

The adverse effects of government spending on private consumption in new Keynesian models

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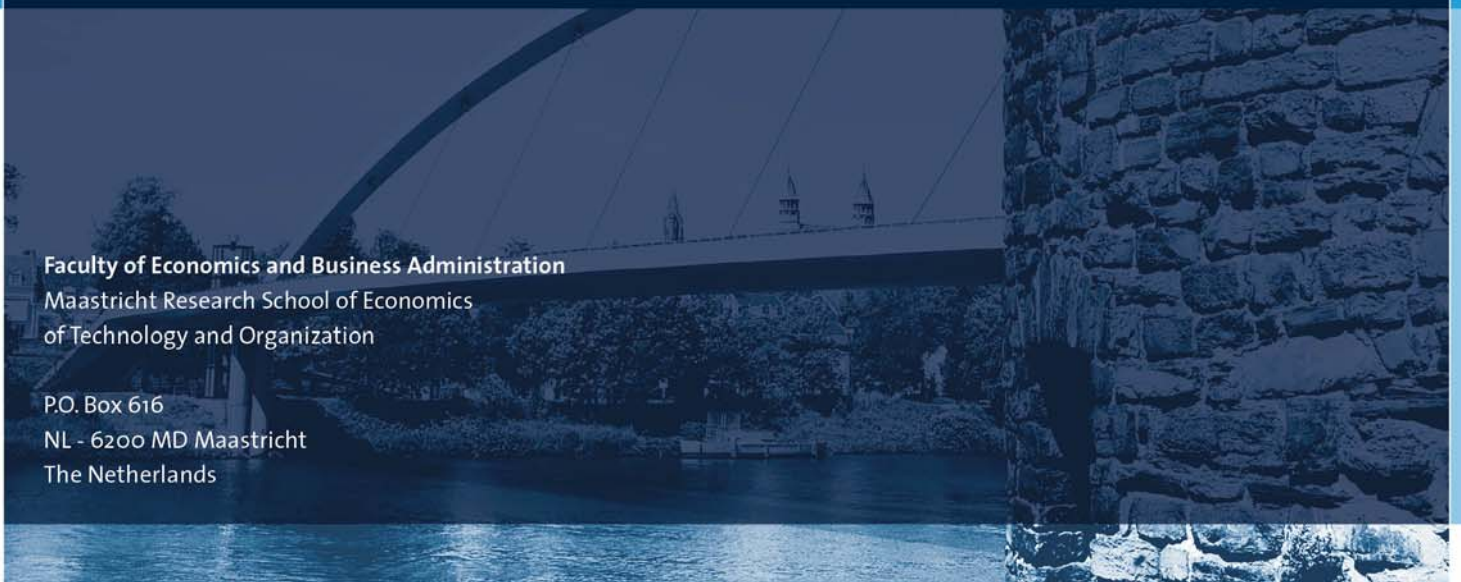
**The Adverse Effects of
Government Spending on Private
Consumption in New Keynesian
Models**

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The Adverse Effects of Government Spending on Private Consumption in New Keynesian Models

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Abstract

Empirical evidence shows that government spending crowds in private consumption, a Keynesian phenomenon. The current state of the art, New Keynesian models based on optimising households and firms, is not able to predict such a result. We show with a graphical framework as well as a formal model why the basic New Keynesian model fails at this. We also show the weaknesses of extensions aimed at generating crowding in like useful government spending or rule of thumb consumers. Finally, we argue that introducing productivity enhancing government spending could potentially lead to crowding in.

JEL: E10 Macroeconomics

1 Introduction

Government spending is an important part of macroeconomic policy. Policy advice on government spending should be using the right tools to make predictions about what a certain type of policy will achieve. Therefore, the predictions of a theoretical model should match the empirically observed response to a certain government spending shock. We analyse the performance of the current state of the art in macroeconomics, closed economy New Keynesian models, from that perspective. We argue that these models fail to predict the empirical impact of government spending on private consumption, a known observation in the literature (Linnemann and Schabert, 2003b). We analyse theoretically what conditions have to be met to allow such a model to match empirical results.

A widely observed empirical result is that increased government spending increases output (Blanchard and Perotti, 2002), an effect that any basic macroeconomic model can

explain. The more troublesome observation is that private consumption also increases upon a government spending shock (Perotti, 2007), a phenomenon labelled "crowding in". In a microfounded representative optimising agent model an increase in output is caused by an increase in labour supply, which in turn requires consumption to fall in order to occur (Baxter and King, 1993). Thus the predictions by the representative agent model seem at odds with empirical evidence. An induced rise in consumption is a typical Keynesian feature, so one should expect a class of models labelled New Keynesian, which features price stickiness, to show these kind of effects.

Unfortunately, this is not true. We show that the simple introduction of a Keynesian feature, price stickiness and the consequence of demand induced deviations of output from its natural level, is not sufficient to generate crowding in effects. Keynesian enhancements of the labour market structure, like real wage rigidity or involuntary unemployment due to labour market frictions, also do not allow private consumption to increase upon a government spending shock. Furthermore, attempts to force the model to deliver the required results, like complementary government spending or rule of thumb consumers, fail in their aim either due to a lacking intuitive and empirical foundation or due to the extreme dependence on parameterisations. The conclusion to be drawn is that a representative agent model with a simple production function and price stickiness is not able to predict the effects of a government spending shock on private consumption as they are estimated by empirical evidence.

This paper's contribution lies in the systematic classification of approaches to have a New Keynesian model generate crowding in of private consumption. Furthermore, the graphical framework allows the systematic proposition of new approaches. Using this systematic analysis, we find that labour supply or labour demand increases are required for crowding in, underlining the fact that the New Keynesian model is still essentially a supply-based model. Furthermore, an increase in consumption demand, a right shift of the IS curve, also supports the model's potential for crowding in, although it is unlikely to cause crowding in on its own. We conclude that the only way to generate consumption crowding in using the framework of intertemporal optimising households with rational expectations is to introduce direct or indirect productivity effects of government spending.

