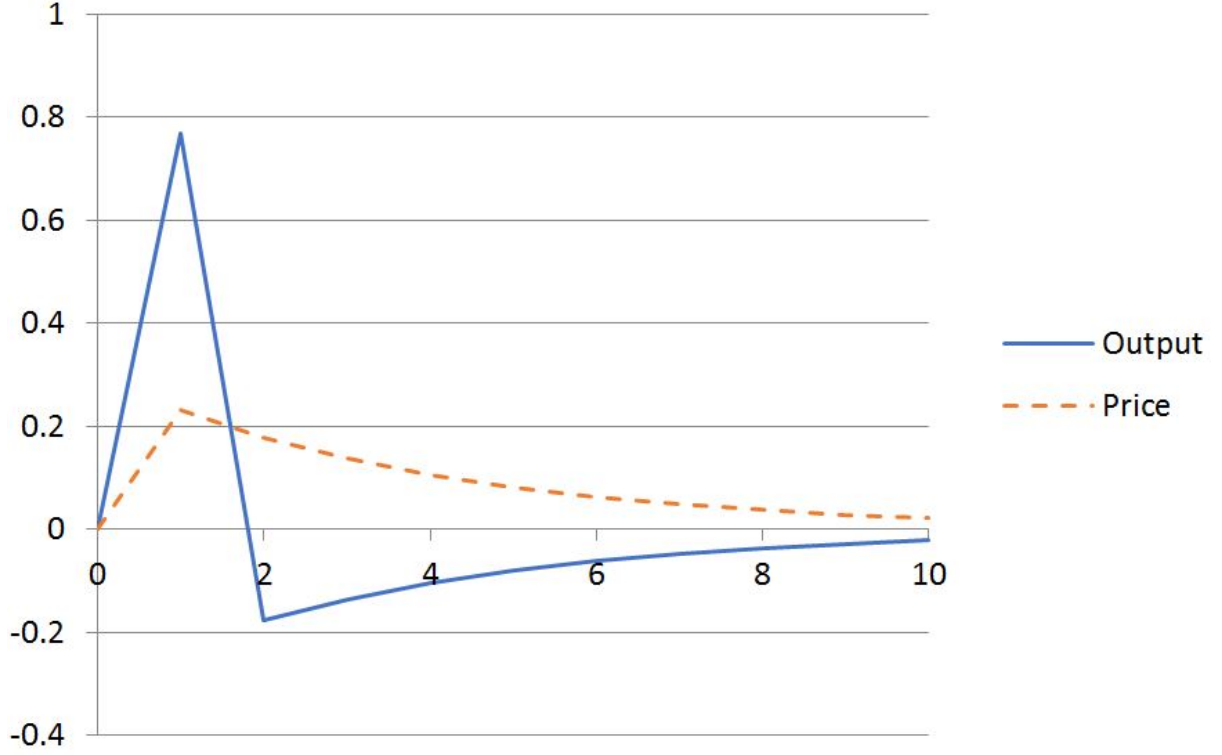


Figure 3: Effect of higher government spending . The parameter values are  $g_t = 0, t \neq 1$ ,  $g_1 = 0.01$ ,  $p_0 = 1$ ,  $i_t = 0$ ,  $\kappa = 1$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ .

prices and output become:

$$p_t = \frac{p_{t-1} + \kappa(\mu + g_t - \bar{y}_t)}{1 + \kappa\lambda(1 + \gamma i_t)}. \quad (3)$$

$$y_t = \frac{p_t - p_{t-1}}{\kappa} + \bar{y}_t = \frac{\mu + g_t + \lambda(1 + \gamma i_t)(\kappa \bar{y}_t - p_{t-1})}{1 + \kappa\lambda(1 + \gamma i_t)}. \quad (4)$$

Higher government spending increases equilibrium prices and output. To illustrate the dynamic effects, consider a government spending increase of one percent of output in period 1 only. Figure 3 shows the response of output and prices. Both prices and output increase. Prices gradually return to their initial value and output first decreases below its initial value before returning to its initial value. Output undershoots because prices take time to come back to their initial value. Overall, the effects of higher government spending represent those of a standard demand shock.

