# GOOD (AND NOT SO GOOD) POLICY AT THE ZERO BOUND*

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ABSTRACT

The fact that nominal interest rates cannot be negative implies that alternative policies must be considered at the zero bound to provide stimulus, should it be needed. This note is an assessment of fiscal policies at the zero bound. Using a model for the euro area, we illustrate and quantify the effects of fiscal policy responses to a major recession that leads the economy to the zero lower bound on interest rates. First, we show that ad-hoc fiscal policy measures lead to results that are very different from the efficient allocation. Then, drawing on the results in Correia, Farhi, Nicolini and Teles (2011), we show how fiscal policy should be designed to replicate the efficient allocation.

## 1. Introduction

Nominal interest rates cannot be negative. If they could, people would make arbitrarily large profits just by borrowing and holding money. So when the policy rate is very close to zero, as has been the case in the last three years in the US and other economies, nominal interest rates cannot be further reduced. If further stimulus is necessary, alternative policies must be considered. This note is an assessment of fiscal policies at the zero bound. It draws heavily on work by Correia, Farhi, Nicolini and Teles (2011).

If prices and wages were flexible, the fact that interest rates cannot be negative would be irrelevant for policy. In most models, the zero bound would actually be the optimal policy, the Friedman rule, named after Milton Friedman who first derived it. The argument of Friedman is straightforward. The nominal interest rate, the return on riskless short-term nominal debt, is the opportunity cost of holding money. It is the price of money. Given that the cost of producing money is, if not zero, very close to it, a simple efficiency argument would equate the price of money to its marginal cost, ***i.e***. zero. The nominal interest rate should therefore be zero or very close to it. With flexible prices and wages, a zero nominal interest rate does not restrict real interest rates, or real allocations. The real interest rate is the nominal rate minus inflation, and if inflation is not costly, it is always possible to achieve a target for the real rate, at zero cost, through a particular target for the inflation rate. If the real interest rate ought to be negative, say minus 4 per cent per year, this can be done at the zero bound with 4 per cent inflation per year.

Most economists would agree that the swings in inflation rates that would be necessary to achieve good outcomes at the Friedman rule would be hard to implement and, if possible, would come at a cost. They would require synchronized movements in all prices in the economy that, because of information costs or more direct menu costs, would be hard to achieve. The movements in inflation rates would also have to be credible, meaning that future policy would have to confirm them. But most mandates of central banks in the developed world include objectives of price stability, and inflation swings of that order of magnitude would not comply with those mandates.

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* The opinions expressed in the article are those of the authors and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. Any errors and omissions are the sole responsibility of the authors.

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At the end of 2008, in response to the major events in financial markets in the US and elsewhere, policy rates were lowered to the historically low levels of 0 to 25 basis points in the US. If possible, nominal interest rates would have been further reduced. But they could not be. What are, then, alternative policies?

An obvious candidate is government spending. In Portugal, total government expenditure as a share of GDP was raised from 43.7 per cent in 2007 to 48.1 per cent in 2009. The case of Portugal is striking given the very high levels of public and foreign debt, and the recent history of low GDP growth rates,[1] but this was a common pattern across the world. Still, the evidence on the effects of government spending is controversial, at most. And it is particularly scarce at the zero bound. Models can be used to assess the effects of policy at the zero bound, even if they are not as reliable as one would wish because some of the assumptions, as the ones on price and wage stickiness, are not policy invariant.

There is theoretical and quantitative work on the effects of government consumption on economic activity at the zero bound, as in Eggertsson (2009), Eggertsson and Woodford (2003, 2004a, 2004b) or Christiano, Eichenbaum and Rebelo (2009).[2] They show that the fact that interest rates cannot be reduced is responsible for a much higher multiplier of government spending. Christiano, Eichenbaum and Rebelo (2009), in particular, show that the multiplier on government spending is larger; the larger is the need to use it. In these models there would be no effect on output if government spending was a substitute for private consumption. In fact, the effect on output is larger when government consumption is useless. The analysis is about effects of government consumption on economic activity, not about effects of this on welfare. The effects on welfare, if positive, are much lower.

Correia *et al*. (2011) show that taxes can be used to achieve efficient outcomes. The intuition is simple. Suppose that for some reason, possibly associated with increased uncertainty, agents wanted to save more. If the nominal interest rate was way above the zero bound, then it could be lowered, and, for a stable inflation rate, the resulting low real rates would reduce the incentives to save, preventing consumption, and production, from decreasing. But if the necessary cut on nominal interest rates was very large, then the economy would hit the zero bound. How can real rates be lowered at the zero bound? High expected inflation would bring real interest rates down. But high inflation is hard to implement, because of the need to raise prices of all goods and because it may be hard to convince the public that the central bank would allow for high inflation in the future, even if temporary.

Consider now a policy in which consumption taxes are lowered today to be raised in the future. An expected increase in consumption taxes is future inflation. But it has two advantages relative to inflation in producer prices. Consumption taxes move all prices together keeping producer prices unchanged and, furthermore, it can be credible.

