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Abstract

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JEL Classification: E60, E62

Keywords: industrial networks, fiscal adjustment plans, output growth

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The Network Effects of Fiscal Adjustments

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Abstract

A large and increasing body of empirical evidence has established that fiscal adjustments based on government spending cuts are less costly in terms of losses in output growth than those based on tax increases. We show that the propagation of fiscal adjustment plans through the industrial network can in theory explain this evidence and that it does so in practice for the US economy. The heterogenous effects of tax-based and expenditure-based adjustments might depend on the difference in their propagation channels in the network of industries. A tax-based adjustment plan is mainly a supply shock which propagates downstream (from supplier industries to customer industries) while an expenditure based plan is a demand shock which propagates upstream (from customer industries to supplier industries). Empirical investigation of these channels on US data based on Spatial Vector Autoregressions reveals that tax based plans propagate through the network with an average output multiplier of close to -2, while the propagation of expenditure based plans does not lead to any statistically significant effect on growth.

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1 Introduction

Macroeconomic theory has traditionally attributed the large impact of fiscal adjustments on the real economy to the propagation mechanism that amplifies the initial impulse. Such a propagation mechanism has been firstly identified with the Keynesian Multiplier (see Diamond (1982) , and Christiano et al. (2011)), which concentrates on the demand side effects, but propagation to the real economy also depends on changes in the incentives of workers and firms, the supply side of the economy (see for example Christiano et al. (2011)). While the propagation through the Keynesian Multiplier always implies stronger output effects of expenditure based adjustments than tax based adjustments, the results can be different in a model that includes supply-side effects. Alesina et al. (2017) introduce the possibility of persistent adjustment plans in a standard New Keynesian framework to show that when fiscal adjustments are close to permanent, spending cuts are less recessionary than tax hikes.

The empirical literature on the macroeconomic effects of fiscal policies has notoriously found a wide range of estimates and is far from having reached a consensus for fiscal multipliers. A new fact, however, is consistently confirmed by a number of recent papers (e.g. Alesina et al. (2015); Guajardo et al. (2014)): fiscal consolidations implemented by raising taxes imply larger output losses compared to consolidations relying on reductions in government spending.

In this paper we explore a new propagation mechanism of fiscal policy related to the work on the network effects of macroeconomic shocks (see Acemoglu et al. (2012), Acemoglu et al. (2016) and Ozdagli & Weber (2017)). This mechanism has the potential of explaining the new fact in the empirical evidence and we investigate this possibility using US data over the period 1978-2014.

Network analysis of the transmission of macroeconomic shocks is based on the intuition that input-output linkages can neutralize the law of large numbers that makes local shocks irrelevant for the global economy because local shocks that hit sectors that are particularly important as suppliers to other sectors do translate into aggregate fluctuations. Studying the propagation of adjustments through input-output linkages produces some interesting theoretical implications. In fact, as shown by Acemoglu et al. (2016), theory predicts that supply-side shocks propagate downstream more powerfully than upstream: downstream customers of directly hit sectors are affected more strongly than upstream suppliers. The converse is true for demand shocks that propagate more powerfully upstream. The reason for this asymmetric pattern lies in the fact that supply side shocks change the prices faced by customer industries while demand side shocks have much minor effects on prices and propagate upstream.

In the simplified benchmark model studied in much of the literature (Long Jr & Plosser (1983) and Acemoglu et al. (2012)), both production functions and consumer preferences are Cobb-Douglas (so that income and substitution effects cancel out), and the asymmetry in the propagation of demand and supply shocks becomes extreme as there is no upstream effect from supply-side shocks and no downstream effect from demand-side shocks.

Fiscal adjustments based on changing taxation work mainly as supply side adjustments while expenditure based adjustments are one of the typical cases of demand-side adjustments. As their propagation is totally different, the size of their final effect on total output depends on different elements of the input-output matrix. The empirical analysis of a network based propagation mechanism of fiscal adjustment can therefore be interesting to provide an assessment of the relevance of the theoretical mechanism and of its capability to explain the new fact in the empirical literature. This paper is organized as follows. We start by illustrating in Section 2 the theoretical mechanism of the network diffusion of a payroll-tax shock and a government expenditure shock. In Section 3 we describe how an empirical specification consistent with the theoretical mechanism can be identified and estimated, then we bring it to the data to illustrate our main results and some robustness check. Section 7 concludes.

