

## Supply-Side Policies and the Zero Lower Bound

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*Supply-side policies can play a role in fighting a low aggregate demand that traps an economy at the zero lower bound (ZLB) of nominal interest rates. Reductions in mark-ups or future increases in productivity triggered by supply-side policies generate a wealth effect that pulls current consumption and output up. Since the economy is at the ZLB, increases in interest rates do not undo this wealth effect. The paper illustrates this mechanism with a New Keynesian model. [JEL E30, E50, E60]*

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### Introduction

**S**upply-side policies can help those economies trapped at the zero lower bound (ZLB) of nominal interest rates. Policies that raise future output—for instance, by liberalizing the goods market and reducing mark-ups or by removing regulations that lower productivity—generate a wealth effect that increases consumption and hours worked. Supply-side measures work because they address the core of the problem of the ZLB: the weakness of current aggregate demand.

Therefore, the proposals of structural reforms in the Euro zone countries that have suffered from the dire consequences of the ZLB are not “more of the same,”

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but parts of a coherent strategy to fight stagnation.<sup>1</sup> Reforming labor market institutions, strengthening competition, or improving vocational education can play an important role in these countries. Our point is different from the traditional “grow-out-of-debt” argument that, as a country grows, its debt burden becomes proportionally smaller. Although that argument is trivially true as an accounting proposition, its formulation usually fails at specifying how to get that growth going. We discuss, in comparison, which mechanism works to deliver the desired result.

The possibility of using supply-side policies to remedy the ZLB is not a reason for inaction along other fronts. Fiscal and monetary policy can be used for the same goal, often in a coordinated fashion.<sup>2</sup> For instance, fiscal policy can be directed toward expenditures, such as investments in infrastructure or Research and Development (R&D), that, beyond pulling up aggregate demand today, raise future productivity. Our position is that supply-side policies should not be forgotten and that, in many economies, they may be one of the few tools left.

Think, for instance, about the cases of countries such as Portugal or Spain. Without their own currency, these countries cannot rely on monetary policy. Similarly, policies such as exchange rate depreciation or tariffs, which may push aggregate demand up, are out of the question while the currency union is maintained. At the same time, fiscal policy is limited by a growing level of sovereign debt and the cost of servicing it (see the evidence in Ilzetzki, Mendoza, and Végh, 2010, that fiscal multipliers in high-debt countries are zero). With monetary and fiscal policy off the table, supply-side policies become a second line of defense (or, in the case where monetary and fiscal policy still work, a complementary one). Furthermore, supply-side policies may alleviate the negative consequences of monetary or fiscal policies designed to fight the ZLB today. For example, they may generate higher future tax revenues to pay down the debt incurred by expansionary fiscal policy.

Fortunately, these countries also have a sufficient number of “low-hanging fruit” in terms of supply-side reforms. Anyone familiar with the inadequacies of the labor markets of Southern European countries or with the regulations in many sectors of their economies cannot but forecast considerable gains out of structural reforms. For instance, Forni, Gerali, and Pisani (2010), using a dynamic equilibrium model, have simulated a reform that reduces mark-ups in the Italian services sector to the average Euro zone level over a five-year period (a policy exercise similar to the one in our paper, but outside the ZLB). The authors argue that such reform will add, on average, during this five-year period, almost

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<sup>1</sup>Technically, Euro zone countries are not at the ZLB, since the nominal interest rates are slightly positive. However, the ECB will not let the short-term nominal interest rate fall further. The rigidity of the nominal interest rate is all we need to deliver the results here. In fact, having a slightly positive nominal interest rate when the natural interest rate should be negative makes the situation worse.

<sup>2</sup>Monetary policy can fix that problem by increasing the long-run price level, either through temporarily higher inflation (Krugman, 1998; Eggertsson and Woodford, 2003) or through lump-sum transfers of cash (Auerbach and Obstfeld, 2005). Similarly, as shown by Correia and others (2010), fiscal policy can neutralize the ZLB and achieve first best by using taxes to replicate the optimal price path.

1.3 percentage points to the yearly growth rate of output, with a cumulative effect of roughly 11 percentage points.