The combination of low consumption taxes today with high consumption taxes in the future can distort the allocation of labour. But there are ways of correcting this. Labour income taxes must be adjusted to compensate for the changes in consumption taxes. Variable consumption taxes also distort the allocation of capital. If they are low today and high tomorrow, capital accumulation becomes relatively expensive and so capital income taxes would have to be lowered to remove that distortion. Finally, payroll taxes may also have to be used to avoid the need for movements in wages that could also be hard to put in place, given the institutional and political conditions.

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1 With a balanced growth rate of $\gamma = 1\%$, a real interest rate of $r^* = 3\%$, and a level of public debt $(D)$ of $85\%$ of GDP, it would be necessary to have a permanent primary surplus of $T - G = \frac{(r^* - \gamma)}{1+\gamma} D = 1.7\%$ of GDP, where $T$ and $G$ stand for government revenue and expenditure, respectively, in order to pay for the debt.

2 See also Gomes, Jacquinot, Mestre and Sousa (2010). They also look at the effects of changes in taxes at the zero lower bound.

Correia *et al*. (2011) show that there is a combination of all those taxes that leads to the same outcomes that could be achieved away from the zero bound, or, alternatively, in a world where prices and wages could be automatically adjusted without cost.

In this article, we are going to play the role of a policy maker unaware of the results in the literature. Our policy maker will use a model that lets him, or her, experiment alternative policies without social costs. The model was developed and estimated to resemble the actual economy, with the aim of answering questions close to the ones we are interested in answering here. It is a version of the Smets and Wouters (2003) model for the euro area, modified to take into account the zero bound constraint on nominal interest rates. We proceed by trial and error, performing different policy experiments. We compare the effects of those policies to the efficient ones, which would be the same ones that would be achieved in an economy without sticky prices or wages.

We are not alone with Correia *et al*. (2011) in proposing these kinds of policies as a way of overcoming the zero bound constraint on nominal interest rates. Martin Feldstein proposed it for Japan back in 2003 (see Feldstein, 2003). Robert Hall and Susan Woodward made similar proposals for the US. There are also sectorial or regional policies aimed at giving agents the incentive to anticipate consumption. As pointed out by Correia *et al*. (2011), the US Consumer Assistance to Recycle and Save (CARS) program and tax holidays at the regional level are examples of these policies.

The remainder of the article proceeds as follows. Next we present a simple model where we illustrate the details of the general results in Correia *et al*. (2011). Then, we proceed to the policy experiments.

## 2. A simple model

To illustrate the results in Correia *et al*. (2011) we first use a model where there are no frictions in the adjustment of prices and wages. We show that it is possible to conduct fiscal policy at the zero bound on interest rates that achieves efficient outcomes and that does not require prices and wages to respond to aggregate shocks. Since prices and wages do not have to move, the nominal rigidities, that are likely to be present, are not effective. With this kind of policy, the economy with sticky prices and wages behaves in the same efficient way as the economy without price or wage stickiness that we are now going to describe.

The model is deterministic. There are no shocks, but there are still movements over time because productivity moves over time, government spending also moves, and there may also be movements in preference parameters. In the model, there is a representative household and a representative firm. There is also a government.

The preferences of the households depend positively on consumption $C_t$ and negatively on labour $N_t$,

$$U = \sum_{t=0}^{\infty} \beta^t u\left(C_t, N_t, \xi_t\right) \tag{1}$$

where $\xi_t$ is a time-varying preference parameter.

Government consumption $G_t$ is exogenous. The production technology is

$$C_t + G_t + I_t = A_t F\left(N_t, K_t\right) \tag{2}$$

where $K_t$ is capital and investment $I_t$ is such that

$$K_{t+1} = \left(1-\delta\right)K_t + I_t. \tag{3}$$

$A_t$ is an aggregate productivity time-varying parameter and the production function has constant returns to scale.

The government finances public consumption with time varying taxes on consumption $\tau_t^c$, labour income $\tau_t^n$, capital income $\tau_t^k$, as well as a payroll tax paid by firms, $\tau_t^p$. We also allow for lump sum taxes, $T_t$.

The budget constraint of the households can be written as

$$\frac{1}{1+i_t}B_{t+1}^h + P_t K_{t+1} = B_t^h + \left(1-\delta\right)P_t K_t + + \left(1-\tau_t^k\right)U_t K_t + \left(1-\tau_t^n\right)W_t N_t - \left(1+\tau_t^c\right)P_t C_t - T_t \quad (4)$$

together with a no-Ponzi games condition. $B_{t+1}^h$ are nominal bonds that cost $\frac{1}{1+i_t}$ and pay one unit of money in period $t+1$. $i_t$ is the nominal interest rate, $W_t$ is the nominal wage and $U_t$ is the rental cost of capital.

