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Frictional product market, supply chains and the impact of government expenditures on private consumption

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Abstract

Standard macroeconomic models predict positive values of the government spending multiplier and a decreasing relationship between private consumption and government expenditures. The latter result is at odds with empirical evidence, suggesting that this negative pattern is either moderate or insignificant. Moreover, there are works indicating that this relationship is positive. The aim of this paper is to rationalize positive reactions of both output and consumption induced by higher government spending. To explain those patterns, I use a theoretical model including two ingredients: search frictions in the product market and simple supply chains. It is shown that, in isolation, these two elements give rise to the standard prediction found in the theoretical literature: an increase in fiscal expenditures crowds out private consumption. However, the interaction of both elements generates two equilibria and one of them features both a positive fiscal multiplier and an increasing relationship between government spending and private consumption.

Keywords: fiscal policy, government spending multiplier, supply chains, search frictions, private consumption

JEL: E21, E62, H31, H32, H50

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1. Introduction

The impact of government expenditures on private consumption is crucial for the assessment of fiscal policy from the welfare perspective. Moreover, it is key for the emergence of the multiplier effects resulting from higher government purchases. Empirical evidence indicates that the influence of higher fiscal spending on private consumption is rather positive. This is an intriguing outcome because conventional wisdom could suggest that government uses the resources that could be otherwise consumed by households when it raises fiscal expenditures and, as a consequence, could crowd out household spending.

In this paper, I propose a simple framework to study the impact of an increase in government consumption on aggregate output and private consumption that uses two ingredients: frictional product market and the presence of supply chains within the firms' sector. It is shown that, in isolation, these two mechanisms imply a negative reaction of consumption to government spending. The interaction of these elements, however, generates two equilibria and one of them features a positive response of private consumption to a rise in government purchases. This occurs due to a novel mechanism: higher fiscal spending coordinates firms to scale up their capacities which, in turn, decreases the effective price paid by households for consumption goods which, as a result, boosts private spending. This effect is present despite the assumption that the government purchases exactly the same goods as those consumed by households and, as such, it lowers the amount of resources available to consumers.

The first ingredient – frictional product market – is applied in the analysis because it gives a precise meaning to the notion of product market tightness (i.e. the relationship between the orders placed by customers and the aggregate output capacity of firms). Additionally, as discussed by Storesletten, Rios Rull and Bai (2011), frictional product market gives rise to a situation in which aggregate output is determined not only by the level of production factors, but also by the demand created by customers (e.g. meals in restaurants are produced only if customers show up and order them). In other words, product market frictions imply that output becomes demand-driven. As such, the presence of product market frictions engenders an intuitive channel through which additional demand generated by government spending increases output manufactured by firms.

The second ingredient – supply chains within the firms' sector – implies that tighter markets (e.g. resulting from an increase in government spending) are not always beneficial for firms. This may seem somewhat counterintuitive because, as discussed above, the increased product market tightness means that firms find it easier to sell their output. The situation is different, however, if one considers a model with supply chains in which firms search for production factors in a frictional product market. This occurs because higher product market tightness raises the effective price at which firms purchase production factors. The opposite holds if the product market drops: firms enjoy cheaper production factors, incentivizing them to expand output. This effect, as explained later, is crucial for the main result of this paper, i.e. the increasing relationship between government spending and private consumption.

The rest of the paper is organized as follows. Section 2 presents the related literature. Section 3 lays out the model with the frictional product market and shows that it cannot replicate the pattern documented in the literature, i.e. that an increase in government spending crowds out private consumption. An analogous result obtains in the model with supply chains that is presented in Section 4. Section 5 studies the model in which these two ingredients (frictional product market and supply chains) are combined and analyses the effects of an expansion in fiscal consumption in that setting. Section 6 summarizes the main findings of the paper.

2. Literature

Empirical evidence. I do not discuss empirical studies documenting positive government spending multipliers (i.e. the fact that output rises as a result of higher government spending) as it seems that there is a broad consensus on this issue among researchers.

Instead, I concentrate on the strand of the literature that describes the relationship between public expenditures and private consumption. An overview of the empirical evidence concerning this issue is presented by Gali, Lopez-Salido and Valles (2007). They conclude that, on the one hand, some empirical works find large, positive and statistically significant responses of private consumption to higher fiscal expenditures. On the other hand, there are papers documenting negative responses which, however, are generally found to be small in absolute terms and often statistically insignificant. Blanchard and Perotti (2002) and Fatas and Mihov (2001) use the Vector Autoregression (VAR) model to study the impact of a persistent rise in government expenditures. Both papers conclude that fiscal expansions cause large increases in private consumption. Ravn, Schmitt-Grohe and Uribe (2012) use the structural panel VAR and document that an increase in government consumption raises private consumption. Fisher and Peters (2010) identify government spending shocks with statistical innovations to the accumulated excess returns of US military contractors. They document a positive relationship between government spending and private consumption. Mountford and Uhlig (2009) find that government expenditures crowd out private investment, but they barely influence consumption. Finally, Ramey (2011) finds that the response of non-durable consumption is negative (but small in absolute terms) and the reaction of consumption of services is positive.

Government expenditures in the Real Business Cycle (RBC) model. This strand of literature emphasizes the impact of government consumption on hours worked. This channel plays a key role since, in the absence of an instantaneous adjustment of capital (which is pre-determined and fixed in the current period in the RBC model), output in the short run can increase solely if the number of hours worked rises. Aiyagari, Christiano and Eichenbaum (1992) view jumps in government consumption as exogenous reductions in disposable income of households. They argue that if the income effect resulting from a contraction in disposable income on leisure is zero, then changes to government spending have no effect on hours and, consequently, on output. In contrast, the government spending multiplier is positive if lower disposable income has an impact on labour supply decisions of households. This paper, however, does not focus on the effects of government spending on consumption. This issue, in turn, is discussed in an influential work by Baxter and King (1993) investigating the impact of permanent and temporary expansions in government spending. Baxter and King (1993) find that the former can lead to output multipliers (both short-run and long-run) that exceed unity. As in Aiyagari, Christiano and Eichenbaum (1992), Baxter and King (1993) highlight the role of an increase in hours worked that gives rise to the multiplier mechanism. Additionally, they notice that a rise in hours that follows a permanent fiscal expansion increases the marginal productivity of capital. This, in turn, generates the incentives to accumulate capital, which boosts private investment. This effect, coupled with the standard effect of an absorption of available resources by the government, leads to lower private consumption.