## 5 Comparison with New Keynesian Models

This section compares the business cycle implications of the pain-of-paying model to a standard New Keynesian model. Both models are characterized by the same Phillips equation as above. The New Keynesian model is also characterized by the Euler equation:

$$c_t = E_t c_{t+1} - \sigma(i_t - E_t \pi_{t+1} - \rho), \quad (\text{Euler})$$

where  $\sigma$  is the intertemporal elasticity of substitution and  $\rho$  is the discount rate. This equation implies that a higher real interest rate  $i_t - E_t \pi_{t+1}$  increases the opportunity costs of consumption and hence makes consumers postpone their consumption.

I replicate three prominent New Keynesian puzzles and then shows how replacing the Euler equation by the Demand equation, keeping the Phillips equation the same in the two models, eliminates these puzzles.

Note that there is a subtle difference between the two models. The equations of the New Keynesian models are log-linearized, which implies that prices and output are expressed as the logarithm of their original value. By contrast, the Demand equation is already linear, so prices and output are equal to their original value. Although the Phillips equation is the same in both models, it uses the original values for price and output in the pain-of-paying model but it uses logarithmic values in the New Keynesian model. I will focus on comparing qualitative predictions of these two models, so this subtle difference is of secondary importance.

### 5.1 Are Negative Supply Shocks Expansionary?

I first study the effect of an unexpected negative supply shock on the equilibrium. I follow the experiment in Wieland (2019). The natural output decreases by 1 percent for four periods and then returns to its initial value ( $\bar{y}_t = 1, t = 0, 5, 6, \dots$  and  $\bar{y}_t = .99, t = 1, 2, 3, 4$ ). Figure 4 shows how production responds in the pain-of-paying and New Keynesian models.

In the pain-of-paying model, output gradually decreases until period 4 and then re-