The household that maximizes utility subject to the budget constraint must equate the marginal rate of substitution between consumption and labour to the real wage distorted by the consumption and the labour income taxes,

$$-\frac{u_C\left(C_t, N_t, \xi_t\right)}{u_N\left(C_t, N_t, \xi_t\right)} = \frac{\left(1+\tau_t^c\right)P_t}{\left(1-\tau_t^n\right)W_t}. \quad (5)$$

The optimal decision on the nominal bonds and capital implies, respectively

$$\frac{u_C\left(C_t, N_t, \xi_t\right)}{P_t\left(1+\tau_t^c\right)} = \beta\left(1+i_t\right)\frac{u_C\left(C_{t+1}, N_{t+1}, \xi_{t+1}\right)}{P_{t+1}\left(1+\tau_{t+1}^c\right)}, \quad (6)$$

and

$$P_t\left(1+i_t\right) = \left[P_{t+1}\left(1-\delta\right) + \left(1-\tau_{t+1}^k\right)U_{t+1}\right]. \quad (7)$$

The firms are competitive. They take prices as given and maximize profits, so that the price of the good must equal marginal cost,

$$P_t = \frac{\left(1+\tau_t^p\right)W_t}{A_t F_n\left(\frac{K_t}{N_t}\right)} = \frac{U_t}{A_t F_k\left(\frac{K_t}{N_t}\right)}, \quad (8)$$

where $\tau_t^p$ is a payroll tax.

In a competitive equilibrium all these conditions must be satisfied. In addition, the zero bound on nominal interest rates must also be verified so that

$$i_t \geq 0.$$

## Efficiency

What are the efficient allocations in this economy? If we were to maximize the utility of the representative household taking into account only the resource constraints (2) and (3), the resulting efficient allocation would be described by the following marginal conditions: the marginal rate of substitution between consumption and leisure would be equal to the marginal productivity of labour, the marginal rate of substitution between consumption today and tomorrow would be equal to the marginal productivity of capital, and total production would be equal to private and public consumption plus capital accumulation:

$$-\frac{u_C\left(C_t,N_t,\xi_t\right)}{u_N\left(C_t,N_t,\xi_t\right)}=\frac{1}{A_tF_n\left(K_t,N_t\right)}, \tag{9}$$

$$u_C\left(C_t,N_t,\xi_t\right)=\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)\left[A_{t+1}F_k\left(K_{t+1},N_{t+1}\right)+1-\delta\right] \tag{10}$$

and

$$C_t+G_t+K_{t+1}-\left(1-\delta\right)K_t=A_tF\left(K_t,N_t\right). \tag{11}$$

We now need to show that this efficient allocation can be achieved even if the nominal interest rate is zero, with prices and wages that remain constant, using fiscal policy.

## Efficient policy at the zero bound

Let the price level and the aggregate wage be constant, $P_t=P$ and $W_t=W$. In order for an efficient allocation satisfying (9), (10) and (11) to be a competitive equilibrium it would also have to satisfy

$$-\frac{u_C\left(C_t,N_t,\xi_t\right)}{u_N\left(C_t,N_t,\xi_t\right)}=\frac{\left(1+\tau_t^c\right)P}{\left(1-\tau_t^n\right)W}, \tag{12}$$

$$\frac{u_C\left(C_t,N_t,\xi_t\right)}{\left(1+\tau_t^c\right)P}=\left(1+i_t\right)\frac{\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)}{\left(1+\tau_{t+1}^c\right)P}, \tag{13}$$

$$P=\frac{\left(1+\tau_t^p\right)W}{A_tF_n\left(\frac{K_t}{N_t}\right)}, \tag{14}$$

$$\frac{W}{A_tF_n\left(\frac{K_t}{N_t}\right)}=\frac{U_t}{A_tF_k\left(\frac{K_t}{N_t}\right)}, \tag{15}$$

$$\frac{u_C\left(C_t,N_t,\xi_t\right)}{\left(1+\tau_t^c\right)}=\frac{\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)}{\left(1+\tau_{t+1}^c\right)}\left[1-\delta+\left(1-\tau_{t+1}^k\right)\frac{U_{t+1}}{P_{t+1}}\right], \tag{16}$$

From conditions (12) and (14), we have

$$-\frac{u_C\left(C_t,N_t,\xi_t\right)}{u_N\left(C_t,N_t,\xi_t\right)}=\frac{\left(1+\tau_t^c\right)}{\left(1-\tau_t^n\right)}\frac{\left(1+\tau_t^p\right)}{A_tF_n\left(\frac{K_t}{N_t}\right)} \tag{17}$$

Notice that if we set the joint distortion to zero, $\frac{\left(1+\tau_t^c\right)}{\left(1-\tau_t^n\right)}\left(1+\tau_t^p\right)=1$, then it is possible to satisfy the efficiency condition (9). This is possible because we allow for lump sum taxes that pay for government spending without imposing distortions. Condition (16), together with (14) and (15), can be used to write

$$\frac{u_C\left(C_t,N_t,\xi_t\right)}{\left(1+\tau_t^c\right)}=\frac{\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)}{\left(1+\tau_{t+1}^c\right)}\left[1-\delta+\left(1-\tau_{t+1}^k\right)A_{t+1}F_k\left[\frac{K_{t+1}}{N_{t+1}}\right]\right]. \tag{18}$$

There is always some capital income tax, that can respond to the consumption tax and eliminate the intertemporal distortion so that the efficiency condition (10) is also satisfied.