2 The Theoretical Mechanism

To illustrate the network effects of fiscal policy we adapt the benchmark model designed to analyze the network transmission of demand and supply shocks (Long Jr & Plosser (1983) and Acemoglu et al. (2012)). Consider a perfectly competitive economy with n sector, where each sector has a Cobb-Douglas production function of the form

$$y_i = e^{z_i} l_i^{\alpha_i^l} \prod_{j=1}^{n} x_{ij}^{\alpha_{ij}}$$

where x_{ij} is the quantity of goods produced in industry j used as inputs by industry i. All alpha's are non negative.

$$\alpha_i^l + \sum_{j=1}^{n} a_{ij} = 1$$

The market clearing condition for industry i can be written as:

$$y_i = c_i + \sum_{j=1}^{n} x_{ji} + G_i$$

G_i are government purchases and the government can impose either a lump sum or a distortionary payroll tax, to finance its purchases:

$$\sum_{j=1}^{n} p_i G_i = T + \tau w l$$

The preference side of the economy is summarized by a representative household with a utility function:

$$u\left(c_1, c_2, ... c_n\right) = \gamma\left(l\right) \cdot \prod_{j=1}^{n} c_i^{\beta_i}$$

$$\sum_{i=1}^{n} \beta_i = 1$$

Following Acemoglu et al. (2016) we consider the following simple functional form assumption for (dis-)utility of labour

$$\gamma\left(l\right) = \left(1 - l\right)^{\lambda}$$

and the representative household's budget constraint can be written as:

$$\sum_{i=1}^{n} p_i c_i = wl - T$$

The competitive equilibrium of this static economy is defined so that all firms maximize profits and the representative household maximizes its utility. Firms and households take all prices as given, and the market clearing conditions are satisfied in the goods market and the labour market. Government actions are taken as given in the competitive equilibrium and the wage is chosen as a numeraire $\left(w = 1\right)$.

Profit maximization with the Cobb-Douglas specification for the production function implies:

$$a_{ij} = \frac{p_j x_{ij}}{p_i y_i}, \quad \alpha_i^l = \frac{w\left(1 + \tau\right) l_i}{p_i y_i} \tag{1}$$

Utility maximization instead implies:

$$\frac{p_i c_i}{\beta_i} = \frac{p_j c_j}{\beta_j} \tag{2}$$

substituting in the budget constraint this FOC yields:

$$p_i c_i = \beta_i \left(wl - T \right) \tag{3}$$

the FOC for labour supply, implies:

$$\frac{\lambda}{(1-l)} = \frac{w}{wl - T} \tag{4}$$

and given that the wage is the numeraire we have :

$$l = \frac{1 + \lambda T}{1 + \lambda} \tag{5}$$

and by using (5) to substitute for l in (3)

$$p_i c_i = \frac{\beta_i}{1 + \lambda} (1 - T) \tag{6}$$

2.1 The effect of a payroll-tax (supply) shock

Consider an increase in payroll tax which is implemented by keeping the government expenditure constant ($dG_i = 0$) and therefore by reallocating taxation between the non-distortionary and the distortionary component.

Take logs in the production function and totally differentiate by assuming no productivity shocks to obtain:

$$d \ln y_i = \alpha_i^l d \ln l_i + \sum_{j=1}^{n} a_{ij} d \ln x_{ij} \tag{7}$$

Totally differentiate the conditions for profit maximization:

$$\begin{gathered} d \ln y_i + d \ln p_i - d \ln p_j = d \ln x_{ij} \\ d \ln y_i + d \ln p_i = d \ln l_i + d \ln \left(1 + \tau \right) \end{gathered} \tag{8}$$

as wages are chosen as numeraire. Substituting these two equations in the previous one:

$$d\ln y_i = \alpha_i^l \left(d\ln y_i + d\ln p_i - d\ln\left(1+\tau\right)\right) + \sum_{j=1}^{n} a_{ij}\left(d\ln y_i + d\ln p_i - d\ln p_j\right) \quad (9)$$

Using (6) we have

$$d\ln p_i + d\ln c_i = d\ln(1-T) \quad (10)$$

and using (10) into (9) , we obtain:

$$d\ln y_i = \alpha_i^l \left(d\ln y_i - d\ln c_i + d\ln(1-T) - d\ln\left(1+\tau\right)\right) + \sum_{j=1}^{n} a_{ij}\left(d\ln y_i - d\ln c_i + d\ln c_j\right)$$

as $\alpha_i^l + \sum_{j=1}^{n} a_{ij} = 1$, it follows that

$$d\ln c_i = \alpha_i^l d\ln\left(1-T\right) - \alpha_i^l d\ln\left(1+\tau\right) + \sum_{j=1}^{n} a_{ij} d\ln c_j,$$