Our argument does not depend on a permanent change in the growth trend of the economy, but only on an increase in the level of output (arguably, a much more plausible scenario). As long as we generate a wealth effect that is significant, supply-side policies will play a positive role. Thus, we are much more sanguine about the role of supply-side policies in euro zone countries than in the United States or the United Kingdom where, arguably, there are less productivity gains to be picked up.<sup>3</sup>

We illustrate the previous paragraphs with a two-period New Keynesian model. Prices are fixed in the first period but can be changed, at a cost, in the second period. This nominal rigidity makes output demand-determined. The representative household consumes, supplies labor, holds money, and saves. The (gross) nominal interest rate is fixed, by government policy, at 1. Because of the nominal rigidities, prices cannot adjust fast enough and the real interest rate is too high to induce sufficient consumption in the first period. Then, if we increase productivity in the second period or, alternatively, we lower the market power of firms, future output and consumption will rise. Because of the Euler equation of consumption, higher future consumption is followed by either higher interest rates and/or higher consumption today. Since, at the ZLB, the nominal rates are stuck at zero, this wealth effect of higher future output causes higher consumption and hours worked today.

Part of our reasoning is close to that of Krugman (1998), who used a drop in future productivity caused by population aging as the cause of the ZLB. In our paper, we reverse the direction of the change in future output and think about it as a policy option.<sup>4</sup> Our alternative channel of increased competition is original to us.

A possible motive for why this point is not discussed more often is that increments in productivity in the current period make the problem of the ZLB worse. Higher productivity today means that the current weak demand is satisfied with less hours worked. That is why we focus on reductions in mark-ups or future productivity gains, both of which do not suffer from this problem. Most policies that increase productivity have long implementation lags. In practice, when we talk about supply-side policies, we are talking about future productivity increases (and stronger competition in the goods market has positive effects in the short run even if it was implemented in the first period).

Finally, our model is of interest in itself. It allows us to easily find a solution and to characterize it. Also, it embodies all the classical results about the ZLB highlighted in the literature. Our quest for simplicity puts us close to Mankiw and Weinzierl (2011). Our emphasis is, however, different. We incorporate a labor supply decision, monopolistic competition, money, and partial price rigidity in the second period. These features are relevant for the economics of the mechanism we

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<sup>3</sup>One must also be aware, though, of the political-economic barriers to the introduction of structural reforms. Our argument highlights a benefit of overcoming those barriers that the literature has not explored: its expansionary effect on current aggregate demand.

<sup>4</sup>Rogoff (1998), in his discussion of Krugman's paper, makes *en passant* the same point that future productivity gains are a solution to the ZLB problem, but without linking it to a policy strategy.

explore. For example, monopolistic competition is required in order to talk about variations in the market power of firms. On the other hand, we have a simpler set of policy tools, since our objective is not to assess fiscal or monetary policy (although it would be easy to incorporate additional policy instruments).

The rest of the paper is organized as follows. In Section I we outline our model and in Section II we present our main results. We conclude in Section III. An online appendix provides further derivations.

## I. Model

We fix a monetary environment with two periods,  $t \in \{1, 2\}$ . Money is not used in the first period, but it enters the utility function in  $t = 2$ . This gives money value in the long run without having to worry about the demand for it in the short run (first period). More important, it sets up a terminal condition that pins down equilibrium prices. Nominal rigidities appear in two forms. First, prices in the first period are predetermined (for instance, because firms set their prices in the past). Second, firms pay a cost to change their prices in the second period. Nominal rigidities make output demand-determined and give the ZLB a real bite.

To keep the model tractable, we make three assumptions. First, we eliminate uncertainty. Second, the ZLB is imposed by government policy: the central bank has a standing facility (financed through lump-sum taxes) that borrows and lends at a zero net interest rate. Third, fiscal policy is trivial. In previous drafts, we had more general assumptions (for instance, endogenizing the price level at  $t = 1$  or regarding why the economy is at the ZLB), but we discarded them because they did not bring additional economic insights for our argument.