Government expenditures in the New Keynesian (NK) model. The fact that standard Dynamic Stochastic General Equilibrium (DSGE) models predict a decreasing relationship between private consumption and fiscal spending (which is at odds with the empirical evidence) motivates the paper by Gali, Lopez-Salido and Valles (2007) studying an extended version of the standard NK model. In particular, they allow for the presence of the rule-of-thumb consumers spending their entire labour income on consumption. This assumption implies that expansions in government purchases are able to raise aggregate consumption through the induced increase in employment and the rise in real wages. This is because the latter two factors boost labour income and hence they raise consumption of hand--to-mouth consumers. This, in turn, boosts aggregate demand, output, employment and wages even further, so that the multiplier effect emerges. The theory presented in this paper provides an alternative explanation to the one proposed by Gali, Lopez-Salido and Valles (2007). Moreover, the result obtained in my work does not rely on the assumption about the existence of hand-to-mouth consumers that was made by Gali, Lopez-Salido and Valles (2007), which leads to unrealistic responses of private spending to future macroeconomic shocks (Auclert, Rognlie, Straub 2018; Kaplan, Moll, Violante 2018; Hagedorn, Manovskii, Mitman 2019, among others).

Government expenditures and the Zero Lower Bound (ZLB). This literature analyses the impact of a rise in government spending in the situation when the short-term nominal interest rate is constrained by the ZLB.

The first channel through which various policies affect the economy at the ZLB is the expected inflation channel. The idea (see, e.g. Eggertsson 2011) is that policies that aim at boosting aggregate supply are counterproductive as they spur the deflationary expectations and hence they increase real interest rates, making households postpone their consumption. The effects of policies stimulating aggregate demand (e.g. government expenditures) are just the opposite. Eggertsson (2011) uses the standard New Keynesian model to show that a temporary increase by one dollar in fiscal spending leads to the output growth by 2.3 dollars. The key driving force of this effect is that the expectations about future policy (under which the government commits to sustain spending until the recession characterized by the ZLB is over) in all future states in which the ZLB binds inflates the price level in those periods. This in turn creates inflationary expectations in the current period and causes a drop in real interest rates, which stimulates aggregate demand. Notice that, in the NK model without capital, an increase in output is split solely between private and public consumption. This means that if the multiplier is higher than one then, automatically, consumption increases when the government consumption rises. It is worth mentioning that Eggertsson's analysis implies that negative supply shocks are expansionary at the ZLB. This prediction was tested by Wieland (2019), who used the episodes of the Great East Japan earthquake and global oil supply shocks that occurred in the ZLB environment to show that Eggertsson's results are not consistent with empirical observations. Additionally, as shown by Bachmann, Berg and Sims (2015), US households' readiness to spend more in response to changes in inflation expectations is statistically insignificant inside the liquidity trap. This implies that the empirical support for the expected inflation channel used by Eggertsson (2011) in his theoretical analysis is not very strong.

Models with search frictions in the product market. One of the key ingredients in my analysis is the frictional product market. This environment was studied by Storesletten, Rios Rull and Bai (2011) and Michaillat and Saez (2015). Storesletten, Rios Rull and Bai (2011) show that demand shocks are responsible for the total factor productivity (TFP) volatility if product market frictions are in place. Michaillat and Saez (2015) develop a theoretical, continuous-time model with search frictions both in the market for goods and in labour market, and use it for studying the sources of unemployment fluctuations in the US.

Models with multiple equilibria. My work is also related to the articles describing the models with multiple equilibria. I propose a novel source of the multiplicity that arises from the interaction between search frictions on the product market and the fact that firms need to visit their suppliers and thus they are subject to search frictions, too. In a large class of models (Benhabib, Farmer 1994; Farmer, Guo 1994; Diamond 1982; Diamond, Fudenberg 1989), the multiplicity obtains because of the increasing returns to scale either in production or in matching. These features are absent in my analysis.

3. Model with the frictional product market

In this section, I present a tractable static model with the frictional product market (based on the framework presented in an influential paper by Michaillat, Saez 2015) and study the impact of changes to government spending in that setting.

General setting. The economy is populated by a continuum of households and firms. Each population has measure one. There are two types of goods traded in the economy: the non-produced good (which is a numeraire) and the good manufactured by firms. Each firm has an exogenous capacity normalized to 1. The non-produced good is traded on a perfectly competitive market, whereas the market on which the produced good is traded is characterized by search frictions (specified later).

Households. Household preferences are specified as follows:

$$u(c,m) = logc + \chi logm \tag{1}$$

where c denotes the consumption of manufactured goods and m denotes the amount of non-produced goods that are consumed. Logarithmic utility function is assumed to simplify calculations and χ is a positive preference parameter.

Search frictions are modelled as in Michaillat and Saez (2015): to purchase manufactured goods, households have to visit firms – each visit costs $\phi > 0$ units of manufactured goods and the number of visits made by a household is v.[1] Due to the presence of search frictions, some visits are successful and some are not. If a visit is successful, then the number of manufactured goods purchased by a household is one, which occurs with probability $g(x)$, where x is the product market tightness (which is defined later). This means that the following relationship between the number of visits and the amount of consumed manufactured goods holds (see Michaillat, Saez 2015):

$$c + \phi v = q(x)v \tag{2}$$

I abstract from randomness at the individual level throughout the paper. This means that all households get the equal amount $q(x)v$ of produced goods. Let us define the "wedge" in the market for manufactured goods as

$$\tau(x) = \frac{\phi}{q(x) - \phi}$$

[1] An alternative way of specifying search costs (i.e. in terms of disutility from search activities) is described in Storesletten, Rios Rull and Bai (2011). As I show in the Appendix, the main results from the core text hold under their specification of search costs, too.

As explained, inequality $q(x) > \phi$ holds and therefore $\tau(x)$ is always positive.

Household's income consists of two components: endowment μ of non-produced goods and profits Π generated by firm(s). Those resources are spent on m, c and to cover the costs associated with the search. This means that the budget constraint reads:

$$pc + p\phi v + m = \mu + \Pi \tag{3}$$

where p is the price of produced goods.

By substituting 2 into 3 and using the definition of $\tau(x)$ we get:

$$p\left(1+\tau(x)\right)c + m = \mu + \Pi \tag{4}$$

The household maximizes 1 subject to 4 with respect to c and m, taking p, μ, Π and $\tau(x)$ as given. This yields the following first order condition (FOC) that pins down the formula for the private demand of households:

$$c = \frac{m}{\chi p\left(1+\tau(x)\right)} \tag{5}$$

Firms. In this simple model firms have an exogenous capacity normalized to 1. Since there are search frictions in place, they are able to sell a proportion $f(x)$ of their products. This means that the firm's profit is: $\Pi = p \cdot f(x) \cdot 1$.

Search frictions and the price-setting mechanism. The aggregate number of successful trades on the product market is given by $M(1, v)$, where M is the so-called matching function and combines the capacity of firms (equal to one) and visits of firms v to generate the number of successful trades on the market. M is increasing in both arguments, it is strictly concave and it exhibits constant returns to scale. This means that a firm finds a customer with probability given by:

$$f(x) = \frac{M(1,v)}{1} = M\left(1, \frac{v}{1}\right) = M(1,x) \tag{6}$$

since the tightness of the product market is defined as $x = \frac{v}{1}$.

The probability that a household's visit is successful reads:

$$q(x) = \frac{M(1,v)}{v} = M\left(\frac{1}{v}, 1\right) = M\left(\frac{1}{x}, 1\right)$$

Since there is no universal theory that pins down prices in the situation when the trade is decentralized in a search-and-matching environment, I follow Michaillat and Saez (2015) by assuming that prices are perfectly rigid, i.e. p enters into the model as a strictly positive parameter.