The paper first reviews empirical evidence on the effects a government spending shock has on various macroeconomic variables. In Section 3 the response of a representative optimising agent model to a government spending shock is reviewed. Section 4 shows this effect in a New Keynesian model with price rigidity. Section 5 demonstrates the effects an enhanced labour market structure has on the impact of government spending. In Section 6 attempts to force consumption crowding in on the model are analysed and criticised. Section 7 shows how productivity effects induced by government spending can

produce crowding in of private consumption. Finally, the paper concludes.

2 Review of Empirical Evidence

A large number of authors have estimated the empirical impact of a government spending shock on various macroeconomic variables. The first difficulty is the identification of these fiscal shocks. Ramey and Shapiro (1998) use a scheme of identifying three massive defense build-ups in recent US history as fiscal shocks and estimate the response of various variables. A second approach, first applied by Blanchard and Perotti (2002), is to estimate a multivariate structural VAR, where the additional information of the size of automatic stabilisers is used to recover fiscal shocks orthogonal to the other variables (most notably GDP). An implied assumption is the independence of discretionary fiscal shocks from contemporaneous output. A first finding is that government spending shocks are highly persistent but not permanent. All theoretical analyses in this paper will make use of this fact by looking at persistent temporary government spending shocks.¹

All studies we reviewed conclude that output increases upon a government spending shock. The size of the effect of government spending, dY/dG , depends on the country and the time since the shock. Blanchard and Perotti (2002) as well as Bouakez and Rebei (2007) find a positive impact response of GDP of roughly 1 for the USA. Other authors like Burnside et al. (2004) (for USA), Castro (2006) (for Spain), Galí et al. (2007) (for USA) or Fatas and Mihov (2001) find a hump-shaped response with a maximum impact of around one and the timing of the peak ranging between 5 and 16 quarters. Blanchard and Perotti (2002) also find a high impact of similar magnitude between 12 and 20 quarters, while the GDP response for quarters 4 to 8 is lower. Perotti (2005) estimates the impact of government spending for 5 OECD countries and finds firstly that the effects of fiscal policy tend to be small, with only the USA having a multiplier larger than one, and secondly that the effects of government spending shocks have become substantially weaker in the post 1980- period compare to pre-1980. Summarising, government spending shocks induce increases in output, although there is some indication that the output response comes with a lag.

The source for the increase in output is hard to pinpoint. Burnside et al. (2004) as well as Galí et al. (2007) find a hump-shaped positive response of hours worked, while Bouakez and Rebei (2007) and Fatas and Mihov (2001) find no significant increase in hours. This suggests some increase in labour productivity to be the reason for increased output.

When looking at the composition of GDP, the interesting result emerges that the

¹More specifically, we look at an autoregressive process of the form $G_t - G^* = \rho(G_{t-1} - G^*)$, $\rho < 1$

private consumption response correlates closely with the response of output. Almost all authors find a significant positive response of private consumption to a government spending increase. In absolute terms the response of private consumption is smaller than that of output. There is no clear picture for how private investment behaves in face of a government spending shock. Blanchard and Perotti (2002), Perotti (2005) as well as Bouakez and Rebei (2007) find a strong negative response of investment. Burnside et al. (2004) do not find any, while Fatas and Mihov (2001), Castro (2006) as well as Galí et al. (2007) find a hump-shaped positive investment response.

The impact of government spending on the prices of factors of production has also been tested. Real wages increase according to Bouakez and Rebei (2007), Galí et al. (2007) and Perotti (2007), while after tax compensation decreases according to Burnside et al. (2004). Fatas and Mihov (2001) find that real wages in manufacturing and goods production increase more than total real wages. The real interest rate rises in the estimation of Castro (2006), Fatas and Mihov (2001) as well as Perotti (2005) (for Germany, Canada and Australia). For the USA and GBR Perotti (2005) finds a negative response of the real interest rate.

Different components of government spending have different effects on economic variables. Castro (2006) as well as Heppke-Falk et al. (2006) find that GDP and private consumption both have a hump-shaped response in face of a shock to both purchases of goods as well as public investment, while private investment does not respond. In face of a shock to government wage spending Castro (2006) finds that GDP, consumption and private investment fall, while Heppke-Falk et al. (2006) find no effect. Fatas and Mihov (2001) find an increase in consumption and investment when both government spending on wages and non-wages increases, while there are no effects in face of a government investment shock.

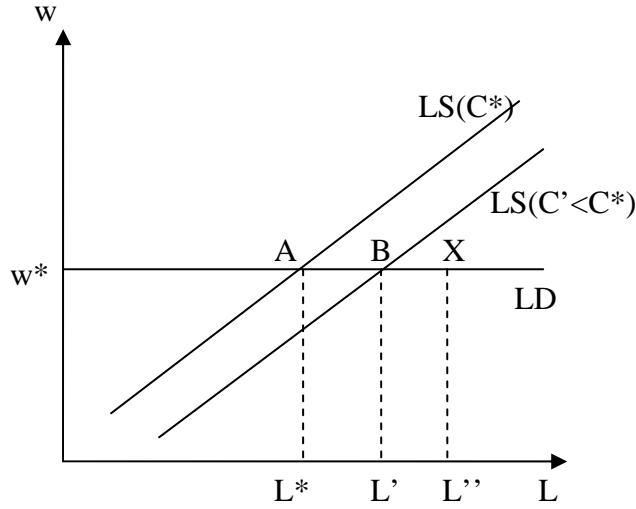
The empirical evidence on the effects of government spending is very diverse. There is a dependence on the sample and the methodology. Nevertheless, the conclusion that a government spending shock leads to increased output and private consumption is strongly supported by the data. Unfortunately, the impact on other variables cannot be clearly observed.