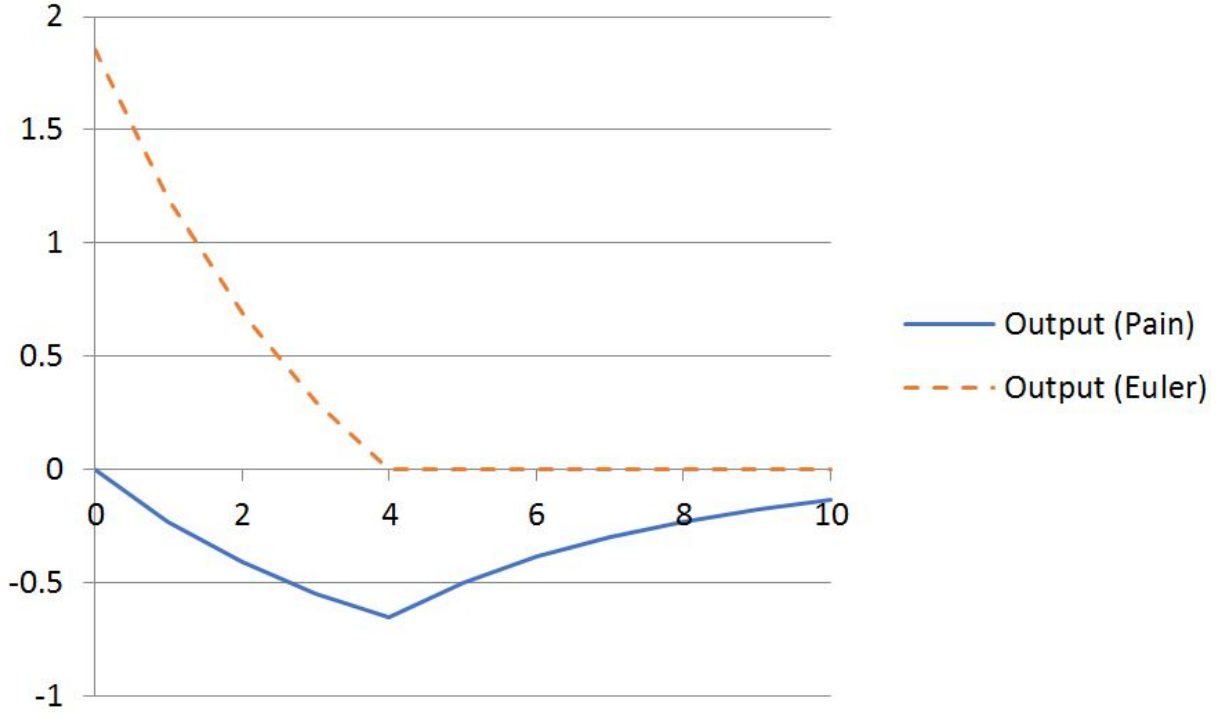


Figure 4: Effect of lower supply on output (in percent deviation from steady state). The parameter values are  $\bar{y}_t = 1, t = 0, 5, 6, \dots$ ,  $\bar{y}_t = .99, t = 1, 2, 3, 4$ ,  $p_0 = 1$  (in the pain of paying model),  $i_t = 0$ ,  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ ,  $\sigma = 1$ ,  $\rho = 0$ .

covers to its initial value. This response is similar to the one already presented in Figure 1, but more persistent because the shock lasts longer.

In the New Keynesian model, by contrast, the same negative shock is expansionary (Eggertsson, 2010, 2012; Eggertsson et al., 2014). As already shown in these references, this result obtains if the interest rate is exogenous and if inflation is assumed to be zero once the shock ends ( $\pi_t = 0, t \geq 5$ ). As a result, the output gap is also zero and production is equal to its natural level ( $y_t = \bar{y}_t, t \geq 5$ ). Using these values, the Euler equation yields the output level  $y_4 = y_5 - \sigma(i - \pi_5 - \rho) = 1$  if  $\sigma = 1$ ,  $i = 0$ , and  $\rho = 0$ . We can then solve for inflation in period 4 using the Phillips equation  $\pi_4 = \kappa(y_4 - \bar{y}_4) = 0.003$  if  $\kappa = 0.3$  and  $\bar{y}_4 = 0.99$ . Further solving backward yields the curve displayed in Figure 4.

What explains the different responses of the two models? Consumers in the New Keynesian increase their current spending because they anticipate higher future prices. Consumers in the pain-of-paying model also anticipate that prices will be higher but do not increase their spending because their budget is not affected in equilibrium and because