Equilibrium. The resource constraint for the produced good is:

$$c + \phi v = f(x) \cdot 1 \tag{7}$$

and for the non-produced good it reads:

$$m = \mu \tag{8}$$

Using the definition of tightness in the product market and combining it with 5, 7, and 8 yields:

$$\frac{\mu}{\chi p\left(1+\tau(x)\right)} = f(x) - \phi x \tag{9}$$

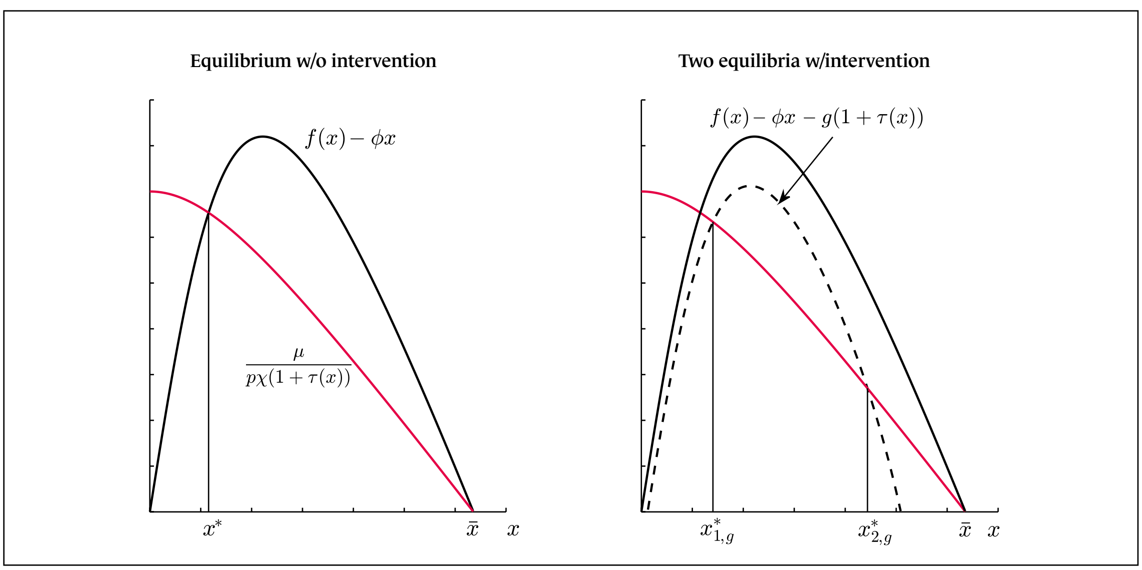
Equation 9 characterizes the equilibrium value of x.

Note that condition 5 together with equation 8 can be used to reformulate 7 to obtain:

$$\frac{\mu}{p\chi} = f(x)$$

By assuming that $f(\bar{x}) > \frac{\mu}{p\chi}$ (where $\bar{x}$ solves $q(\bar{x}) = \phi$) and by observing that $f(0) = 0$ and $f' > 0$ we conclude that the solution $x^* \in (0, \bar{x})$ to 9 exists and is unique.

Figure 1
Model with the frictional product market



The left panel of Figure 1 illustrates the equilibrium condition 9. One could infer from Figure 1 that $x = \overline{x}$ is the second equilibrium. Observe, however, that for $x \to \overline{x}$ we have $\tau(x) \to +\infty$ and thus $\tau(x)$ is not well-defined for $x = \overline{x}$ and thus x^* is the only equilibrium.[2]

Effects of an increase in fiscal spending. Let us analyse the impact of an increase in government spending from 0 to some positive number $g > 0$ that is financed by lump-sum taxes levied on households. I assume that government consumption is financed by lump-sum taxes because it seems that it is a natural benchmark for isolating the theoretical effects of a rise in government spending on aggregate activity.

Symmetrically to households, it is assumed that the government has to visit firms on a decentralized and frictional market to purchase goods. This means that if the government wants to buy g of goods it has to make v_G visits, where v_G satisfies:

$$g + \phi v_G = q(x) \cdot v_G$$

We have to modify the definition of tightness x to take into account the government's visits:

$$x = \frac{v + v_G}{1}$$

Using the modified definition of x and the expression for $\tau(x)$ enables to reformulate the formula for the "gross" fiscal expenditures:

$$g + \phi v_G = g \cdot (1 + \tau(x)) \equiv G(x)$$

Household's budget constraint is:

$$p(1 + \tau(x))c + m + T = \mu + \Pi$$

where the lump-sum tax $T = p \cdot G(x)$ guarantees that government runs a balanced budget.

The resource constraint for the economy with $g > 0$ becomes:

$$c + \phi v + g + \phi v_G = f(x) \cdot 1$$

This, combined with the optimal policy of households, yields:

$$\frac{\mu}{\chi p(1 + \tau(x))} = f(x) - \phi x - G(x) \tag{10}$$

[2] I used the following parameter values to prepare the plots in this section: $\phi = 0.3$, $\mu = 1$, $\chi = 1$, $p = 2$, $L = 2$ (parameter associated with the Den Haan-Ramey-Watson specification of the matching function), $\alpha = 0.5$, $g = 0.03$.

The right panel of Figure 1 illustrates equation 10. This equilibrium condition can be reformulated to get:

$$\frac{\mu}{p\chi}+G(x)=f(x) \tag{11}$$

Observe that since $G(x)$ is an increasing function on $[0,\bar{x})$, $\lim_{x\to\bar{x}} G(x)\to+\infty$, $f(\bar{x})>\frac{\mu}{p\chi}$ holds, and, by assuming that g is sufficiently small, means that equation 11 has two solutions. I denote them by $x^*_{1,g}$ and $x^*_{2,g}$. Without the loss of generality, I consider the situation when $x^*_{1,g}<x^*_{2,g}$. In what follows, I ignore the equilibrium characterized by $x^*_{2,g}$. It is because the response of the economy to an increase in g is "discontinuous" – an arbitrarily small value $g>0$ leads to significant change from x^* (which is the only equilibrium when $g=0$ as argued before) to $x^*_{2,g}$.

Hence, let us concentrate on the relationship between x^* and $x^*_{1,g}$. A simple application of the Implicit Function Theorem to equation 11 in the neighbourhood of $x^*=x^*_{1,g=0}$ implies that (recall that $f'>0$).

$$\frac{dx^*_{1,g}}{dg}=-\frac{1}{g\cdot\left(1+\tau'\left(x^*\right)\right)-f'\left(x^*\right)}$$

Which is strictly positive because $g=0$ and which means that the government intervention increases tightness on the product market. On the one hand, a rise in tightness leads to a growth in output since $f(x)\cdot 1$ is an increasing function. The intuition behind this outcome is straightforward: government spending boosts the demand for manufactured goods and hence it increases the rate/probability at which firms sell their output. Since the capacity of firms is fixed and equal to one, then aggregate output rises. On the other hand, however, since $\tau(x)$ grows in x, then fiscal expansion causes a drop in private consumption (by equation 5 combined with condition 8). This occurs because the effective price of manufactured goods $p(1+\tau(x))$ rises together with x, which lowers the demand for produced goods.