3 The Baseline Model

Current state of the art macroeconomic models employ a framework of utility maximising households that use bonds to intertemporally smooth their consumption.² Within a certain period, the households equalise the marginal utility of consumption and leisure, thus

²See Goodfriend and King (1997) for a survey on this type of models.

Figure 1: The basic representation of the labour market

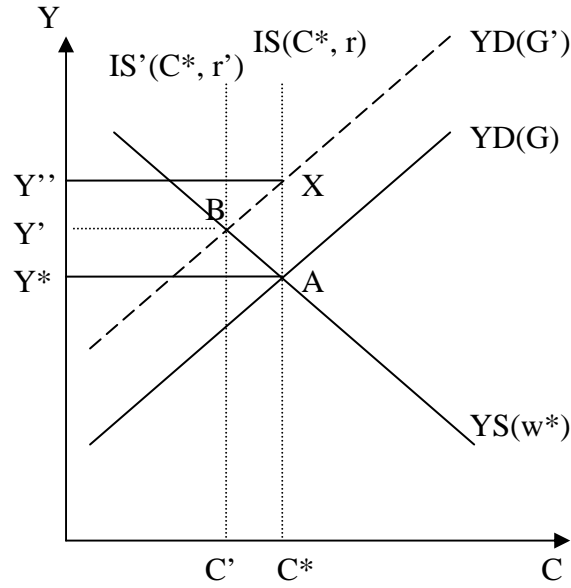


determining their labour supply. Since there is no unemployment, this labour supply is used in a production function to determine output, which in turn determines consumption via the resource constraint.

The labour market, depicted in Figure 1, shows labour demand and labour supply depending on real wage w . For simplicity of exposition we choose a simple production function $Y = L$, with Y representing aggregate output and L aggregate labour supply. This representation implies a constant marginal product of labour and a profit maximising real wage of w^* , determined by the firms' markup on marginal costs. Hence, the labour demand curve LD in Figure 1 is horizontal. All qualitative results in this paper also hold for a downward sloping labour demand curve. The labour supply curve LS is upward sloping since a higher real wage increases the marginal costs of leisure, thus increasing labour supply by households. Furthermore, intratemporal substitution between household consumption and leisure implies that leisure decreases together with consumption; hence the labour supply curve shifts right upon an exogenous consumption decrease. The inverse relationship between consumption and labour supply defines a downward sloping output supply curve YS in Figure 2. The YS curve would shift right if the real wage w were to increase due to exogenous reasons. Actual output in point A is determined in conjunction with the output demand curve YD , which is derived from the resource constraint $Y = C + G$, where C is household consumption and G is government spending.

To complete the model, we introduce the consumption demand curve in Figure 2, which is commonly labelled IS curve. Intertemporal consumption smoothing implies that future consumption, represented by the long-run value C^* , is the anchor point in determining current consumption. Since current income does not affect current consumption demand, the IS curve is vertical at C^* when the real interest rate is at its natural level, r^* , the latter

Figure 2: The basic representation of the equilibrium output and consumption



being the inverse of the rate of time preference. A real interest rate above its natural level induces consumers to shift consumption towards the future, reducing current consumption demand and shifting IS left. Appendix A.1 shows the mathematical derivation.

Consumption smoothing requires bonds to be available to households. Standard RBC and New Keynesian literature usually ignores discussion of bond markets and assumes that households can simply trade these.³ There is a fixed stock of bonds existing and held both by the government and households. In a flexible price closed economy the real interest rate is determined endogenously to match the consumption path with the available output path. If for an exogenous reason households demand more consumption than what they earn ($C^d > Y - G$) they want to sell bonds in return for real goods. Since households are identical, no one buys these and the resulting excess supply of bonds leads to a fall in their price and a rise in the real interest rate, which in turn brings consumption demand in line with available resources ($C = Y - G$) and eliminates the reason for households to sell bonds. To debt finance government spending bonds are sold to households, which will also affect the interest rate if households are not willing to buy the bonds at the original interest rate.⁴

An exogenous increase in government spending from G to G' shifts the output demand curve up to $YD(G')$ in Figure 2. The actual demand for output and labour depends on the response of consumption demand. If IS were to stay in its initial position because the government spending shock was temporary and the long run C^* was unchanged, a

³With identical households, the question who issues or buys the bonds arises

⁴In a model without investment, as is often used in the literature, this also implies zero aggregate national saving.

situation of excess demand for output and labour is created, shown by the distance \overline{XA} in Figures 1 and 2. This causes the real interest rate to rise, as explained above. The higher real interest rate induces consumers to reduce their current consumption demand, shifting IS left. The fall in C increases labour supply, shifting LS right as well as moving up along the YS curve to point B, through which IS ultimately also has to pass for excess demand to disappear. The real wage will still be at w^* due to perfect price flexibility.

Consumption always has to fall given output, independent of whether government spending is financed by debt or taxes.⁵ Ricardian equivalence holds since in a closed economy the government always takes resources from households - an aspect labelled negative wealth effect by Baxter and King (1993). This result shows the basic problem of this type of model in matching the empirical evidence of increasing consumption in response to a government spending shock. Output has to increase by more than the government spending increase to allow consumption to increase as well.

In terms of the model, the YS curve has to shift upwards to compensate for the upward shift of the YD curve, implying a higher output given consumption. Alternatively, the intersection of LS and LD has to be higher by the amount \overline{XA} . The literature has seen a number of approaches leading to shifts in LS or LD on the impact of G , and/or changes in the general slope of LS or LD. In the following sections we discuss the introduction in the baseline model of (1) price setting rigidity, (2) labour market frictions and wage setting rigidity, and (3) changing consumption behaviour. We check whether these features help to resolve the crowding in puzzle using the analytical tools developed in this section.