### Household

There is a representative household with preferences:

$$\log c_1 - l_1 + \beta \left( \log c_2 - l_2 + \frac{1}{1-\eta} \left( \frac{m}{p_2} \right)^{1-\eta} \right),$$

where  $c_t$  is consumption at time  $t$ ,  $l_t$  is hours worked, and  $(m_2)/(p_2)$  are real balances (nominal money  $m_2$  divided by the price level  $p_2$ ) at the end of  $t = 2$ . We assume that  $\eta > 1$ , as suggested by the data.<sup>5</sup>

The budget constraints are:

$$c_1 + \frac{b}{p_1} = w_1 l_1 + T_1 + F_1$$

and

$$c_2 + \frac{m}{p_2} = w_2 l_2 + R \frac{b}{p_2} + T_2 + F_2,$$

<sup>5</sup>Aruoba and Schorfheide, 2011, for example, estimate  $\eta = 31.8$ . Remember that  $1/\eta$  is the elasticity of money demand to interest rates, which most empirical studies find is small.

where  $b$  is an uncontingent nominal bond,  $R$  is the gross nominal interest rate,  $w_t$  is the wage in period  $t$ ,  $F_t$  denotes profits from firms, and  $T_t$  are lump-sum transfers from the government.

The FOCs of the household's problem are:

$$c_1 = w_1, \tag{1}$$

$$c_2 = w_2, \tag{2}$$

$$c_2 = \left(\frac{m}{p_2}\right)^\eta, \tag{3}$$

$$c_1 = \frac{1}{\beta} \frac{\Pi}{R} c_2. \tag{4}$$

where  $\Pi = p_2/p_1$ . These four conditions, together with the two budget constraints, determine the six choices of the household. The first two conditions are the static optimality conditions that equate the ratio of marginal utilities of leisure and consumption with their relative prices. The third equation is the demand for money in the second period. The final equation is the Euler equation.

### The Final Good Producer

There is one final good produced using intermediate goods with the production function:

$$y_t = \left( \int_0^1 y_{it}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{5}$$

where  $\epsilon > 1$  is the elasticity of substitution.

The final good producer is perfectly competitive and maximizes profits subject to the production function (equation (5)), taking as given intermediate goods prices  $p_{it}$  and the final good price  $p_t$ . Thus, the input demand functions are:

$$y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\epsilon} y_t \forall i,$$

and the price level  $p_t = \left( \int_0^1 p_{it}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ .

### Intermediate Goods Producers

Each intermediate firm produces differentiated goods with a technology  $y_{it} = A_t l_{p,it}$ , where  $l_{p,it}$  is the labor input rented by the firm for production and  $A_t$  is productivity. Hence, the real marginal cost of all intermediate goods producers is  $mc_t = (w_t)/(A_t)$ .

The monopolistic firms face nominal rigidities. Prices in period 1,  $p_1$ , are fixed. At time 2, they reoptimize their prices to  $p_{i2}$ , but firms need to use an amount of

hours  $(\phi)/(2)[(p_{i2})/(p_{i1})-1]^2$  per unit of goods sold to change prices. Thus, the firm hires

$$l_{s,i2} = \frac{\phi}{2} \left[ \frac{p_{i2}}{p_{i1}} - 1 \right]^2 y_{i2}$$

units of labor to change prices (the amount of hours per unit times the total number of units) and pays  $w_2 l_{s,i2}$  for doing so. This Rotemberg setup introduces nominal rigidities without keeping track of distributions (as would happen with Calvo pricing) or solving a menu cost problem. We express the adjustment cost in terms of hours used instead of the final good (as it is more common in the literature) to simplify the expressions below.<sup>6</sup>

Hence, prices  $p_{i2}$  solve

$$\max_{p_{i2}} \left\{ \left( \frac{p_{i2}}{p_2} - mc_2 - \frac{\phi}{2} \left[ \frac{p_{i2}}{p_{i1}} - 1 \right]^2 w_2 \right) y_{i2} \right\}$$

taking  $y_{i2} = ((p_{i2})/(p_2))^{-\varepsilon} y_2$  as given. The solution of that problem leads to an expression for aggregate inflation:

$$\Pi = \frac{\varepsilon - 1}{\varepsilon - 2} \pm \sqrt{\frac{1}{(\varepsilon - 2)^2} + \frac{2}{(\varepsilon - 2)\phi} \left( \frac{\varepsilon - 1}{w_2} - \frac{\varepsilon}{A_2} \right)}.$$

## Government

The government policy sets  $R = 1$ . This can be implemented, for example, with a standing financing facility ready to borrow or lend any quantity at that interest rate. In  $t = 2$ , the government prints currency  $m$  and distributes it to the household. Transfers in the first and second period balance the budget.