One comment is in order. Observe that if we changed the assumption that the initial amount of fiscal spending is zero and replaced it with a positive value then the model with a single friction would exhibit two equilibria (see Figure 1). Note that, in the equilibrium associated with higher tightness (i.e. $x^*_{2,g}$), further increases in g would cause a drop in the product market tightness, which would raise private consumption (see formula 5). One could argue that this fact indicates that the model with a single ingredient (i.e. search frictions on the product market) is able to reproduce the pattern observed in the data and hence the addition of the second element (supply chains) is redundant. To see why this is not the case, observe that the equivalent of aggregate output in the model is $f(x)\cdot 1$ (with $f'>0$). As it has been discussed, $x^*_{2,g}$ drops when g rises which, in turn, implies a decrease in $f(x)$ and hence causes a decline in output (i.e. negative government spending multiplier). All this means that the economy with a single ingredient (search frictions on the product market) is not able to reproduce the pattern we want to obtain because it generates either a negative fiscal multiplier and a positive response in private consumption (see equilibrium $x^*_{2,g}$) or a positive fiscal multiplier and a negative response in private consumption (see equilibrium $x^*_{1,g}$). Both sets of results cannot be reconciled with the discussed empirical evidence that I aim at replicating: positive fiscal multiplier and an increasing relationship between government spending and private consumption.

4. Model with supply chains

In this section, I describe the model in which each firm needs to purchase goods from other firms to get resources needed to generate output (i.e. simple supply chains).

Contrary to the model presented in the preceding section, the environment developed in this part is characterized by the frictionless product market and flexible prices to isolate the impact of supply chains on the propagation of fiscal stimulus from the influence of the frictional product market.

General setting. Types of agents, types of goods and sizes of populations remain unchanged in comparison to the model presented in the previous section. There are two important differences, though. First, both markets are perfectly competitive. Second, firms' production technology becomes more sophisticated. In particular, the firm's capacity ceases to be exogenous: to generate output, the firm needs to buy goods manufactured by other firms, which can be thought of as a simple supply chain.

Households. Households' preferences are the same as in the previous section:

$$u(c,m) = logc + \chi logm \tag{12}$$

The budget constraint is:

$$pc + m = \mu + \Pi \tag{13}$$

Household maximizes 12 subject to 13 with respect to c and m taking p, Π and μ as given. This yields the following formula for the optimal choice of c:

$$c = \frac{m}{\chi p} \tag{14}$$

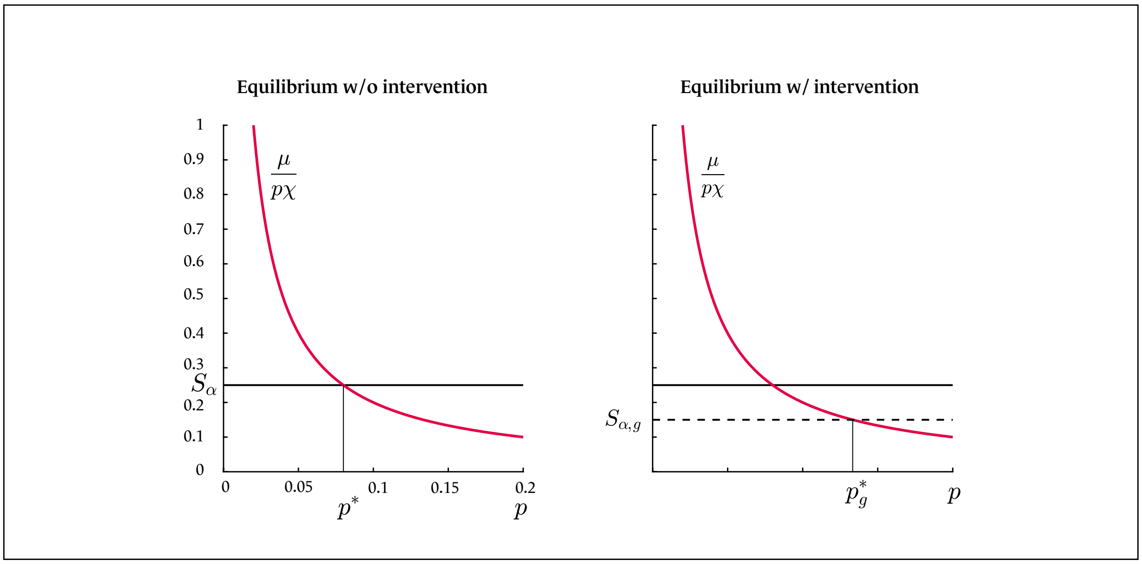
Firms. Firms operate a concave technology (described by parameter $\alpha \in (0,1)$) that transforms y goods purchased from other firms (obtained using the supply chain) into y^{α} of their own products. Thus, the profit function is:

$$\Pi = \max_{y} p \cdot \left(y^{\alpha} - y\right)$$

and the associated FOC implies that the optimal production plan is characterized by:

$$y_{opt} = \alpha^{\frac{1}{1-\alpha}}$$

Figure 2
Model with simple supply chains



Equilibrium. The resource constraint for manufactured goods is:

$$c = y_{opt}^{\alpha} - y_{opt} \tag{15}$$

The RHS of equation 15 is the amount of final goods available to households. It describes the value added created by all firms in the economy and hence it is an analogue of GDP. Plugging optimal polices into the model and combining them with the resource constraint on the market for non-produced goods (i.e. $m = \mu$) yields the following formula for p that characterizes the equilibrium in this simple economy:

$$\frac{\mu}{p\chi} = \alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}$$

The left panel of Figure 2 presents a graphical illustration of this equation (note that I define $S_\alpha = \alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}$).[3] Since $\alpha \in (0,1)$, the RHS of the formula above is positive and there exists a unique price p^* that solves it.

Effects of an increase in fiscal spending. Let us analyse the impact of an increase in government spending from 0 to some positive number $g > 0$ that is financed by lump-sum taxes levied on households.

If we modify the resource constraint for the produced good accordingly, we get $c + g = y_{opt}^{\alpha} - y_{opt}$. This equation combined with the optimal plans of households and firms yields:

[3] I have used the following parameter values to prepare the plots in this section: $\mu = 0.02$, $\chi = 1$, $p = 2$, $\alpha = 0.5$, $g = 0.1$.

$$\frac{\mu}{p\chi} = \alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}} - g \equiv S_{\alpha,g} \tag{16}$$

The RHS of 16 is denoted by $S_{\alpha,g}$ and the impact of fiscal intervention is presented in Figure 2 (see the right panel). It is self-evident that since the aggregate supply $y_{opt}^{\alpha} - y_{opt}$ remains unaffected by changes to g, the increase in fiscal spending reduces the amount of goods available to households. It is a pure crowding-out process driven by the effect of an increase in g on prices: it leads to a rise in price $p^* < p_g^*$ and, by equation 14, it induces a drop in private consumption. Thus, the model with a simple supply chain and the frictionless product market is not able to generate the empirically observed pattern (i.e. a positive relationship between government spending and private consumption).