From condition (13), we have

$$\frac{u_C\left(C_t,N_t,\xi_t\right)}{\left(1+\tau_t^c\right)P}=\left(1+i_t\right)\frac{\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)}{\left(1+\tau_{t+1}^c\right)P}. \tag{19}$$

If the nominal interest rate is zero, $i_t=0$, there is still a path for consumption taxes that satisfies this condition. Given that the nominal interest rate is zero and the real interest rate could actually be negative, then there must be inflation. Here we are imposing that producer prices are constant. Inflation comes from consumption taxes that will have to increase so that the real interest rate is the efficient one.

The labour income tax must then respond to the changes in the consumption tax to verify condition (12), and the payroll tax must also move to verify condition (14). Condition (15) will be satisfied by a rental cost of capital, and, as we have already mentioned, condition (16) is satisfied by a response of the capital income tax to the movements in the consumption tax.

### Policy in normal times

In normal times, the nominal interest rate is positive. This is possible with constant prices and consumption taxes, provided the real rate $\frac{u_C\left(C_t,N_t,\xi_t\right)}{\beta u_C\left(C_{t+1},N_{t+1},\xi_{t+1}\right)}-1$ is positive. The efficient allocation can then be implemented in a simpler way. It won't be necessary to move consumption taxes or the capital income tax. The other two taxes, the labour income and the payroll tax, will still have to move in order to keep prices and wages stable in response to shocks.

Condition (13) will be satisfied by a time varying interest rate. Since prices and wages do not move, the labour income tax will have to move to satisfy condition (12) and the payroll tax will have to move to satisfy condition (14).

### Sticky prices and sticky wages

We have analysed a model where prices and wages are flexible. How can we draw conclusions from this analysis that may be relevant in a world where, for many reasons, prices and wages may be slow to adjust? In the model, it was possible to use policy to achieve efficient outcomes by stabilizing prices and wages. If prices and wages are stable, then sticky price or sticky wage restrictions have no impact.

The economy with sticky prices and sticky wages behaves exactly like the one with flexible prices and wages. If it is possible to achieve efficiency under flexible prices and wages, it is also possible to respond optimally to aggregate shocks when prices or wages are sticky.



## 3. Policy experiments

In this section we use a New-Keynesian model very similar to the one in Smets and Wouters (2003) which is probably the most widespread framework used for policy analysis. It is considerably more complex than the one we used in the section above. Prices and wages are sticky and there is a number of other features that are useful to have it track the data better. We are going to use the model to perform various policy experiments. We proceed by trial and error as if we did not know what the optimal policy is. We do know it and describe it at the end of this section. Meanwhile we increase government spending, cut various taxes and possibly raise some as we lower others.

### The model

In the simulations below, we use a closed economy model with a similar structure to that in Smets and Wouters (2003), enlarged to include several taxes and to explicitly take into account the zero bound on interest rates.[3] To calibrate the model we mostly rely on the estimation results in Smets and Wouters (2003).

There are four agents in the economy, households, firms, a fiscal and a monetary authority. Households have preferences over final consumption and leisure with external habit persistence in consumption.[4] Private and public consumption and investment are composite goods aggregating a continuum of differentiated intermediate goods. Households' labour is also differentiated. Labour used for production of each intermediate good is also a composite of the different varieties. Production of each intermediate good uses labour and capital, with variable capital utilization. The technology has constant returns to scale. There are also adjustment costs in investment.

Households set wages as in Calvo (1983), which means that in each period there is a constant and exogenous probability of being able to reoptimise wages. Households that cannot reoptimise partially adjust their wages according to past inflation. Households own physical capital that they rent to firms. They can change their capital stock by investing in new capital and they also decide on the degree of utilisation of installed capital. Households own the firms, receive dividends and hold both state-contingent and noncontingent nominal bonds. The return on these noncontingent bonds is the policy rate of the central bank.

There is a continuum of firms each producing an intermediate good and one representative firm producing the final good, which is the Dixit-Stiglitz aggregator of the continuum of intermediate goods. The final good can be used for consumption (private or public) and investment purposes. The market for intermediate goods is monopolistic competitive and the market for the final good is perfectly competitive.

Intermediate good firms set prices as in Calvo (1983). The firms that cannot change prices partially update prices with previous period aggregate inflation (as in Christiano, Eichenbaum and Evans, 2005).

The government purchases the final good, receives revenue from levying taxes and issues debt. We assume that households pay taxes on consumption purchases, wage income and capital income while firms pay payroll taxes.[5] Finally, the monetary authority's behaviour is assumed to be well described by a

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3 See Woodford (2003) for a detailed discussion of these models.

4 External habit means that the habit formation depends on past aggregate consumption rather than the individual consumer's past consumption. This allows for hump shaped responses of consumption to different shocks which is a feature of the data.

5 There are also lump sum taxes (or subsidies) on households.

Taylor rule outside the zero bound. The interest rate reacts to inflation deviations from target and output growth, and there is interest rate smoothing.[6]

### 3.1. The great recession

To induce a recession we assume, as in Eggertsson (2009), that there is an exogenous change in households' preferences that induces them to save more[7] and therefore reduce consumption. We also assume that there is an exogenous increase in the cost of installing capital that depresses investment.