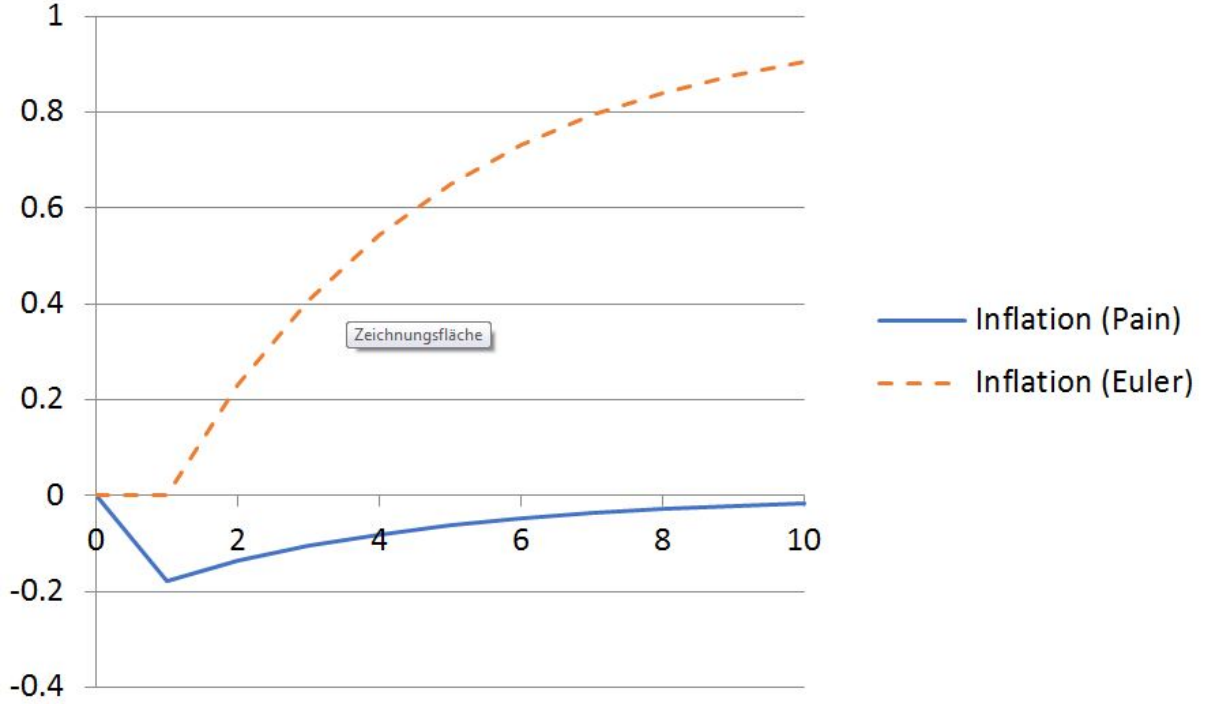


Figure 5: Effect of a permanent nominal interest rate shock on inflation (in percent). The parameter values are  $i_t = 0, t \leq 0$ ,  $i_t = 0.01, t \geq 1$ ,  $p_0 = 1$  (in the pain of paying model),  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ ,  $\sigma = 1$ ,  $\rho = 0$ .

they do not consider the opportunity costs of consumption. Thus, negative supply shocks are contractionary.

The empirical evidence documents that, at the zero lower bound, negative supply shocks are contractionary and hence favors the pain-of-paying model. Cohen-Setton et al. (2017) show that mandatory wage increases and hours restrictions depressed the French economy in the 1930s, a period of relatively stable nominal interest rates. Wieland (2019) shows that both the 2011 earthquake and oil price shocks during episodes of zero interest rates contracted the Japanese economy.

## 5.2 Are Lower Interest Rates Deflationary?

Next, I study how inflation responds to a higher nominal interest rate. I follow the experiment in Cochrane (2018). The nominal interest rate permanently increases from 0 to 1 percent. Figure 5 shows how inflation responds in the pain-of-paying and New Keynesian models.



In the pain-of-paying model, inflation becomes negative and then gradually returns to zero. A higher nominal interest rate in the pain of paying model depresses demand. This decreases production as well as inflation. Once prices have reached their new steady-state and output has returned to its natural level, inflation is equal to zero.

In the New Keynesian model, by contrast, inflation becomes positive, a property referred to as the Neo-Fisher effect (García-Schmidt and Woodford, 2019; Cochrane, 2018). To find this curve, rewrite the Phillips equation as  $y_t = \bar{y}_t + \pi_t/\kappa$ . Assuming  $\bar{y}_t = \bar{y}_{t+1}$  and replacing inflation in the Euler equation yields  $\pi_t = \pi_{t+1} - \sigma\kappa(i_t - \pi_{t+1} - \rho)$  or  $\pi_{t+1} = (1 + \sigma\kappa)^{-1}(\pi_t + \sigma\kappa(i_t + \rho))$ . Figure 5 simulates this dynamic equation using  $\sigma = 1$ ,  $\rho = 0$ , and  $\kappa = 0.3$ .

What explains the different response of the two models? The main difference is the presence or not of a natural rate of interest. In the pain-of-paying model, the real interest rate is free to fluctuate and is not constrained by technological forces, as in New Keynesian models. In New Keynesian models, by contrast, there is a natural real rate of interest that is independent of nominal variables. In the specific example considered here, natural real rate of interest is 0%. With an initial nominal interest rate of 0, the inflation rate compatible with the zero natural real interest rate was also zero. Once the nominal interest rate increases to 1%, the inflation rate has to be equal to 1% to reach the natural real interest rate.

In general, central bankers think of higher interest rates as being deflationary, which is consistent with the pain-of-paying model. While the neo-fisher effect puzzles many economists, it has recently received empirical support (Uribe, 2018). Further work is needed to determine whether the neo-fisher effect is desirable in business cycle models.

### 5.3 How Powerful is Forward Guidance?

Next, I study how output responds to forward guidance. I follow the experiment conducted in McKay et al. (2016). In period 0, the central bank announces that it will increase the interest rate by 1 percent in period 5 only. I then study how output responds to this announcement.