5. Model with the frictional product market and supply chains

In this section I study the interplay of the two elements that have been investigated separately so far. As a result, I obtain a model with two equilibria and one of them exhibits the reactions of private consumption and output to higher government spending that are consistent with the discussed empirical evidence.

General setting. Types of agents, types of goods and the sizes of populations remain unchanged in comparison to the models presented in previous sections. In this part, however, I combine the two elements that before were studied separately: I assume that there are search frictions in the product market and that firms need to search for their suppliers to produce goods.

Households. Consumers purchase non-produced goods on a perfectly competitive market and manufactured goods on the frictional market. The household's problem is the same as in Section 3. This means that the household's behaviour can be summarized by the following FOC (see equation 5):

$$c = \frac{m}{\chi p\left(1+\tau\left(x\right)\right)} \tag{17}$$

Firms. In this section I assume that firms are visited not only by households that want to get manufactured goods, but also that a part of their output is sold to other firms searching for the resources needed to generate their own products. This means that $f(x)$ is the probability that a firm is visited by either consumers or firms.

Production technology is described by the concave function that transforms y units of "raw materials" purchased from other manufacturers into y^{α} units of goods.

Symmetrically to households, firms incur cost $p\phi v_y$ of making v_y visits when searching for their production inputs. Moreover, they face probability $q(x)$ that a visit is successful and ends with a purchase of one unit of inputs. This means that the firm's problem can be formalized as follows:

$$\max_{y, v_y}\left(pf\left(x\right)y^{\alpha} - py - p\phi v_y\right)$$

subject to:

$$y + \phi v_y = q(x) v_y \tag{18}$$

where p, $q(x)$, and $f(x)$ are taken as given.

I use constraint 18 and the definition of $\tau(x)$ to simplify the maximization problem by eliminating v_y

$$\max_y \left(pf(x) y^{\alpha} - p\left(1+\tau(x)\right) y \right) \tag{19}$$

Observe that an increase in product market tightness x (defined by equation 21) has two opposite effects on firm's profits. On the one hand, higher x raises $f(x)$ (recall that $f' > 0$), which means that firms sell their output more easily and their profits grow. On the other hand, however, an increase in x means that the effective price of inputs $p\left(1+\tau(x)\right)$ rises. The optimal solution to problem 19 is denoted y^* and combines those two effects:

$$y^* = \left[\frac{\alpha f(x)}{1+\tau(x)} \right]^{\frac{1}{1-\alpha}} \tag{20}$$

Note that equation 20 describes the firm's demand for inputs.

Search frictions and the price-setting mechanism. Search frictions are almost the same as in Section 3. The only difference is the definition of tightness which becomes:

$$x = \frac{v + v_y}{y^{\alpha}} \tag{21}$$

As in Section 3, price p is fixed and it is a positive parameter.

Equilibrium. Observe that the aggregate amount of resources available to households (final goods used by consumers for consumption and covering the search costs they incur) is:

$$f(x)\left(y^*\right)^{\alpha} - \left(1+\tau(x)\right) y^*$$

$$\frac{\left(\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}\right)\left(f(x)\right)^{\frac{1}{1-\alpha}}}{\left(1+\tau(x)\right)^{\frac{\alpha}{1-\alpha}}} \equiv Y(x)$$

In the Appendix, I show that $Y'(x) > 0$ for $x \in [0, x_P)$ and $Y'(x) \leq 0$ for $x \in [x_P, \bar{x}]$ where $0 < x_P < \bar{x}$ and where $\bar{x}$ solves $q(\bar{x}) = \phi$. Moreover, it is easy to see that: $Y(x) > 0$ (for $x \in (0, \bar{x})$), $Y(0) = 0$ and $\lim_{x \to \bar{x}} Y(x) = 0$ (the latter follows from the definition of wedge $\tau(x)$). Note that $Y(x)$ is the value added in the analysed economy and can be thought of as GDP.

From equation 17, coupled with the market clearing condition for non-produced goods (i.e., $m = \mu$), we get the following expression for the aggregate demand of households:

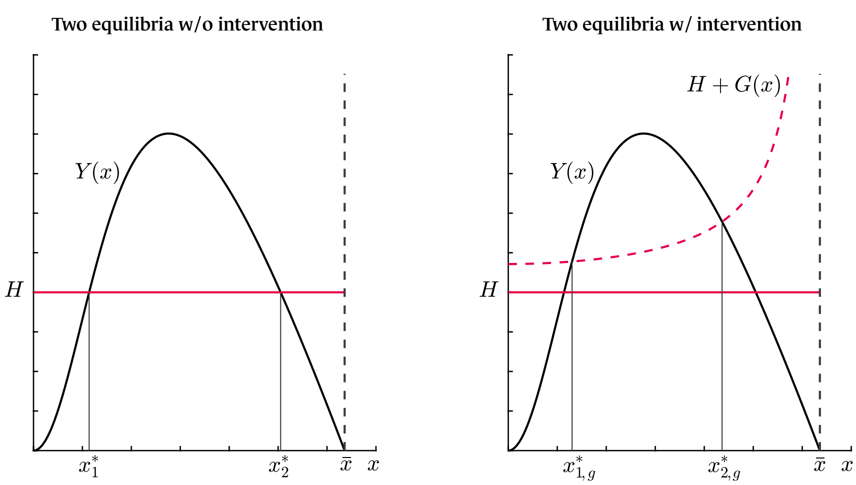
$$c\left(1+\tau\left(x\right)\right)=\frac{\mu}{\chi p}$$

Thus, the market clearing condition for manufactured goods is:

$$\frac{\mu}{\chi p}=Y\left(x\right) \tag{22}$$

which characterizes the equilibrium values of x.

Figure 3
Static model with frictions and supply chains



From what was said above (about function $Y(x)$), it is clear that 22 has two solutions provided that μ is sufficiently low (or, alternatively, χ is high enough). Let us denote them by x^*_1 and x^*_2 (and, without the loss of generality, let us assume that $x^*_1 < x^*_2$). To economize on the notation, I denote $H \equiv \frac{\mu}{\chi p}$. Observe that the aggregate output of final goods (i.e. Y) is equal in both equilibria (it amounts to H). Condition 22 is illustrated in the left panel of Figure 3.[4]

Effects of an increase in fiscal spending. In this part I analyse the impact of an increase in government expenditures (financed with lump-sum taxes) on the allocations associated with the equilibria characterized by x^*_1 and x^*_2. Similarly to the case analysed in Section 3, the government sets number $g>0$ and, given that its purchases are constrained by search frictions, it purchases $G\left(x\right)=\left(1+\tau\left(x\right)\right)g$ of manufactured goods and, at the same time, it makes $v_G=\frac{g}{q\left(x\right)-\phi}$ visits. Therefore, the resource constraint for manufactured goods is:

[4] I have used the following parameter values to prepare the plots in this section: ϕ = 0.3, μ = 1, χ = 1, p = 25, L = 2 (parameter associated with the Den Haan-Ramey-Watson specification of the matching function), α = 0.5, g = 0.005.

$$\frac{\mu}{\chi p}+G(x)=Y(x) \tag{23}$$

and market tightness x is redefined in the following way:

$$x=\frac{v+v_y+v_g}{y^\alpha}$$

to account for the government's visits.