These shocks hit the economy in period one and then vanish slowly according to an autoregressive process. After around four years the shocks have basically died out. The combination of the two shocks implies a reduction of consumption of about 2 per cent and a 8 per cent contraction in investment in the first year after the shock, of comparable order of magnitude to the 2009 contraction in euro area private consumption and investment.[8]

The shocks imply a fall in inflation lasting for one year. Given the considerable contraction in economic activity, the nominal interest rate is cut, hitting the zero bound and remaining there for five quarters. The fact that the nominal interest rate cannot fall below zero implies that the central bank is prevented from providing further stimulus via the interest rate. As deflation sets in, the real interest rate rises which contributes to deepening the recession.

### 3.2. Fiscal policy I

As in Gomes *et al*. (2010) we simulate the scenario where the economy reaches the zero lower bound and consider different fiscal policies that may overcome its effects. The results are different depending on the particular policy.

We first consider a persistent increase in government consumption and a persistent cut in the consumption tax, the labour income tax, the tax on capital income, and the payroll tax, one at a time. The initial increase in government consumption is 2 per cent of steady-state output, and the initial reduction in each tax rate would reduce steady-state revenue also by 2 per cent of output. The spending and tax changes first occur in the quarter when the recessionary shocks hit. Thereafter we assume a gradual return of the instruments to their long-run equilibrium levels.[9] The policy changes are displayed in chart 1 and the results of these simulations are summarised in chart 2.

We first simulate an increase in government spending. The measure alleviates considerably the contraction in output but the fall in consumption and investment is not significantly reduced. Thus an important part of the improvement in output is due to government consumption. This policy reduces the time spent at the zero bound as inflation drops by less than in the no fiscal response case.

We then proceed by lowering taxes. The cut in the consumption tax is also successful in lessening the output contraction, but in this case the drop in consumption is much reduced. The fact that consumers know that the tax is lower today than in the future motivates them to anticipate consumption. The measure is the one that leads to the lowest drop in consumption but investment still drops considerably.

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6 This rule is different from the one in Smets and Wouters (2003), where the interest rate reacts also to the output gap, defined as deviations of actual output from the output that would prevail in a flexible price and wage economy and also to changes in inflation. We also take a lower degree of interest rate smoothing as this helps us in making the zero lower bound constraint binding.

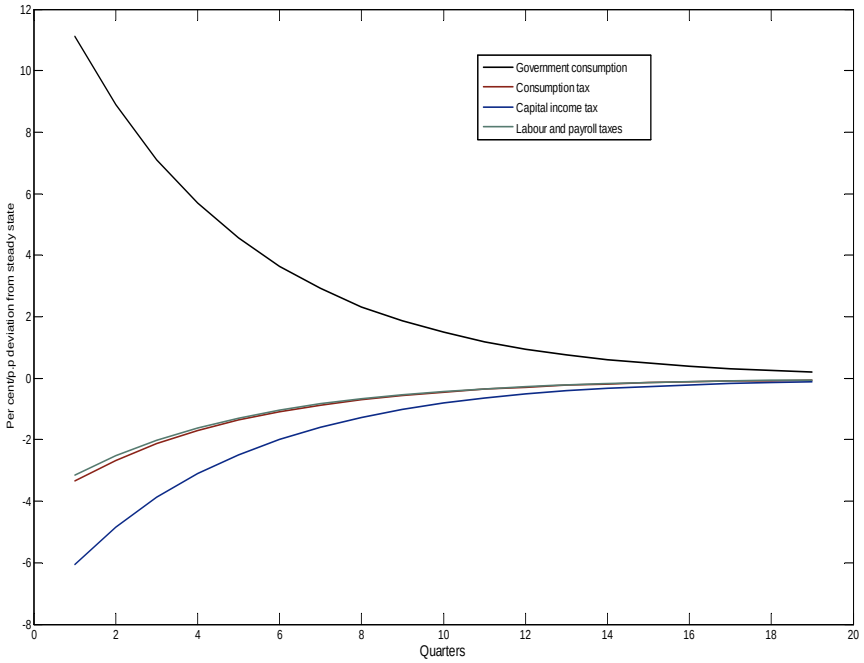
7 Possibly because of increased uncertainty and higher precautionary savings.

8 Implicitly assuming policy did not react.

9 After four years the fiscal policy instruments have basically returned to their steady-state level.

**Chart 1**

**FISCAL SHOCKS EQUIVALENT TO 2 PER CENT OF GDP (*EX-ANTE*)**




The remaining taxes don't have a considerable impact on either consumption or investment and as such on output. The time spent at the zero bound is not significantly reduced. In fact, the reduction of the payroll tax actually lengthens the period over which the zero bound constraint is binding (to 6 quarters). This is so because the reduction in this tax implies a significant fall in firms' marginal costs and therefore induces them to reduce prices. The resulting deflationary effect is stronger than in the case of no fiscal response. Therefore, a monetary authority following a Taylor rule will want to cut interest rates more aggressively and as such hits the zero bound for a longer period.