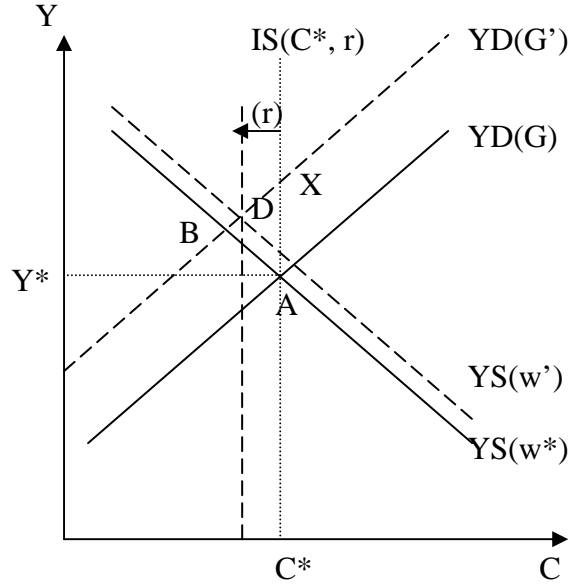
4 Government Spending in a Standard New Keynesian Model

The first method to increase labour supply and output is by increasing the marginal value of leisure through an increase in the real wage. In a flexible price setting, this possibility is ruled out since firms adjust prices immediately in response to a change in their nominal production costs. However, the New Keynesian methodology of applying a staggered price setting mechanism pioneered by Calvo (1983) allows real wages to deviate from their steady state level. Higher real wages will lead to higher inflation today.⁶ This also implies a different adjustment to the impact of government expenditure. In our model the LD and YS curves are not fixed to w^* anymore. Another effect of staggered price setting

⁵Distortional income taxation will influence labour supply and hence its timing is important. For simplicity, we focus on lump sum taxation throughout this paper.

⁶The New Keynesian Phillips curve, derived for example by Galí and Gertler (1999), is used to obtain this result.

Figure 3: Government Spending Shock in a New Keynesian Model



is that firms set prices with a higher mark-up on marginal costs due to the chance of a cost increase upon which they might not be able to increase prices.

The key point of the New Keynesian model is that demand determined short run deviations of output from its natural level are possible. A temporary government spending shock causes excess demand illustrated by the distance \overline{XA} in Figure 3. Not all firms can increase prices in response to the increased pressure on wages, which leads to a rise in real wage. Realised markup of firms falls under desired markup, which shifts the LD curve, which could also be seen as a price setting curve, upwards. Therefore, the YS curve also shifts up, while at the same time the IS curve shifts left since increased inflation causes the central bank to raise the real interest rate⁷, reducing consumption demand. The resulting equilibrium point along the YD' line in Figure 3 is between points B and X.

Since consumption after the spending shock will always be below C^* , the standard New Keynesian model cannot generate a realistic response of private consumption to a government spending shock. Next, we look at modifications to the labour market structure that influence the YS curve and investigate their effect on the consumption crowding in puzzle.

⁷The assumption of a central bank increasing the real interest rate in response to inflation is the Taylor principle and a known requirement for macroeconomic stability (Edge and Rudd, 2007)

5 Labour Market Modifications and Government Spending

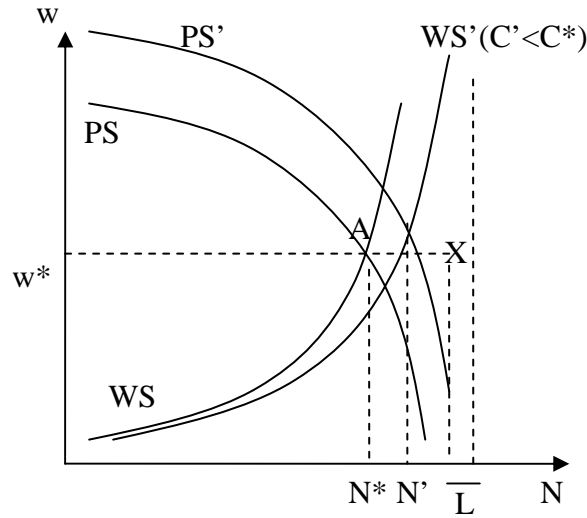
This section explores the effects of two labour market modifications on the consumption crowding in puzzle. First, real wage rigidities are a natural extension to look at in a model that is meant to show Keynesian features. Second, introducing involuntary unemployment due to labour market frictions creates additional channels for increasing output. We will show that these labour market extensions can have a positive impact on private consumption compared to the standard model, but will still not lead to crowding in.

In the standard model the optimality condition of households implies that the real wage equals the marginal rate of substitution between labour and consumption ($w = mrs$). Blanchard and Galí (2007) introduce real wage rigidity through the ad-hoc assumption that the real wage is partially determined by lagged real wage, and partially by the mrs . Appendix A.2 shows the mathematical implementation of this. As a direct consequence the LS curve becomes flatter since an equal rise in current real wage causes a stronger response of labour supply. An upward shift of the LD curve caused by excess demand in response to a government spending shock therefore leads to a larger increase in labour supply.

The implications for the response of the model to a temporary government spending shock are rather limited. The response of real wages, and therefore of inflation and the interest rate, will be lower compared to the standard New Keynesian model. However, real wages and inflation will be more persistent, which depresses consumption demand due to consumption smoothing. For a broad range of real wage rigidities there is hardly any effect on consumption compared to the analysis in Figure 3. When real wages are very rigid, inflation is very low and consequently consumption crowding out is very small. Nevertheless, consumption after the government spending shock will always be below C^* . This shows that real wage rigidity alone does not align the New Keynesian model with empirical evidence.