Since $G'(x)>0$ then it is easy to see that (as long as g is sufficiently small) the property that the model has multiple equilibria is preserved. They are characterized by numbers $x_{1,g}^*$ and $x_{2,g}^*$ (without the loss of generality I assume that $x_{1,g}^* < x_{2,g}^*$).

Equation 23 is shown in the right panel of Figure 3. Analogously to Section 3, I abstract from the possibility that the agents' expectations switch so that the economy behaves in a non-continuous manner after the intervention. For instance, I exclude the possibility that the economy characterized by $x_{1,g}^*$ when $g=0$ exhibits value $x_{2,g}^*$ of product market tightness when $g>0$.

First, observe that both equilibria feature positive fiscal multipliers. This occurs because $Y(x_1^*)<Y(x_{1,g}^*)$ and $Y(x_2^*)<Y(x_{2,g}^*)$ (see the right panel of Figure 3). There is, however, an important qualitative difference between their reaction to an increase in g. Notice that $x_{1,g}^*>x_1^*$, i.e. the product market tightness increases in g. This resembles the effects of the fiscal expansion analysed in Section 3: government consumption g raises the product market tightness and hence both firms and households find it harder to purchase manufactured goods as their effective price $p(1+\tau(x))$ grows. By equation 17, it can be concluded that private consumption drops when the equilibrium characterized by x_1^* is affected by a rise in government purchases.

Let me concentrate on a more interesting case pertaining to the equilibrium characterized by x_2^*. As mentioned, the aggregate output of final goods grows in response to a rise in government consumption g, i.e., $Y(x_2^*)<Y(x_{2,g}^*)$. More importantly, an increase in g causes a fall in the product market tightness: $x_{2,g}^*<x_2^*$ (see the right panel of Figure 3). This, coupled with equations 17 and $m=\mu$, implies that private consumption increases when government purchases grow. Thus, the reaction of the economy to a rise in government spending is consistent with the discussed empirical evidence predicting higher output and higher private spending resulting from the fiscal stimulus.

To understand why it happens (i.e., why x lowers when g rises), let us analyse equation 20 in a greater detail. In particular, observe that the firm's demand for inputs can be reformulated as follows:

$$y^*(x)=\left[\frac{\alpha f(x)}{1+\tau(x)}\right]^{\frac{1}{1-\alpha}}=\frac{Y(x)}{1+\tau(x)}\frac{\alpha^{\frac{1}{1-\alpha}}}{\left(\alpha^{\frac{\alpha}{1-\alpha}}-\alpha^{\frac{1}{1-\alpha}}\right)} \tag{24}$$

Recall, that in the equilibrium described by x_2^*, fiscal intervention increases the output of final goods $Y(x)$ and decreases $\tau(x)$. These two forces work in the same direction and hence $y^*(x)$ grows. This means that, in the equilibrium characterized by x_2^*, the reaction of the production capacity y^α to a rise in g is so strong that tightness (given by $x=\frac{v+v_y+v_g}{y^\alpha}$) falls despite the fact that v_g increases.

The resulting drop in $\tau(x)$ compensates the decrease in $f(x)$ and, consequently, firms decide to expand their output by scaling up their capacity $\left[y^*(x)\right]^\alpha$. This, in turn, decreases product market tightness even further and, as a result, lowers the effective price $p(1+\tau(x))$ faced by other firms that choose to increase their capacity. In short, in the equilibrium characterized by x_2^*, an increase in government expenditures coordinates firms to raise their capacities, which sets in motion the mechanism that decreases the value of product market tightness.

Let us take a closer look at the technical aspects that are behind the mechanism described above. First, let us rewrite the equation characterizing firm's profits for an arbitrary level of y:

$$pf(x)y^\alpha - p(1+\tau(x))y$$

Observe that f is concave. It is an immediate consequence of the assumption about the concavity of M and the fact that $f(x)=M(1,x)$ (see equation 6). Second, notice that τ is convex (I prove this fact in the Appendix). These properties imply that, in the equilibrium characterized by x_2^* (i.e. when the product market tightness is relatively high when compared to the other equilibrium described by x_1^*), a downward change in x causes a small drop in revenue driven by lower $f(x)$ (because it is concave) which is compensated by a large drop in effective costs $p(1+\tau(x))$ (because $\tau(x)$ is convex). This incentivizes firms to expand their capacities by increasing y which, in turn, raises the aggregate capacity y^α and lowers x even further.

6. Conclusions

I have presented a simple framework in which the expansion in government expenditures may lead to both an increase in private consumption and a positive fiscal multiplier. To obtain this outcome, I have used two simple building blocks – search frictions on the product market and simple supply chains capturing the fact that firms generate output using the resources produced by other enterprises. I have also argued that, in isolation, neither of those elements is able to replicate both the positive relationship between private consumption and government spending and the positive value of the fiscal multiplier.

The coexistence of positive reactions of household spending and output to higher government purchases emerges because, in one of the two equilibria in the model with search frictions and supply chains, government intervention coordinates firms to increase their capacities to supply more goods. This, in turn, lowers the product market tightness, decreases effective production costs faced by other firms, and creates incentives for them to scale up their capacity. This feedback loop implies that higher government spending may lead to lower product market tightness, which raises the availability of goods faced by households that respond by increasing their spending.

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Appendix

Properties of function *Y*(*x*). Let's calculate the derivative of *Y*(*x*):

$$Y'(x)=\left(\alpha^{\frac{\alpha}{1-\alpha}}-\alpha^{\frac{1}{1-\alpha}}\right)\frac{\frac{1}{1-\alpha}\left(f(x)\right)^{\frac{1}{1-\alpha}-1}f'(x)\left(1+\tau(x)\right)^{\frac{\alpha}{1-\alpha}}-\frac{\alpha}{1-\alpha}\left(f(x)\right)^{\frac{1}{1-\alpha}}\tau'(x)\left(1+\tau(x)\right)^{\frac{\alpha}{1-\alpha}-1}}{\left(1+\tau(x)\right)^{\frac{2\alpha}{1-\alpha}}}$$

We have to concentrate on the sign of expression:

$$\frac{f'(x)}{f(x)}-\alpha\frac{\tau'(x)}{1+\tau(x)}\gtreqless 0$$

as the remaining part of $Y'(x)$ is strictly positive.