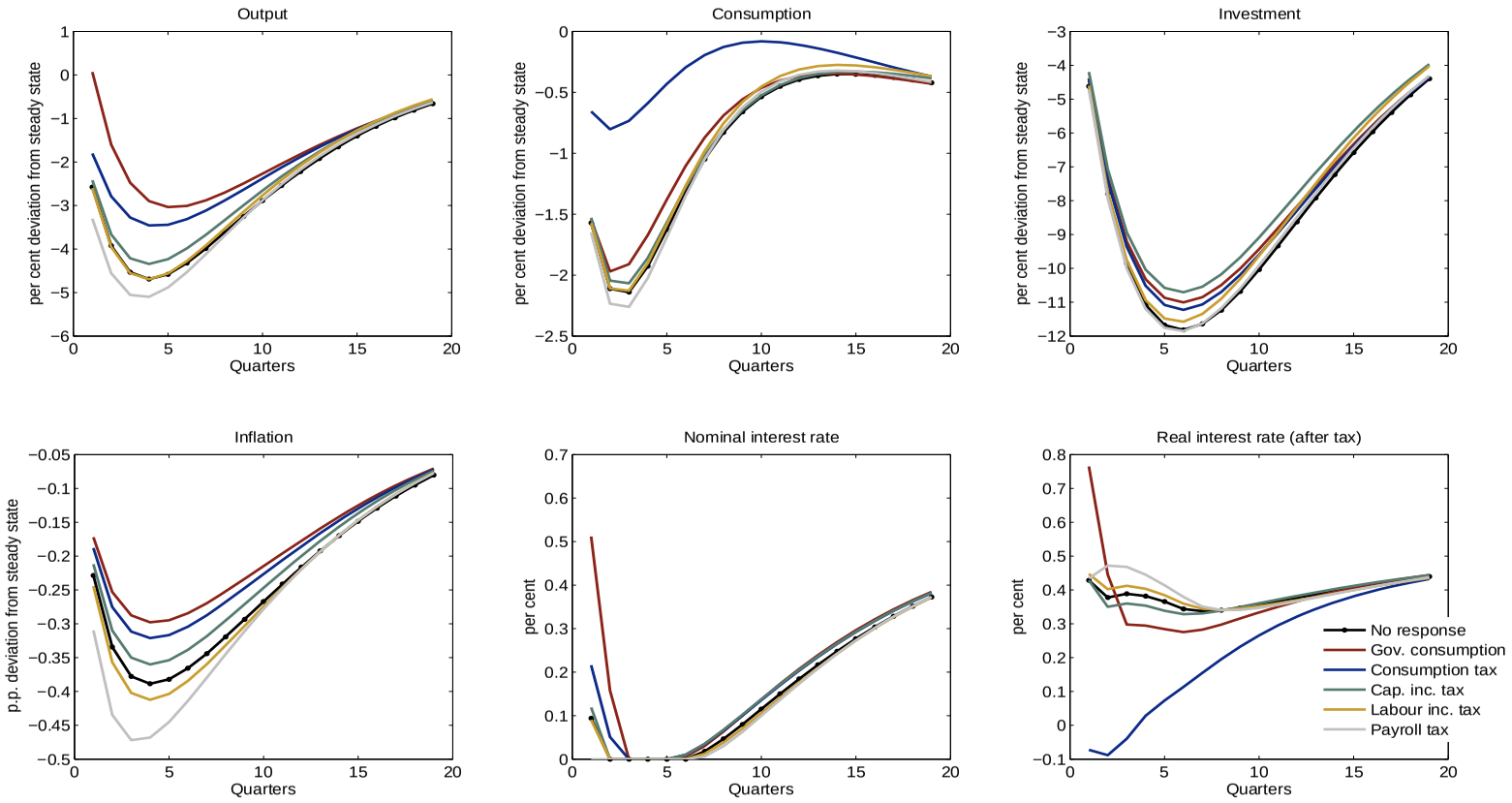
### 3.3. Fiscal policy II

The most successful of the above tax policies in countering the downturn in both output and consumption is the change in the consumption tax. The reason is that it changes the intertemporal incentives for saving. But a cut in consumption taxes also has deflationary implications. In fact wages can be lower and prices too. A higher labour income tax has the opposite effect on inflation. We now experiment cutting the consumption tax and raising the labour income tax. This has another advantage: the scenarios described above imply either a decline in revenue or an increase in spending by the fiscal authority. We can design an experiment in such a way that the impact on the primary deficit would be zero if applied to steady-state level.

We start by decreasing the consumption tax and increasing the labour income tax. We consider changes in the taxes that, if applied to the steady state levels, would not affect tax revenue. Because the policy is revenue neutral (at the steady state) we can increase the magnitude of the changes in both taxes. We therefore simulate a change that is twice as large as the ones described in the previous section, so the effect on steady-state revenue of each tax is equivalent to 4 per cent of output. The results (Chart 3)

## Chart 2

### ALTERNATIVE FISCAL INSTRUMENTS



show that this experiment has a positive impact on consumption that in the short run actually implies an expansion, but it also reduces investment relative to the "no fiscal response" scenario. The final outcome in terms of output is a smaller contraction, which ends up being of a similar order of magnitude to the best scenario (in terms of output) of the single instrument policy increases, *i.e.*, the increase in government spending. Inflation shows a much smaller decline which, together with the impact on output, implies that the monetary authority cuts the interest rate by much less and so interest rates no longer hit the zero lower bound.