Comparing forward guidance in the two models raises one difficulty. Consumers consider the nominal interest rate in the pain-of-paying (and compare it to their budget, which is also a nominal variable) while they consider the real interest rate in the New Keynesian model. I follow McKay et al. (2016), who provide a simple and authoritative illustration of the forward guidance puzzle, and consider a shock to the real interest rate in the New Keynesian model. However, considering the exact same shock in the pain-of-paying model would be uninteresting because consumers consider the nominal interest rate, and the path of nominal interest rates consistent with this experiment would not look like forward guidance to those consumers. The nominal interest rate indeed increases immediately to a potentially very high value. I thus consider a shock to the future value of the nominal interest rate in the pain-of-paying model, an experiment that may not produce the forward guidance puzzle in the New Keynesian model. While the two experiments are not identical, they capture the essence of forward guidance according to each model of consumer behavior. Figure 6 shows how production responds to these shocks in the pain-of-paying and New Keynesian models.

In the pain-of-paying model, output does not respond to forward guidance at the time of the announcement. Output only decreases in period 5, that is, when the interest rate actually decreases. In period 6, the nominal interest rate is back to its initial value and output increases above its initial value. This is because the lower interest rate in period 5 has decreased prices and, because of nominal rigidity, prices are lower than their initial value, which stimulates demand and output.

In the New Keynesian model, by contrast, output responds strongly and immediately to forward guidance, as already shown by Carlstrom et al. (2015); Del Negro et al. (2015); McKay et al. (2016). Output decreases by 1 percent and stays at this level until period 5. Once the real interest rate recovers, output returns to its steady-state value. This response is driven by the Euler equation. A 1 percent real interest in period 5 implies that consumption should decrease by 1 percent. Since the real interest rate is 0 in all previous periods, this implies that consumption growth is also zero and that consumption is stuck at its lower level.