Blanchard and Galí (2008) combine a Diamond-Mortensen-Pissarides model with nominal rigidities to arrive at a New Keynesian model that features involuntary unemployment. Firms face a constant job separation rate that needs replacement as well as hiring costs that rise with labour market tightness, which is defined as the ratio of hires to unemployment. A higher usage of the available pool of workers, thus a low unemployment rate, implies higher steady state costs incurred to keep this amount of workers. Blanchard and Galí (2008) make the important assumption that the available pool of workers is fixed and always larger than the amount of workers employed by firms.

Figure 4: The labour market with frictions



The labour market is represented by a price setting and wage setting equation.⁸ Using Nash bargaining, workers demand a higher wage as their marginal rate of substitution of labour increases as well as when there is a tighter labour market. Firms take wages and hiring costs into account for their price setting decision, which implicitly leads to downward sloping price setting curve since bigger hiring costs leave less room for wages given a certain optimal markup (Blanchard and Gali, 2008). Figure 4 depicts the labour market with the WS and PS curves as well as the equilibrium unemployment $U^* = \bar{L} - N^*$. A fall in consumption shifts the WS curve downwards. Theoretically, the YS curve should approach an upper limiting output given by the fixed total labour supply. For our purposes the YS curve is simply downward sloping like in Figure 2, since we assume that the government spending shock is small and an output increase of size \overline{XA} in Figure 2 does not exhaust the pool of unemployed workers.

A temporary government spending shock leads initially to the familiar excess demand situation \overline{XA} . Sticky prices implies that not all firms can realise their desired markup when prices increase, causing a fall in aggregate markup and an upward shift of the PS curve to PS'. This also shifts the YS curve upward. The higher real wage as well as hiring cost increases marginal costs for firms, which according to the Phillips curve leads to inflation. The resulting higher real interest rate reduces consumption demand, shifting IS left. The outcome is thus remarkably similar to the standard New Keynesian model in Figure 3, with the difference that increases in output additionally increase hiring costs by firms, putting additional pressure on inflation.

Government spending does reduce involuntary unemployment, but it is not able to generate crowding in for the simple reason that IS will never shift right. Under the

⁸Appendix A.2 shows these equations.

assumption of extreme real wage rigidity the best the model can achieve is only very small consumption crowding out. A useful approach therefore either has to shift IS far enough right that the excess demand increases real wages enough for YS to shift up into a position of crowding in, or it has to shift YS up so that the crowding in is generated by the supply side, of a combination of both.

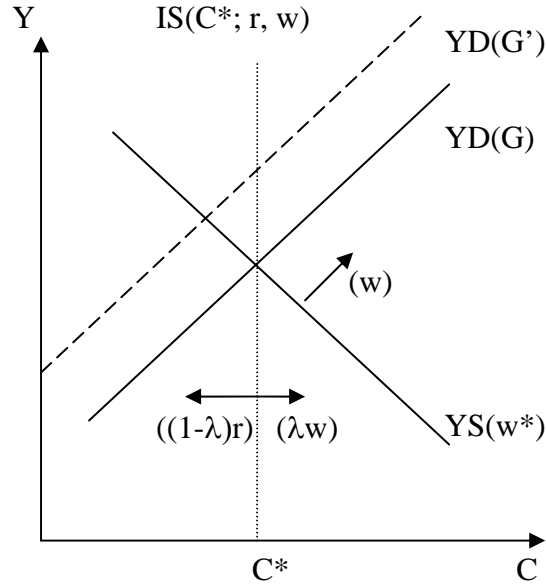
6 Demand Side Modifications and Government Spending

This section looks at the third possibility discussed to increase output supply; by modifying household's consumption behaviour. In a method suggested by Linnemann and Schabert (2003a) government spending enters the household utility function in a way that marginal utility of private consumption is raised when government spending increases. The first consequence is that the IS curve depends positively on G . Given the temporary nature of the government spending shock, current consumption has to be higher than future consumption to equalise marginal utility as required by intertemporal consumption smoothing. The second consequence is that the marginal utility of leisure can also rise, implying a lower level of leisure and thus a higher labour supply. Therefore, the LS curve shifts right and the YS curve shifts upward with G . The mathematical derivation is shown in Appendix A.3.

This approach thus works through a combination of an upward shift of the YS curve as well as a rightward shift of the IS curve. When the complementary effect of utility from government consumption on utility from private consumption is large enough to counter the negative wealth effect, the YS curve shifts up far enough to allow an increase in private consumption and output upon a government spending shock. Unfortunately, it is both intuitively as well as empirically difficult to justify such an effect of the required magnitude (See Ni, 1995; Amano and Wirjanto, 1998; Kwan, 2006, for empirical evidence).

Galí et al. (2007) use the idea also proposed by Mankiw (2000) of having savers and spenders in an economy, also called "optimising" and "rule of thumb" consumers. The latter are supposed not to engage in intertemporal optimisation but rather to only consume their current income, which depends on real wage. Thus, rule of thumb consumers are exposed to an extreme form of credit constraint. As a consequence the IS curve in Figure 5 is amended with the real wage as a shift factor. If λ is the share of rule of thumb consumers in the economy, a rising real wage shifts IS right more as λ increases. In the same instance, the left-shift effect of a rising real interest rate becomes smaller as λ increases. The long run equilibrium is not affected since it is supply determined and both optimising as well as rule of thumb consumers have the same consumption-leisure trade-off. Appendix A.2

Figure 5: Model with Rule of Thumb Consumers

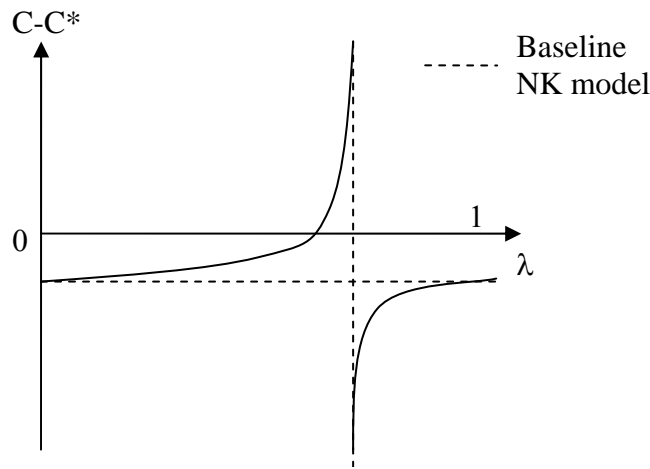


also includes this derivation.