I use the fact that $\tau'(x)=\frac{-\phi q'(x)}{\left(q(x)-\phi\right)^2}$, the definition of $\tau(x)$ and that $xq(x)=f(x)$ to get:

$$\frac{1}{x}\gtreqless-\alpha\frac{\phi q'(x)}{f'(x)\left(q(x)-\phi\right)}$$

It is easy to see that $f'(x)=M_2(1,x)$ and $q'(x)=M(1,x)\frac{-1}{x^2}+\frac{1}{x}M_2(1,x)$. Using this fact yields:

$$\frac{q(x)-\phi}{\alpha\phi}\gtreqless\frac{M(1,x)\frac{1}{x}}{M_2(1,x)}-1$$

I use the CRS property of *M* and the fact that $q(s)=M\left(\frac{1}{x},1\right)$ to obtain:

$$\frac{q(x)-\phi}{\alpha\phi q(x)}+\frac{1}{q(x)}\gtreqless\frac{1}{f'(x)}$$

It is easy to see that the LHS decreases in x and the RHS increases in x (by strict concavity of M). This means that if solution to *LHS* = *RHS* exists then it is unique. Its existence follows if we reformulate the condition

$$f'(x)=\frac{\alpha\phi q(x)}{q(x)-\phi(1-\alpha)}$$

The LHS is decreasing (and its limit is $+\infty$ at 0) and the RHS increases with x (and its limit is $+\infty$ for $x_{\alpha\phi}$ that solves $q\left(x_{\alpha\phi}\right)=\phi(1-\alpha)$). This means that there exists $x_P\in\left(0,x_{\alpha\phi}\right)$ such that $Y'\left(x_P\right)=0$. Moreover, if α is sufficiently low then $x_P<\bar{x}$.

Convexity of function $\tau(x)$**.** The easiest way to show this fact is to calculate τ'' and prove that it is positive. First, notice that:

$$\tau'(x) = \frac{-\phi q'(x)}{\left(q(x)-\phi\right)^2}$$

this follows directly from the definition of $\tau(x)$. It is clear that $q'(x) < 0$, which implies that $\tau'(x) > 0$. The second derivative reads:

$$\tau''(x) = \frac{-\phi q''(x)\left(q(x)-\phi\right) + 2\phi\left(q'(x)\right)^2}{\left(q(x)-\phi\right)^3}$$

Since $xq(x) = M(1,x)$ then:

$$q'(x) = M(1,x)\frac{-1}{x^2} + \frac{1}{x}M_2(1,x)$$
$$q''(x) = M(1,x)\frac{2}{x^3} - M_2(1,x)\frac{2}{x^2} + \frac{1}{x}M_{22}(1,x)$$

Since the denominator of $\tau''(x)$ is always positive let us focus on the numerator:

$$\begin{aligned}
&-\phi q''(x)\cdot\left(q(x)-\phi\right) + 2\phi\left(q'(x)\right)^2 \\
&= -\phi\left[M(1,x)\frac{2}{x^3} - M_2(1,x)\frac{2}{x^2} + \frac{1}{x}M_{22}(1,x)\right]\left(M(1,x)\frac{1}{x} - \phi\right) \\
&\quad + 2\phi\left(M(1,x)\frac{-1}{x^2} + \frac{1}{x}M_2(1,x)\right)^2 \\
&= -\frac{2\phi}{x^3}M_2(1,x)M(1,x) + \frac{2\phi^2}{x^3}M(1,x) - \frac{2\phi^2}{x^2}M_2(1,x) \\
&\quad + \frac{2\phi}{x^2}\left(M_2(1,x)\right)^2 - \frac{\phi}{x}M_{22}(1,x)\left(q(x)-\phi\right) \\
&= M(1,x)\frac{2\phi}{x^3}\left(-M_2(1,x)+\phi\right) - M_2(1,x)\frac{2\phi}{x^2}\left(-M_2(1,x)+\phi\right) \\
&\quad - \frac{\phi}{x}M_{22}(1,x)\left(q(x)-\phi\right) \\
&= \frac{2\phi}{x^2}\left(\phi - M_2(1,x)\right)\left(M(1,x)\frac{1}{x} - M_2(1,x)\right) \\
&\quad - \frac{\phi}{x}M_{22}(1,x)\left(q(x)-\phi\right)
\end{aligned}$$

$$=\frac{2\phi}{x^2}\left(\phi-M_2(1,x)\right)\left(q(x)-M_2(1,x)\right)$$

$$-\frac{\phi}{x}M_{22}(1,x)\left(q(x)-\phi\right)$$

$$>\frac{2\phi}{x^2}\left(\phi-M_2(1,x)\right)^2-\frac{\phi}{x}M_{22}(1,x)\left(q(x)-\phi\right)$$

where the first inequality follows by the fact that $q(x)>\phi$ for $x\in(0,\bar{x})$ and the last inequality holds because $M_{22}(1,x)<0$ (by the strict concavity of *M*).

Alternative specification of search costs. To show that the main result of my analysis (about the possibility of the coexistence of a positive government multiplier and positive response of private consumption to government spending) does not depend on the specification of search costs, I analyse the model with disutility from search, as in Storesletten, Rios Rull and Bai (2011). Let us start with the model that is analogous to the one presented in Section 3. The problem that is solved by households reads:

$$\max_{c,m,v} logc + \chi logm - G(v)$$

$$\text{subject to: } c = q(x)v$$

$$pc + m = \mu + f(x)\cdot 1$$

where the notation is the same as in the core text and *G* is a function that describes disutility from making visits. In particular, it is assumed that *G* is linear, i.e.: $G(v)=\chi_v v$ and $\chi_v>0$.

Observe, that households are producers of goods and hence there are no firms in this version of the model. The reason for this reformulation is discussed later. I solve the household's maximization problem in a similar way to the one presented in Section 3 and I obtain the following FOC:

$$c(x)=\frac{1}{\frac{\chi p}{\mu}+\frac{\chi_v}{q(x)}}$$

which describes the consumer's demand for goods (recall that *p* is a parameter and hence the demand is a function that depends solely on *x)*.

Observe that $c'(x)<0$. The resource constraint (and at the same time the equilibrium condition) for this economy is: $c(x)=f(x)\cdot 1$

Since $f'(x)>0,\ f(0)=0,\ f(x)>0$ for $x>0$ and since $q(0)>0,\ \lim_{x\to+\infty} q(x)=0$, then the equation above has a unique solution. It is easy to show that government intervention (in this case the government does not bear any search costs as it is hard to define the concept of the government's search disutility) characterized by the purchase of $g>0$ goods leads to the following modification of the resource constraint: $c(x)+g=f(x)\cdot 1$ and a simple use of the Implicit Function Theorem implies that $x'(g)>0$ which implies that private consumption drops and output $f(x)\cdot 1$ increases.