As mentioned, this revenue neutral policy is bad for investment, so in order to deal with this we could lower the capital income tax. But to keep this experiment revenue neutral at the steady state, we have to redesign the change in the consumption and income taxes. We started by reducing the consumption tax rate and increasing the labour income tax rate by the same amount. However, given that the labour income share in output is higher, but very close, to that of consumption, this gives us very little margin to decrease the capital income tax and so the end result is similar to the previous case when the capital income tax change is zero. It is actually hard to distinguish the two curves in chart 3.

From these experiments, we would conclude that, while revenue neutral tax policies can help reduce the recession and obtain a better outcome in terms of consumption, they cannot achieve large effects on investment. We now allow for temporary budget deficits.

### 3.4. Fiscal policy III

We maintain the previous policy of a decline in the consumption tax, matched by an increase in the labour income tax, so that the policy change would be revenue neutral in the steady state. On top of that, we lower the capital income tax by an amount equal to 6.4 per cent of steady state output. This obviously implies a sizable increase in the deficit, but that is comparable to the ones observed during this crisis. This policy amounts to a reduction of around 8.3 p.p. in the consumption tax rate and an increase of 7.9 p.p in the labour income tax rate, as well as a reduction to basically zero of the capital income tax rate. The results, depicted in chart 3 (corresponding to "lower change in capital income tax" case in the charts), show that this goes a long way in the right direction in offsetting the contraction in investment.

We proceed by further reducing the tax on capital taking the deficit to very high levels. We keep the changes in the other two tax rates. We succeed in reducing the fall in investment (corresponding to the "higher change in capital income tax" case in the charts). The tax rate on capital income would be negative, meaning that investment would be subsidized. It should be noted that these measures seem to constitute an improvement relative to an increase in government spending, in particular regarding the effect on consumption.

### 3.5. Efficient policy

In the experiments above we proceeded by trial and error. But we know, from Correia *et al*. (2011), that it is possible to use tax policy to achieve full efficiency, overcoming the zero lower bound on nominal interest rates.

The changes in taxes in the model economy that would allow to overcome the zero bound and achieve the efficient allocations, which would be the ones under flexible prices and wages, are displayed in chart 4. To achieve the efficient allocation, the consumption tax would have to be increased over time in order to generate (after-tax) consumer price inflation.[10] But increasing taxes tomorrow relative to today distorts

**10** It should be noted that we chose to start the simulations from the steady state. An alternative implementation would have the consumption tax rate fall on impact and increase back to the steady state, as in the simulations in the previous sections.