In the face of a non-permanent government spending shock, the resulting equilibrium is similar to Figure 3 for small λ , since the effect of the real wage on the IS curve is very small. As λ increases, the left-shifting impact of the interest rate we identified in Figure 3 becomes weaker, while the right-shifting impact of the real wage becomes stronger, leading to higher consumption demand and an increase in real wage to meet that demand with an corresponding labour supply. One should realise that the YS-curve and the LS-curve as such are not affected by the introduction of rule of thumb consumers. However, since the real wage is affected more strongly, the LD-curve and thus the YS curve shift more upwards. Hence, IS and YS intersect at a higher point of the YD curve, eventually at a point above C^* if λ is high enough.

The weakness of the model lies in the fact that further increases in λ eventually cause the IS to shift further than the YS, making an equilibrium above C^* not possible. The reason is that a higher real wage increases consumption demand of rule of thumb consumers one for one, while it does not increase output supply on a one for one basis. When the moderating impact of the real interest rate on consumption demand through optimising consumers falls as λ increases, IS shifts further than YS when the real wage increases. Thus excess demand leads to more excess demand, the model is explosive and does not reach an equilibrium. Galí et al. (2007) call this the region of indeterminacy. The mathematical solution, which does not have an intuitive explanation, is a negative real wage response, so that IS and YS shift down until IS and YS intersect along YD. For $\lambda = 1$, the economy behaves like in the flexible price equilibrium because without agents engaging in consumption smoothing, there will be no excess demand and hence no real

Figure 6: Private Consumption Response depending on the share of Rule of Thumb Consumers



wage increases (C^* and r disappear from the IS-curve). Figure 6 shows the response of consumption depending on λ with the odd switching point described.

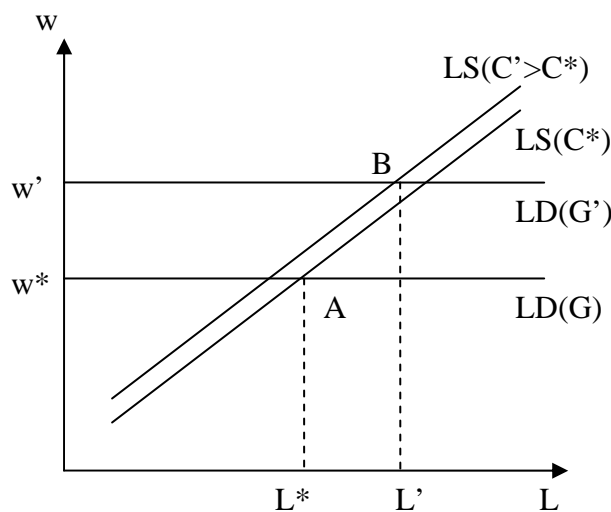
Coenen and Straub (2005) find that the rule of thumb consumer approach does raise private consumption compared to the basic New Keynesian model, but only by small amounts. They conclude that consumption crowding in is unlikely, since it requires a very small range of share of rule of thumb consumers to be viable. Galí et al. (2007) calibrate their model to obtain crowding in by assuming a strong degree of price stickiness and still require a relatively high share of rule of thumb consumers. The common feature of the rule of thumb literature is that under the assumption of a realistic share of rule of thumb consumers reasonable changes parameterisations can move the economy from crowding out to indeterminacy, with only very limited scope for actual crowding in. This shows that a method based on only affecting the IS curve does not work.

7 Productive Government Spending

A number of authors have investigated the effects government spending might have on the productive capacity of private sector resources. Romp and de Haan (2007) undertake an extensive survey on both methodological issues as well as results of empirical research into the productive effects of public capital. They find that there is a general consensus that public capital investment in fact increases the productivity of private production factors. Most output elasticity estimates with respect to public capital range from 0% to 0.5%.

When thinking of productive government spending, the first association is of course made with a public capital stock. However, current expenditures on security, medical services or basic education increase productivity without amending to a capital stock.

Figure 7: The Labour Market with Productive Government Spending



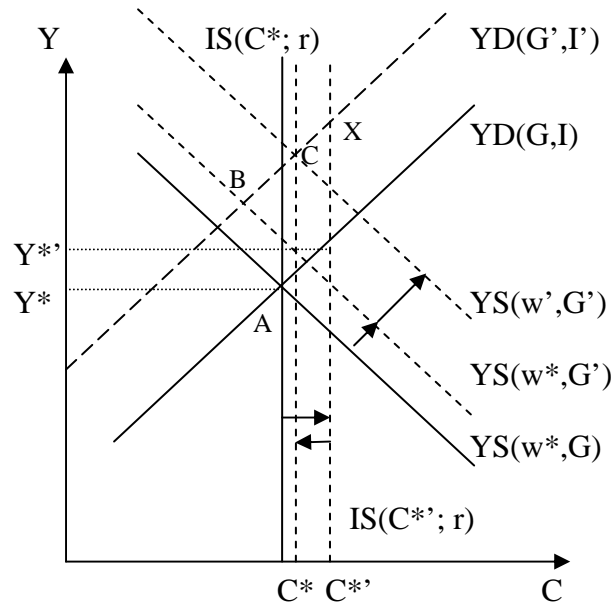
Thus, productive government spending can also be seen as a flow variable. In fact, Barro (1990) used this approach in the analysis of the impact of productive government spending on economic growth. Irmen and Kuehnel (2008) show that the stock and the flow approach have a similar impact on steady state growth. An increase in the constant share of output used for productive government spending increases the steady state growth rate of private consumption. Since the model used in this paper is simple thus far, we keep it that way and disregard the complicating dynamics of a stock approach in favour of a simple flow approach.