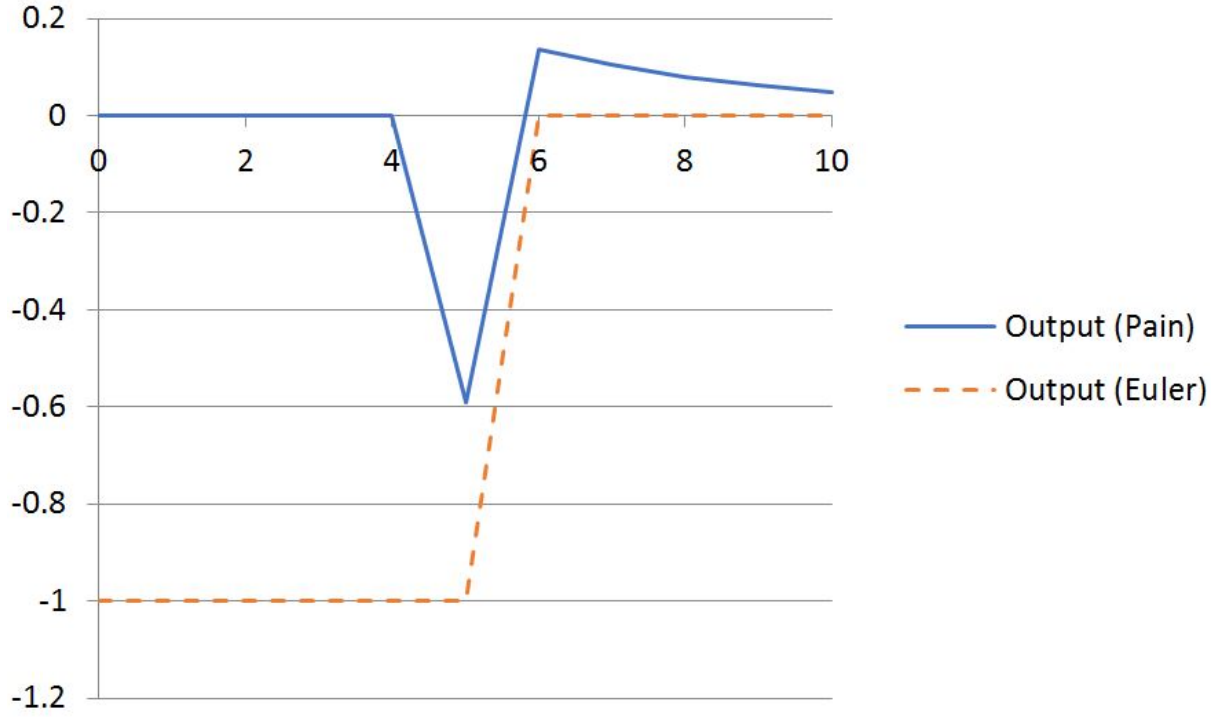


Figure 6: Effect of a future interest rate increase on output (in percent deviation from steady state). In the pain-of-paying model, the shock hits the nominal interest rate, with  $i_t = 0, t \neq 5$  and  $i_5 = 0.01$ . In the New Keynesian model, the shock hits the real interest rate  $r_t = i_t - \pi_{t+1}$ , with  $r_t = 0, t \neq 5$  and  $r_5 = 0.01$ . The parameter values are  $p_0 = 1$  (in the pain of paying model),  $\bar{y}_t = 1$ ,  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ ,  $\sigma = 1$ ,  $\rho = 0$ .

In contrast to the New Keynesian model, consumers in the pain of paying model also anticipate the future change in the interest rate. But since forward guidance does not affect their current budget (they lend as much as they borrow), it does not change their consumption either. Consumers only respond to a change in the contemporaneous interest rate because it changes their cost of borrowing. Forward guidance may, however, have real consequences in a richer version of the pain-of-paying model featuring, for example, both short-term and long-term interest rates. To the extent that forward guidance affects long-term interest rates, consumption could respond to forward guidance if consumers borrow long-term.

## 6 Conclusion

This paper presents a new business cycle model in which consumers incur a pain of paying and neglect the opportunity costs of consumption. This approach yields a tractable model and addresses several puzzles of standard business cycle models.

This paper presents a highly stylized model to preserve clarity. Future work may build a more quantitative version of this model. Furthermore, this paper only focuses on the case of an infinitely-lived representative agent. Future research may extend this approach to richer macro models, for example, with explicit life cycles or idiosyncratic income shocks.

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# Appendix

## A Pain-of-Paying Model with Forward-Looking Phillips Equation

This section shows how to find the solutions for equilibrium prices and output in the pain-of-paying model with a forward-looking Phillips equation:

$$\pi_t = E_t \pi_{t+1} + \kappa x_t. \quad (5)$$

The solution method uses the lag operator technique presented in Cochrane (2018). Write the Dynamic Phillips equation in price level

$$p_t - p_{t-1} = p_{t+1} - p_t + \kappa(y_t - \bar{y}_t)$$

Use the linear approximation of the Demand equation in  $i_t$  and  $p_t$

$$y_t = \mu - \lambda(p_t + \gamma i_t)$$

Replace in the Dynamic Phillips equation

$$p_t - p_{t-1} = p_{t+1} - p_t + \kappa(\mu - \lambda(p_t + \gamma i_t) - \bar{y}_t)$$

Using the lag operator  $L$ , replace  $p_t = Lp_{t-1}$  and isolate  $p_t$

$$(2 + \kappa\lambda - L^{-1} - L)p_t = \kappa(\mu - \lambda\gamma i_t - \bar{y}_t)$$

Multiply the left-hand side by  $L^{-1}L$

$$((2 + \kappa\lambda)L - 1 - L^2)L^{-1}p_t = \kappa(\mu - \lambda\gamma i_t - \bar{y}_t)$$



Find the roots  $R_1$  and  $R_2$  of the second-degree polynomial on the left-hand side

$$R_1 = \frac{2 + \kappa\lambda + \sqrt{(2 + \kappa\lambda)^2 - 4}}{2} > 1$$

$$R_2 = \frac{2 + \kappa\lambda - \sqrt{(2 + \kappa\lambda)^2 - 4}}{2} < 1$$

Use the roots to rewrite the second-order polynomial

$$(R_1L - 1)(1 - R_2L)L^{-1}p_t = \kappa(\mu - \lambda\gamma i_t - \bar{y}_t)$$

Multiply the left-hand side by  $R_1^{-1}R_1$

$$(1 - R_1^{-1}L^{-1})(1 - R_2L)R_1p_t = \kappa(\mu - \lambda\gamma i_t - \bar{y}_t)$$

Isolate  $p_t$

$$p_t = \frac{\kappa(\mu - \lambda\gamma i_t - \bar{y}_t)}{R_1(1 - R_1^{-1}L^{-1})(1 - R_2L)}$$