## Aggregation

By market clearing, we have  $c_1 = A_1 l_1$ ,  $c_2 = A_2 l_{p,2}$ , and  $l_2 = l_{p,2} + l_{s,2}$ , where  $l_{p,2}$  is the total labor used in production in  $t = 2$  and  $l_{s,2}$  is the labor used in changing prices. Note that all firms use the same amount of labor,  $l_1 = l_{i1}$ ,  $l_{p,2} = l_{p,i2}$ , and  $l_{s,2} = l_{s,i2}$ .

## Equilibrium

Given a feasible policy sequence  $\{m, T_1, T_2\}$  and an initial  $p_1$ , an equilibrium is an allocation and prices  $c_1, l_1, R, c_2, l_2, l_{p,2}, l_{s,2}$ , and  $p_2$  that solve the problem of the household, the pricing condition, and clear markets.

<sup>6</sup>With the more common formulation, the results are nearly identical but harder to evaluate.

To compute this equilibrium, we start with the direct results that  $w_1 = c_1$ ,  $w_2 = c_2$ , and:

$$l_1 = \frac{c_1}{A_1},$$

$$l_{p,2} = \frac{c_2}{A_2}.$$

Then, putting together equations (3) and (4), we get a terminal condition (TC):

$$\Pi = \frac{m}{p_1 c_2^{\frac{1}{\epsilon}}} \tag{TC}$$

and an inflation condition (IC)

$$\Pi = \frac{\epsilon - 1}{\epsilon - 2} \pm \sqrt{\frac{1}{(\epsilon - 2)^2} + \frac{2}{(\epsilon - 2)\phi} \left( \frac{\epsilon - 1}{c_2} - \frac{\epsilon}{A_2} \right)}. \tag{IC}$$

The TC and the IC constitute a system of two equations on two unknowns,  $\Pi$  and  $c_2$ .

The TC is decreasing in  $c_2$ . One can think about the TC as a Fisher money equation: for a given money supply  $m$ , there is an inverse relation between transactions ( $c_2$ ) and the price level ( $p_2$ ;  $p_1$  cancels out on both of the expression). When consumption is high, its marginal utility is low, and the household wants to equate that low marginal utility of consumption with a low marginal utility of real balances. This can only occur when inflation is low and real balances are high.

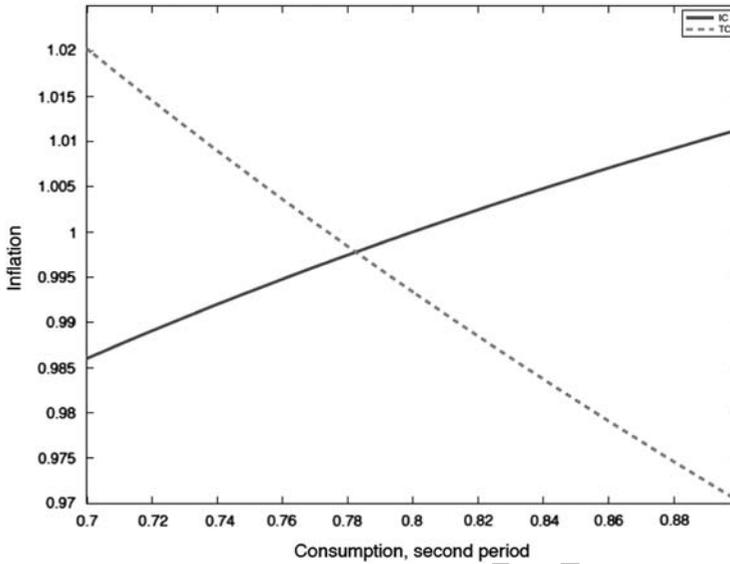
The IC has two possible values: one for the positive and one for the negative root of the square root. Note that the leading term of the IC is  $(\epsilon - 1)/(\epsilon - 2) > 1$ . Thus, if we keep the positive root, we will have  $\Pi > (\epsilon - 1)/(\epsilon - 2)$  and high adjustment costs by firms. If, instead, we keep the negative root, we will have lower inflation—or deflation for some parameter values—and low adjustment costs. Since the ZLB correlates in the data with low inflation, we study the equilibrium generated by the negative root as the empirically relevant one. We refer the reader to Cochrane (2013) for a discussion of multiplicity of equilibria in models with a ZLB. With this negative root, the IC is increasing in  $c_2$ : a higher level of aggregate demand leads firms to increase their prices more.<sup>7</sup> Thus, since the TC is decreasing in  $c_2$  and the IC is increasing in  $c_2$ , if the curves cross, they will only do it once.