The production function is amended with a productivity factor, which increases as government spending increases.⁹ A straightforward consequence of this change is that a government spending increase also shifts the LD curve upward in Figure 7 since the marginal product of labour and hence the profit maximising real wage increases. Since the LS curve behaves as in the standard model, an increase in productivity due to productive government spending shifts the YS curve up along with the upward shift of the YD curve. If there was no long run effect on output and consumption by the government spending shock, consumption crowding in would require the YS curve to shift further than the YD curve, as in Figure 8. The resulting excess supply will lower labour demand, real wages, inflation and thus the real interest rate, inducing consumers to shift more demand to the present and thus shifting IS right. The condition for this to happen is that a rise in government spending leads to a more than proportional rise in productivity. This cannot be found in empirical research.

To obtain a demand driven consumption crowding in, the IS curve has to shift right caused by a rise in C^* . Using an endogenous growth model, Barro (1990) shows that

⁹Appendix A.4 presents the mathematical details.

Figure 9: Model with Permanent Effect of Productive Government Spending



government spending can do so. There is a large amount of literature on the theory of productivity effects of government spending (See for example Devereux et al., 1996; Turnovsky, 2000, for important contributions.). Furthermore, there is empirical support indicating that government spending is indeed productive. Thus this approach is a viable solution to the crowding in puzzle. Modelling the conditions for this approach to work is beyond the scope of this paper.

8 Conclusion

Empirical research finds the Keynesian effect that private consumption rises in face of a temporary government spending shock. Paradoxically, a class of models labelled New Keynesian produces the opposite effect. Although price stickiness allows output to deviate from its natural level, consumption demand simply does not rise in face of a government spending shock, hence disallowing any crowding in. In fact, consumption is crowded out. Changes to the labour market structure like real wage rigidity are only successful at reducing the crowding out effect.

The focus of recent research has hence been to change household behaviour in a way that allows crowding in. The first approach, where household's marginal private utility increases when government spending increases, works out well theoretically but clearly lacks both intuitive and empirical backing. The second approach of savers and spenders enjoys a reasonable intuitive basis but runs into problems due to its extreme dependence on parameterisations to deliver desired results.

A model that is to show crowding in behaviour must feature on the one hand a rise in consumption demand and on the other hand a rise in output that does not cause a strong increase in inflation. Direct or indirect productivity effects of government spending is a method that fulfills both these criteria and hence has the potential to resolve the "crowding in puzzle". Further research will have to model this approach to determine under what conditions crowding in will occur.

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A Mathematical Appendix

The appendix shows the mathematical derivation of the equations used in the figures in the text. We adhere to the standard assumption of rational expectations, but disregard stochastic shocks, thus allowing perfect foresight in our model. Furthermore, we follow the literature by using log-linearised equations, where variables are stated in their percent deviation from their steady state value, $\hat{x}_t = \frac{X_t - X}{X}$. The basic derivation of the consumption Euler equation and the labour supply equation can be found in any advanced textbook, for example in Galí (2008). We assume in line with the literature that the model possesses a steady state and investigate the dynamics close to the steady state when the model is subjected to a temporary government spending shock.

A.1 The standard New Keynesian Model

The YD curve is the resource constraint.

$$YD : \quad \hat{y}_t = \frac{C}{Y} \hat{c}_t + \frac{G}{Y} \hat{g}_t \quad (1)$$

It shows the combinations of output and consumption that are possible given government spending. The household instantaneous utility function is

$$u_t = \log(\tilde{C}_t) - \frac{1}{1+\phi} L_t^{1+\phi} \quad \phi > 0 \quad (2)$$

with L_t being the period's labour supply and \tilde{C}_t being effective consumption. When $\tilde{C}_t = C_t$ and $Y_t = L_t$, the labour supply curve (LS) and output supply curve (YS) follow from the trade-off between consumption and leisure.

$$YS : \quad \hat{y}_t = \hat{l}_t = \frac{1}{\phi} \hat{w}_t - \frac{1}{\phi} \hat{c}_t \quad (3)$$

The New Keynesian IS curve can be derived from the intertemporal Euler equation.

$$IS : \quad \hat{c}_t = \hat{c}_{t+1} - (\hat{R}_{t+1} - \hat{\pi}_{t+1}) \quad (4)$$

Substituting forward, and defining the deviation of the real interest rate from its steady state level as $\hat{r}_{t+1} = \hat{R}_{t+1} - \hat{\pi}_{t+1}$ we obtain

$$IS : \quad \hat{c}_t = \hat{c}_{LR} - \sum_{i=t+1}^{\infty} \hat{r}_i \quad (5)$$

In the paper we implicitly assume that the New Keynesian Phillips curve causes higher inflation when marginal costs, or real wages, increase. The derivation of the NK Phillips curve can be seen for example in Galí and Gertler (1999).

A.2 Labour Market Modifications

The household optimisation equations are as in the previous section. Additionally, we assume a real wage rigidity as is also used by Blanchard and Galí (2007).

$$w_t = \gamma w_{t-1} + (1 - \gamma) mrs_t$$

γ determines the degree of real wage rigidity. Substituting equation 3 for the marginal rate of substitution, we get:

$$YS : \quad \hat{y}_t = \hat{l}_t = \frac{1}{\phi} \left(\frac{1}{1-\gamma} \hat{w}_t - \frac{\gamma}{1-\gamma} w_{t-1} \right) - \frac{1}{\phi} \hat{c}_t \quad (6)$$

If $\gamma > 0$, a current real wage increase leads to a larger upward shift of the YS curve.