Let us turn to a model with search frictions where agents purchase goods from each other to generate their own output. In what follows I consider households that not only consume, but are also able to produce goods. This formulation is motivated by the fact that considering a situation in which firms and households are separate entities and the former have to make visits to buy inputs implies that one has to define the firm's disutility from search activities so that it is symmetric to the consumer's search process. To avoid this methodological problem I assume WLOG that households are producers at the same time. This means that the consumer's-producer's problem reads:

$$\max_{c,m,v_f,v_s,y} logc+\chi logm-G(v_s)-G(v_f)$$

$$c=q(x)v_s$$

$$y=q(x)v_f$$

$$pc+m=\mu+pf(x)y^{\alpha}-py$$

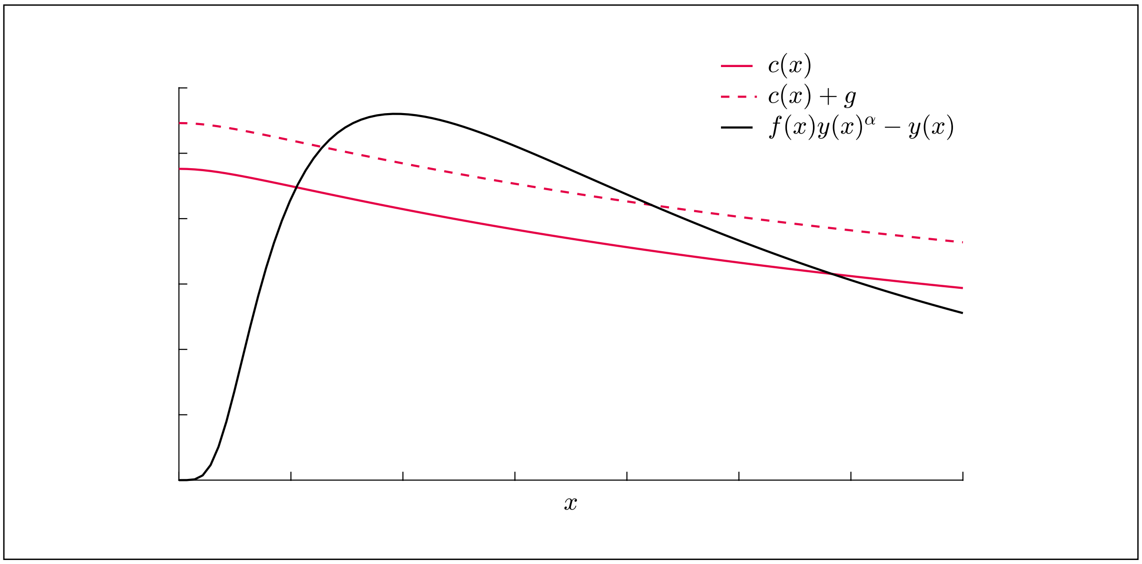
where v_s is the number of visits made by households to get consumption goods and v_f are visits made to get inputs for the household's "factory".

Moreover, it is assumed that $G(v)=\chi_v\cdot v$ with $\chi_v>0$. There are two FOCs that describe the household's solution and implicitly define the demand side and the supply side of the economy:

$$c(x)=\frac{1}{\frac{\chi p}{\mu}+\frac{\chi_v}{q(x)}}$$

$$y(x)=\left(\frac{\alpha f(x)}{1+\frac{\mu\chi_v}{\chi pq(x)}}\right)^{\frac{1}{1-\alpha}}$$

Figure 4
Two equilibria in the model with search disutility



The resource constraint combined with $c(x)$ and $y(x)$ yields:

$$c(x)=f(x)y(x)^{\alpha}-y(x)$$

Since the analytic argument that shows the existence of two solutions in the equation above is hard to formulate, I rely on numerical simulation instead. Figure 4 shows that the equilibrium condition has two solutions and government intervention.[5] This shows that the main result of this work is independent of the specification of search costs.

[5] I have chosen the following parameter values for the simulation: $\mu=0.45$, $\chi=1$, $\chi_v=1$, $p=9$, $L=2$ (parameter associated with the Den Haan-Ramey-Watson specification of the matching function), $\alpha=0.8$.

Frykcyjny rynek produktów, łańcuchy dostaw i wpływ wydatków rządowych na konsumpcję

Streszczenie

Liczne badania empiryczne (Fatas, Mihov 2001; Blanchard, Perotti 2002; Gali, Lopez-Salido, Valles 2007; Fisher, Peters 2010; Ravn, Schmitt-Grohe, Uribe 2012) wskazują na istnienie dwóch zależności:

1) wartość mnożnika wydatków rządowych jest dodatnia,

2) konsumpcja gospodarstw domowych rośnie wraz ze zwiększaniem się wydatków rządowych.

Wyniki wielu prac teoretycznych oraz symulacji modeli strukturalnych są sprzeczne z drugą obserwacją. Przykładowo w modelu realnego cyklu koniunkturalnego zwiększone wydatki rządowe prowadzą do spadku konsumpcji gospodarstw domowych (Baxter, King 1993). Co prawda obie obserwacje udało się zreplikować za pomocą modelu nowokeynesowskiego w warunkach pułapki płynności (Eggertsson 2011), ale mechanizm transmisji polityki fiskalnej w tym modelu był poddany krytyce (Bachmann, Berg 2015; Wieland 2019). Artykuł Gali, Lopez-Salido i Vallesa (2007) przedstawia rozbudowany model nowokeynesowski, w którym obie zależności są spełnione. W swojej pracy przedstawiam model teoretyczny alternatywny w stosunku do pracy Gali, Lopez-Salido i Vallesa (2007), w którym występują obie zależności.

W szczególności wykazuję, że kluczowymi elementami modelu (tzn. koniecznymi do jednoczesnego wystąpienia obu zależności) są: frykcyjny rynek dóbr (opisany w pracy Michaillat, Saez 2015) oraz łańcuchy dostaw w sektorze przedsiębiorstw. Co istotne, model zawierający tylko jeden z tych elementów (albo frykcyjny rynek dóbr, albo łańcuchy dostaw) nie jest w stanie wygenerować omawianych zależności. Oznacza to, że interakcja pomiędzy frykcjami na rynku dóbr oraz łańcuchami dostaw jest kluczowa dla odtworzenia empirycznych prawidłowości 1 i 2 za pomocą teoretycznego modelu.

Mechanizm ekonomiczny, który sprawia, że analizowane zależności mogą wystąpić w modelu z frykcjami na rynku dóbr oraz z łańcuchami dostaw, jest następujący. Zwiększone wydatki rządowe prowadzą do wzrostu popytu na dobra produkowane przez przedsiębiorstwa. W konsekwencji zwiększają one swój potencjał produkcyjny, co w przypadku modelu z łańcuchami dostaw prowadzi do zwiększenia dostępności półproduktów, które są nabywane przez inne przedsiębiorstwa. Ów spadek efektywnych kosztów półproduktów skłania firmy do dalszego zwiększania potencjału produkcyjnego, co powoduje dalsze obniżanie efektywnych kosztów. Opisany mechanizm mnożnikowy sprawia, że rośnie zagregowany produkt (co prowadzi do spełnienia pierwszej zależności). Z kolei większy potencjał produkcyjny przekłada się na większą dostępność produktów w gospodarce, powodując wzrost zagregowanej konsumpcji (co prowadzi do spełnienia drugiej zależności).

Słowa kluczowe: polityka fiskalna, mnożnik wydatków rządowych, łańcuchy dostaw, frykcje poszukiwań, konsumpcja prywatna