We plot, in Figure 1, the TC (continuous line) and the IC condition (dot-dashed line).<sup>8</sup> From the solution of this system, we get the final variable  $c_1 = (1)/(\beta)m^\eta \Pi^{1-\eta}$ .

<sup>7</sup>This is another argument against selecting the positive root: with that positive root, firms will raise prices less when demand is higher. This response is less plausible than the standard Keynesian argument of higher demand leading to higher prices.

<sup>8</sup>For this graph, and only for illustrative purposes, we chose  $\eta = 5$ ,  $\beta = 1$ ,  $\epsilon = 5$ ,  $\phi = 50$ ,  $p_1 = 1$ ,  $m = 0.95$ ,  $A_1 = A_2 = 1$ .

Figure 1. TC and IC Conditions



## II. Exercises

In this section, we undertake four exercises to illustrate our main points about the role of supply-side policies at the ZLB.

### Increasing $A_2$

In our first exercise, we look at the case where supply-side policies increase  $A_2$ . One simple interpretation of this policy is to think about

$$A_t = (1 - \tau_t)A,$$

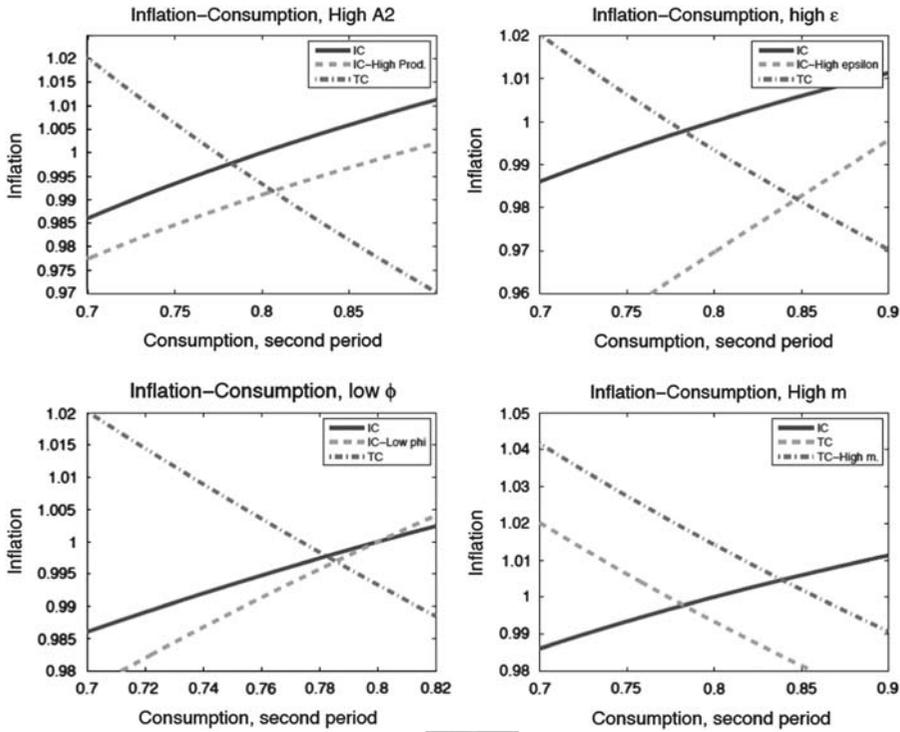
where  $A$  is the level of technological knowledge and  $\tau_t$  is a distortion (an inefficient labor market regulation, resources lost to corruption and red-tape, and so on). The policy will be to reduce  $\tau_2$  and, hence, to increase  $A_2$ .<sup>9</sup>