For a detailed derivation of the model by Blanchard and Galí (2008), see their paper. The important aspect of their model is labour market tightness x as a driving force of marginal costs. It is defined as the ratio of hires to the pool of unemployed, and thus has an upper bound of 1.

$$x_t = \frac{H_t}{U_t} = \frac{N_t - (1 - \delta)N_{t-1}}{\bar{L} - (1 - \delta)N_{t-1}} \quad (7)$$

where \bar{L} is fixed and δ is a constant job separation rate. The introduction of labour market tightness as well as Nash wage bargaining leads to the following wage setting (WS) and price setting (PS) equations.

$$WS: \quad w_t = C_t N_t^\phi + \vartheta \left[Bx_t^\alpha - \beta(1 - \delta)E_t \left(\frac{C_t}{C_{t+1}}(1 - x_{t+1})Bx_{t+1}^\alpha \right) \right] \quad (8)$$

$$PS: \quad w_t = \frac{1}{\mu_t} - Bx_t^\alpha + \beta(1 - \delta)E_t \left(\frac{C_t}{C_{t+1}}Bx_{t+1}^\alpha \right) \quad (9)$$

where ϑ is the bargaining power of workers, B and α are constants related to hiring costs, and μ is the markup firms can have in setting their price.

A.3 Demand Side Modifications

A.3.1 Useful Government Spending

By redefining effective consumption to include government spending as was done by Linnemann and Schabert (2003a), it has an impact on the utility function.

$$\tilde{C}_t = (\alpha C_t^\gamma + (1 - \alpha)G_t^\gamma)^{\frac{1}{\gamma}} \quad \gamma \in (-\infty, 1), \quad \alpha \in (0, 1) \quad (10)$$

The parameter γ determines the impact government spending has on marginal utility of private consumption. When $\gamma < 0$, this impact is positive and private and public consumption are complements. The IS-curve solved forward for this model is

$$IS: \quad \hat{c}_t = \hat{c}_{LR} + \frac{\psi_2}{\psi_1}(\hat{g}_t - \hat{g}_{LR}) - \frac{1}{\psi_1} \sum_{i=t+1}^{\infty} \hat{r}_i \quad (11)$$

where $\psi_1 = (1 - \gamma)(1 - \eta_c) + \eta_c > 0$ and $\psi_2 = -\gamma\eta_g$. The steady state elasticity of \tilde{C} with respect to C_t is defined as $\eta_c = \alpha(\tilde{C}/C)^{-\gamma} > 0$. For $\eta_g = (1 - \alpha)(\tilde{C}/G)^{-\gamma} > 0$ the same holds with respect to G_t . It must further hold that $\eta_c + \eta_g = 1$. The YS curve changes as well to

$$YS: \quad \hat{y}_t = \frac{1}{\phi} \hat{w}_t - \frac{\psi_1}{\phi} \hat{c}_t + \frac{\psi_2}{\phi} \hat{g}_t \quad (12)$$

When government spending plays no role in private utility ($\alpha = 1$), or when it does not affect the marginal utility ($\gamma = 0$), then $\psi_1 = 1$ and $\psi_2 = 0$. The IS and YS curve then collapse to their standard counterparts equation 3 and 5.

A.3.2 Rule of Thumb Consumers

To introduce rule of thumb consumers as done by Galí et al. (2007), we again assume $\tilde{C}_t = C_t$. Rule of thumb consumers have the utility function equation 2 but face the budget constraint:

$$C_t = w_t L_t - \tau_t$$

Consumption then is determined by the log-linearised budget constraint

$$\hat{c}_t^r = \frac{wL}{C}(\hat{w}_t + \hat{l}_t^r) - \frac{\tau}{C}\hat{\tau}_t^r \quad (13)$$

We assume that rule of thumb households make up a share λ of all households in the economy. The log-linearised aggregate consumption and employment are

$$\hat{c}_t = \lambda\hat{c}_t^r + (1 - \lambda)\hat{c}_t^o \quad (14)$$

$$\hat{l}_t = \lambda\hat{l}_t^r + (1 - \lambda)\hat{l}_t^o \quad (15)$$

Using equations 14 and 15 as well as the optimal labour supply of the households, we see that the aggregate YS curve is unchanged. The IS curve solved forward is

$$\begin{aligned} IS : \quad \hat{c}_t = & \hat{c}_{LR} + \frac{\lambda(1 + \phi)}{\frac{C}{Y}\phi + 1}(\hat{w}_t - \hat{w}_{LR}) - \frac{\lambda\frac{\tau}{Y}\phi}{\frac{C}{Y}\phi + 1}(\hat{\tau}_t^r - \hat{\tau}_{LR}^r) \\ & - (1 - \lambda) \sum_{i=t+1}^{\infty} \hat{r}_i \end{aligned} \quad (16)$$

A.4 Productive Government Spending

Consumers optimise the utility function equation 2, meaning the IS curve equation 5 is still valid. The LS curve equation 3 is also valid except for the fact that $\hat{y}_t \neq \hat{l}_t$. We rather assume some impact of government spending on labour productivity, so that

$$Y_t = A(G_t)L_t$$

where $\partial A(G)/\partial G > 0$. We furthermore normalise the steady state value of $A(G) = 1$, so that the log-linearised output is

$$\hat{y}_t = \hat{a}(G_t) + \hat{l}_t \quad (17)$$

Combining equation 3 with equation 17, we obtain the new YS curve

$$YS : \quad \hat{y}_t = \hat{a}(G_t) + \frac{1}{\phi}\hat{w}_t - \frac{1}{\phi}\hat{c}_t \quad (18)$$