Use a partial-fraction decomposition

$$p_t = \frac{\kappa(\mu - \lambda\gamma i_t - \bar{y}_t)}{R_1 - R_2} \left( 1 + \frac{R_1^{-1}L^{-1}}{1 - R_1^{-1}L^{-1}} + \frac{R_2L}{1 - R_2L} \right)$$

or in sum notation

$$p_t = \frac{\kappa}{R_1 - R_2} \left( \mu - \lambda\gamma i_t - \bar{y}_t + \sum_{j=1}^{\infty} R_1^{-j}L^{-j}(\mu - \lambda\gamma i_t - \bar{y}_t) + \sum_{j=1}^{\infty} R_2^jL^j(\mu - \lambda\gamma i_t - \bar{y}_t) \right).$$

Replacing the lag operator yields the equilibrium price

$$p_t = \frac{\kappa}{R_1 - R_2} \left( \mu - \lambda\gamma i_t - \bar{y}_t + \sum_{j=1}^{\infty} R_1^{-j}(\mu - \lambda\gamma i_{t-j} - \bar{y}_{t-j}) + \sum_{j=1}^{\infty} R_2^jL^j(\mu - \lambda\gamma i_{t+j} - \bar{y}_{t+j}) \right).$$

To find the equilibrium output, replace the equilibrium price in the Demand equation

$$y_t = \mu - \lambda\gamma i_t - \frac{\lambda\kappa}{R_1 - R_2} \left( \mu - \lambda\gamma i_t - \bar{y}_t + \sum_{j=1}^{\infty} R_1^{-j}(\mu - \lambda\gamma i_{t-j} - \bar{y}_{t-j}) + \sum_{j=1}^{\infty} R_2^jL^j(\mu - \lambda\gamma i_{t+j} - \bar{y}_{t+j}) \right).$$

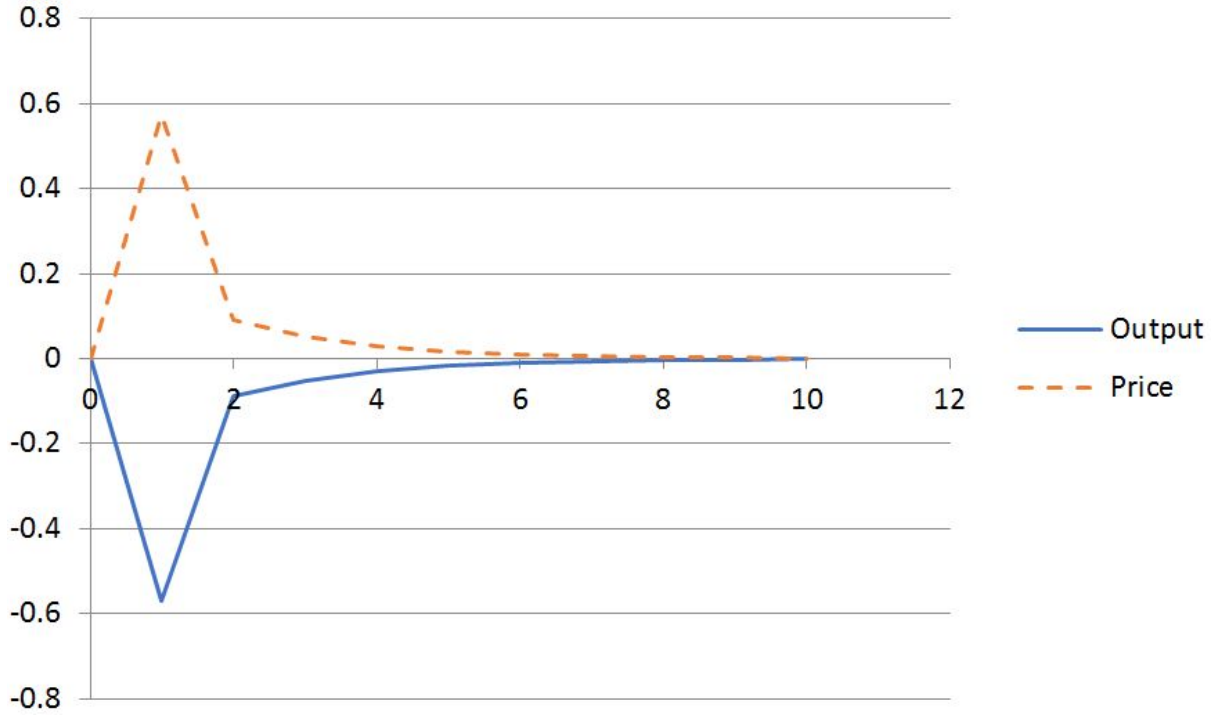


Figure 7: Effect of lower supply on output and price (in percent deviation from steady state). The parameter values are  $\bar{y}_t = 1, t \neq 1$  and  $\bar{y}_1 = 0.99$ ,  $i_t = 0$ ,  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ .

I now use these equations to simulate the response to a surprise one percent decrease in the natural level of output in period 1 ( $\bar{y}_t = 1, t \neq 1$  and  $\bar{y}_1 = 0.99$ ). Figure 7 shows the responses of output and prices to this supply shock. The responses look very similar to the ones presented in Figure 1, suggesting that the forward-looking inflation in the Phillips curve plays a secondary role. If anything, it seems to accelerate the return of prices to their steady-state value.

I then simulate the response to a surprise one percent increase in the interest rate in period 1 ( $i_t = 0, t \neq 1$  and  $i_1 = 0.01$ ). Figure 8 shows the responses of output and prices to the interest rate shock. Again, the responses look very similar to the ones presented in Figure 2.

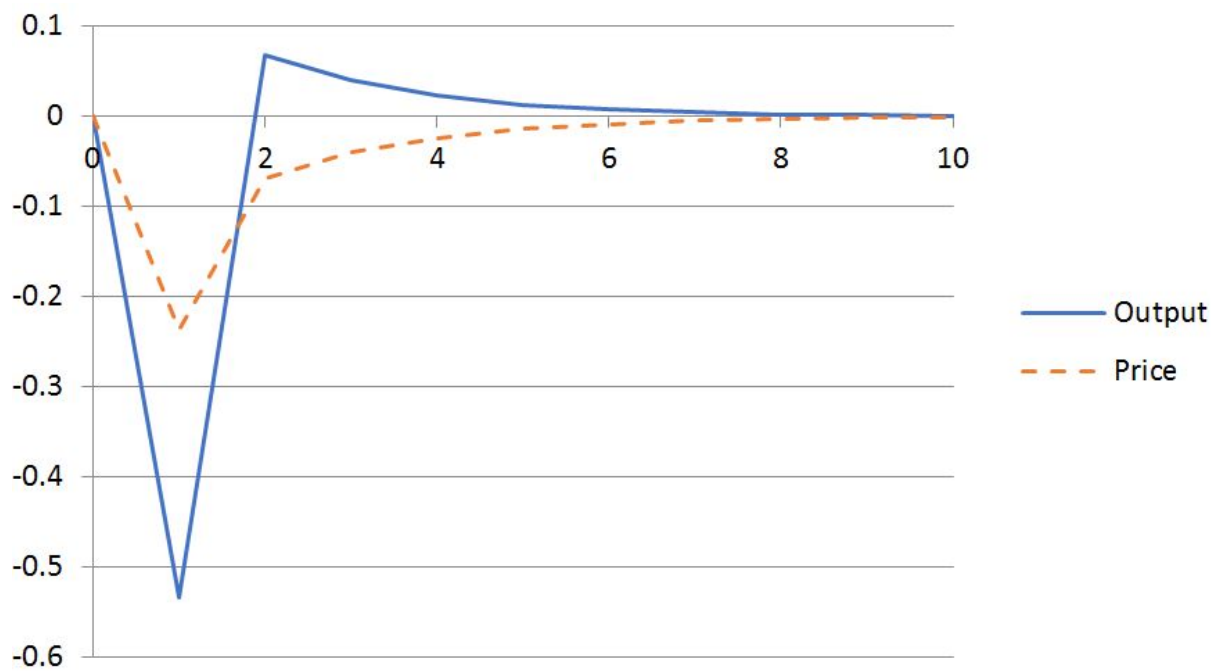


Figure 8: Effect of a higher interest rate on output and price (in percent deviation from steady state). The parameter values are  $i_t = 0, t \neq 1$ ,  $i_1 = 0.01$ ,  $\bar{y}_t = 1$ ,  $\kappa = 0.3$ ,  $u = 2.5$ ,  $\lambda = 1$ ,  $\gamma = 0.5$ ,  $a = 0.5$ .

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