In Figure 2, top-left panel, we plot the same TC as before (dot-dashed line, the TC does not depend on  $A_2$ ), and two ICs, the original one with low  $A_2$  (continuous line) and one with high  $A_2$  (dashed line).<sup>10</sup> The IC is moved down because, with high  $A_2$ , firms are more productive, and, thus, for a given level of demand, they want to increase their prices less (note the term  $\varepsilon/A_2$  in the IC). This leads to lower inflation and higher  $c_1$  and  $c_2$ . Thus, as argued in the introduction, at the ZLB, a higher  $A_2$  triggered by supply-side policies has a positive wealth effect

<sup>9</sup>We thank one of our referees for suggesting this interpretation.

<sup>10</sup>For this graph, we chose the same parameter values as before, plus  $A_2^{high} = 1.1$ .

Figure 2. Exercises



on consumption in both periods. This happens even if the economy still stays at the ZLB.

A version of this model with flexible prices delivers a very different result. As shown in the online appendix, in that version of the model:

$$c_t^{flex} = \frac{\epsilon - 1}{\epsilon} A_t.$$

Thus, an increase in  $A_2$  increases  $c_2^{flex}$  but  $c_1^{flex}$  stays the same. The reason is that, with price flexibility, prices can adjust and deliver the level of the real interest rate that induces such a level of consumption (even with  $R = 1$ ). This change in the real interest rate makes the wealth effect of a higher  $A_2$  irrelevant for  $c_1^{flex}$ .

The result also stands in comparison with the case where, going back to nominal rigidities, we change  $A_1$ , but not  $A_2$ . Since in equilibrium  $c_1$  does not depend on  $A_1$ , a higher  $A_1$  just leads to less hours worked through the condition  $l_1 = (c_1/A_1)$ . Therefore, our model encompasses a version of what has been called the “paradox of productivity” (see, for example, Eggertsson, Ferrero, and Raffo, 2014).

We believe that thinking about structural reforms as changing  $A_2$  rather than  $A_1$  is the empirically interesting case. The supply-side policies currently discussed in

the euro zone typically include measures such as improving the educational systems, reforming labor markets (making hiring and firing easier, having more flexible work rules and collective bargaining), and enhancing R&D systems. Any productivity payoff for these policies will only appear in the middle or long run.

The classical analogy for this process comes from David (1990). David famously argued that electrification in the United States had only a slow impact on productivity because of a number of “diffusion lags.” For example, David pointed to the unprofitability of replacing still serviceable manufacturing plants adapted to water and steam power and how the new electric machines were only adopted over a long period of time. Similarly, firms’ factory layouts had to be radically redesigned and engineers had to find the best implementation of electricity.

Many firms in Spain have organized their work practices, career development strategies, and IT systems based on the need to cope with a number of perverse labor market regulations. Even if those regulations were lifted, it would take some time before new work practices could be designed, tested, and widely implemented, new career development strategies structured, and IT systems replaced. In fact, the adoption of those changes may even temporarily lower productivity in the short run.

Similarly, education reforms require decades before the human capital stock of a country is significantly changed. In the same way, improving R&D is a slow process. Supply-side policies do have an impact on productivity, but almost always their impact is felt only after some time.

Finally, note that our argument does not depend on an increase in the growth trend of an economy. A wealth effect works even if we just generate a one-shot increase in productivity, a much more realistic goal. The economies of countries such as Spain have so many areas of inefficiency (the labor market being the paradigmatic case) that increases in productivity after some reforms are much more likely than in the United States or the United Kingdom. See, as evidence, Prados de la Escosura, Rosé, and Sanz Villarroya (2011) for the historical increases of productivity in Spain after structural reforms.