## Chart 3

### COMBINATIONS OF TAXES

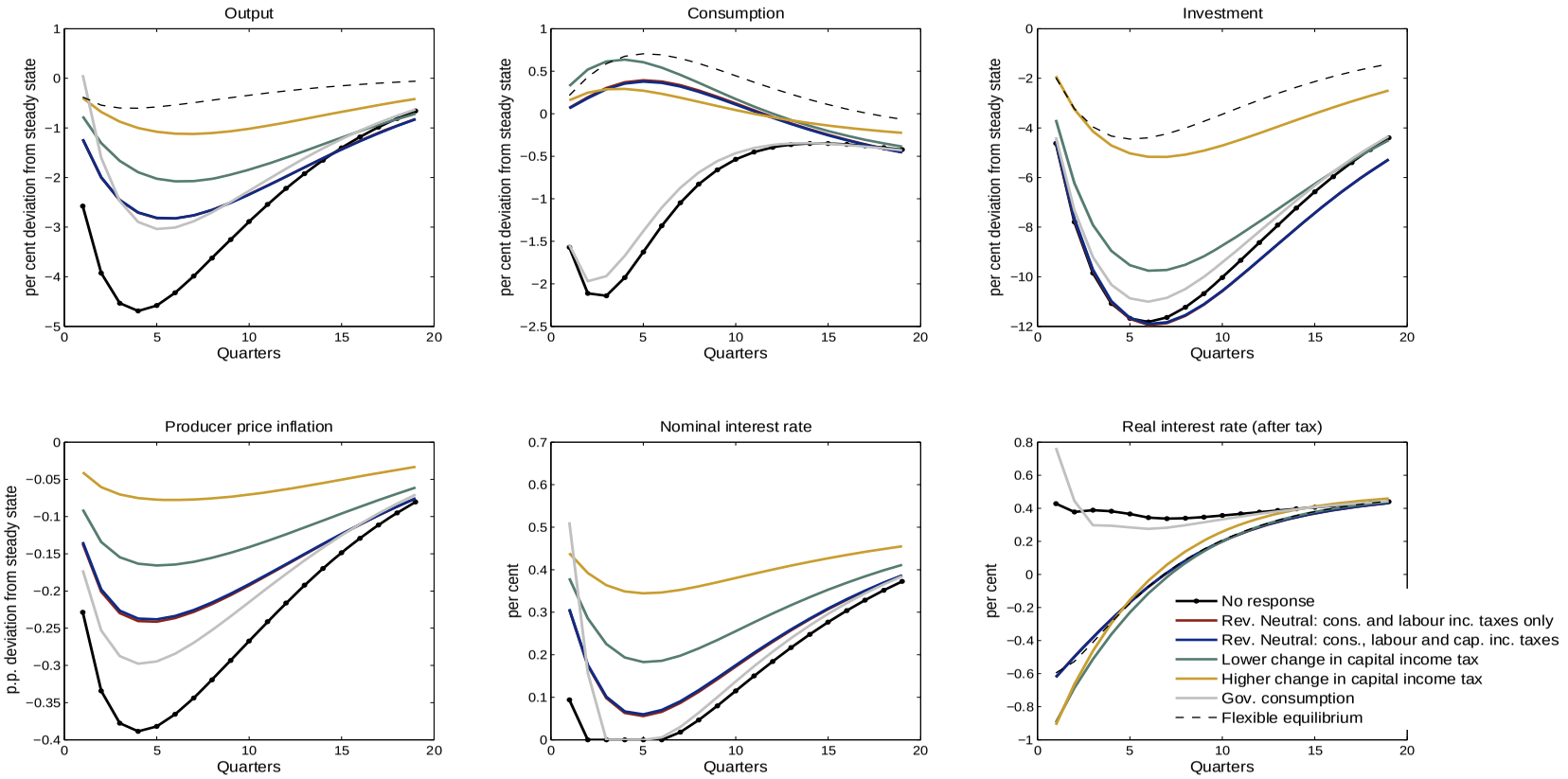
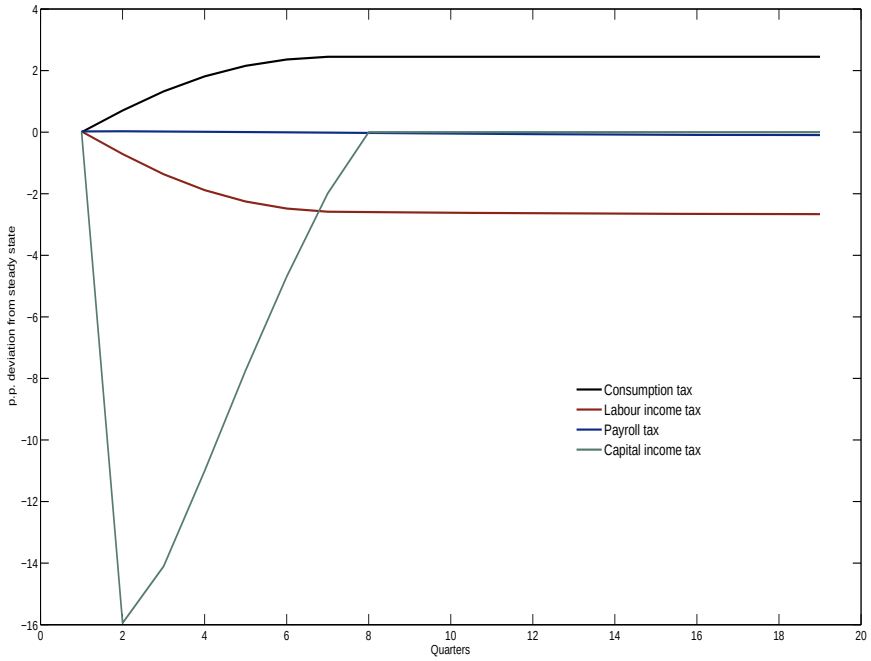


**Chart 4**

**OPTIMAL RESPONSE OF TAXES**




the allocation of labour and capital, so that labour income taxes would have to be lowered accordingly and the tax on capital would also have to be cut. As we could suspect from the results in the previous section, the decline in the capital income tax rate would still have to be sizeable (from 20 per cent in steady state to around 4 per cent in the quarter when it reaches its lower level) but now more manageable. Finally the payroll tax paid by firms would have to marginally adjust to avoid movements in prices.

The response of the economy under flexible prices and wages is displayed in chart 3. As mentioned before, the revenue neutral experiments go in the right direction and as such put the economy closer to the efficient allocation except in the case of investment. In the case of flexible prices and wages investment declines by much less and consumption actually increases in the first periods. Output falls less than in all the other simulations. In order to also achieve a response of investment that is much closer to the efficient one, the reduction in the capital income tax would have to be extremely large and therefore the negative impact on the primary budget is sizeable.

## 4. Final remarks

In this article, we have illustrated how the recent findings in Correia *et al*. (2011) can be used to guide fiscal policy responses to a major recession that leads the economy to the zero lower bound on interest rates. We show that arbitrary fiscal policy leads to results that are far away from the efficient allocation and that, given the model used and the shocks hitting the economy, the required changes in taxes are conceivable in a crisis period. However, the changes in taxes are sensitive to the specific shock hitting the economy (as is optimal monetary policy away from the zero bound) and there is a temporary deterioration of the government budget balance.

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