### Increasing $\varepsilon$

In our second exercise, we look at the case where, instead of affecting productivity, supply-side policies strengthen competition in the economy and reduce the mark-ups (for instance, with an aggressive enforcement of antitrust law). We follow Blanchard and Giavazzi (2003) who explored the merits of goods market de-regulation in Europe by modeling such a policy as increasing  $\varepsilon$  and hence lowering mark-ups (see also, for a related exercise, Forni, Gerali, and Pisani, 2010). One possibility is to think about

$$\varepsilon = (1 + \eta)\tilde{\varepsilon},$$

where  $\tilde{\varepsilon}$  is the technological elasticity of substitution and  $\eta$  is an added difficulty in the substitution among intermediate goods dictated by regulation. For example, there are widespread rules in the health industry that limit the ability to substitute medical doctors and nurse practitioners even when it is technologically feasible with no significant effect on health outcomes (Kleiner and others, 2014).

This reduced-form approach is justified because, for our purpose, we do not need to be explicit about why firms enjoy market power. The results are shown in Figure 2, top-right panel.<sup>11</sup> A higher  $\varepsilon$  pushes the IC down (the low  $\varepsilon$  IC is the continuous line; the high  $\varepsilon$  IC is the dashed line; the TC remains unchanged). Therefore, we get the same results as in the first exercise: higher  $c_1$  and  $c_2$  and lower inflation. The “paradox of productivity” does not apply to reductions in the market power of firms: even if we strengthen competition in period 1,  $c_1$  increases. This result is particularly interesting because, making markets more competitive in some European economies, which have many service sectors shielded from market forces, is quite possible.

### Lowering $\phi$

Our third exercise revisits a classical topic. As pointed out by DeLong and Summers (1986), and more recently by Werning (2011), increasing price flexibility (but short of reaching full price flexibility) may not help when we are at the ZLB. We explore this possibility in our model by lowering  $\phi$ . This may be caused, for example, by changing commercial and labor laws to allow for more frequent renegotiation of contracts or collective bargaining agreements.

In our model, a lower  $\phi$  shifts the IC down and rotates it counterclockwise (dashed line, our representation of higher price flexibility) with respect to the baseline IC (continuous line). Algebraically, the term  $(2)/((\varepsilon-2)\phi)$  in the IC becomes larger. If the new IC crosses the TC further to the right, as in our graph, we will have lower inflation and lower  $c_1$  (but higher  $c_2$ ). If the new IC crosses the TC further to the left, we will have higher inflation and higher  $c_1$  (and lower  $c_2$ ). Welfare implications are, thus, ambiguous. Nevertheless, comparing this exercise with the previous one suggests that reductions in market power may be a better policy tool than reductions in price stickiness to fight the dangers of the ZLB.

### Increasing $m$

Our final exercise, plotted in Figure 2, bottom-right panel, is to increase  $m$ .<sup>12</sup> This exercise would replicate, for example, forward guidance. The higher level of  $m$  moves the TC to the right, causing higher inflation and  $c_2$ . Remember that, in equilibrium

$$c_1 = \frac{1}{\beta} m^\eta \Pi^{1-\eta}.$$

In this expression, we will have two mechanisms at work. First,  $m^\eta$  increases. Second,  $\Pi^{1-\eta}$  decreases. However, given the slopes of the IC and TC, the second mechanism is smaller than the first, and therefore,  $c_1$  increases. This is another

<sup>11</sup>For this graph, we chose the same parameter values as before, plus  $\varepsilon^{high} = 10$ .

<sup>12</sup>For this graph, we chose the same parameter values as before, plus  $m^{high} = 0.96$ .

classical result in the literature of the ZLB that our model encompasses (Auerbach and Obstfeld, 2005).

### III. Conclusions

In this paper we have argued that supply-side policies can play a role in fighting situations where an economy is at a ZLB. Although we do not want to over-emphasize the power of these policies, we should not forget about them either. Our results suggest the need for middle-size business cycle models in the style of Christiano, Eichenbaum, and Evans (2005) modified to incorporate an explicit ZLB to measure how big the potential impact from these policies is and how they complement more traditional monetary and fiscal policies. We leave that investigation for future research.

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