in matrix form

$$\begin{aligned}
\mathbf{d}\ln\mathbf{c} &= \alpha^l d\ln\left(1-T\right) - \alpha^l d\ln\left(1+\tau\right) + A\mathbf{d}\ln\mathbf{c} \\
\mathbf{d}\ln\mathbf{c} &= \left(I-A\right)^{-1}\left[\alpha^l d\ln\left(1-T\right) - \alpha^l d\ln\left(1+\tau\right)\right]
\end{aligned}$$

next combining the market clearing conditions with the first order conditions we obtain

$$y_j = c_j + \sum_{i=1}^{n} x_{ij}$$

$$\frac{y_j}{c_j} = 1 + \sum_{i=1}^{n} a_{ij}\frac{\beta_i y_i}{\beta_j c_i}$$

which, given that G is constant, implies

$$\mathbf{d}\ln\mathbf{c} = \mathbf{d}\ln\mathbf{y}$$

and finally

$$d\ln y_i = \alpha_i^l \cdot \big(d\ln(1-T) - d\ln(1+\tau)\big) + \sum_{j=1}^{n} a_{ij} \cdot d\ln y_j. \tag{11}$$

Introducing the input-output matrix A, allows us to rewrite equation (11) in matrix form:

$$\underset{n\times 1}{d\ln \mathbf{y}} = \underset{n\times 1}{\boldsymbol{\alpha}^l} \cdot \big(d\ln(1-T) - d\ln(1+\tau)\big) + \underset{n\times n}{A} \cdot d\ln \underset{n\times 1}{\mathbf{y}}. \tag{12}$$

The sectoral propagation of a tax adjustment that determines its global impact is driven by the elements in the rows of the input-ouptut matrix A, that describes sectoral linkages in the economy. The sectoral propagation mechanism of a tax shock is downstream ($d\ln \mathbf{y}^{down} = A \cdot d\ln \mathbf{y}$): downstream customers of directly hit sectors are affected while upstream suppliers are not.

2.2 The effect of a government expenditure (demand) shock

We consider now the effect of a government expenditure shock which is fully financed by lump-sum taxation, so for the sake of simplicity we set $\tau = 0$

The unit cost function of sector i is then:

$$C_i(p, w) = B_i \cdot w^{\alpha_i^l} \cdot \prod_{j=1}^{n} p_j^{a_{ij}}$$

where

$$B_i = \left(\frac{1}{\alpha_i^l}\right)^{\alpha_i^l} \cdot \prod_{j=1}^{n} \left(\frac{1}{a_{ij}}\right)^{a_{ij}}$$

Zero profit condition for producer leads to

$$\ln p_i = \ln B_i + \alpha_i^l \ln w + \sum_{j=1}^{n} a_{ij} \ln p_j. \tag{13}$$

Equation (13) illustrates that the vector of prices does not depend on government purchases G, suggesting that equilibrium price is not affected by the demand side shocks and instead, is fully determined by the supply side.

Taking into account the fact that in equilibrium prices and consumption are unchanged, we use (1), (2), (3) and the market clearing condition to obtain the total production change in the economy and the labour demand:

$$d\ln y_i = d\ln x_{ij}$$
$$d\ln y_i = d\ln l_i$$

$$l = \frac{1 + \lambda \cdot \sum_{i=1}^{n} p_i G_i}{1 + \lambda}$$

where $T = \sum_{i=1}^{n} p_i G_i$. Using the fact that wage is the numeraire in the consumption functions

$$p_i c_i = \frac{\beta_i}{1 + \lambda} \cdot (1 - \sum_{j=1}^{n} p_i G_i)$$

which implies

$$d\left(p_i c_i\right) = -\frac{\beta_i}{1 + \lambda} \cdot \sum_{j=1}^{n} dp_i G_i.$$

By differentiating the resource constraint we have:

$$dy_i = dc_i + \sum_{j=1}^{n} dx_{ji} + dG_i$$

combining these two last equations and (1),

$$\begin{aligned} \frac{d(p_i y_i)}{p_i y_i} &= \sum_{j=1}^{n} a_{ji} \frac{p_j y_j}{p_i y_i} \frac{d(p_j y_j)}{p_j y_j} + \frac{dG_i}{y_i} - \frac{\beta_i}{1 + \lambda} \sum_{j=1}^{n} \frac{dp_j G_j}{p_i y_i} \\ &= \sum_{j=1}^{n} \hat{a}_{ji} \frac{d(p_j y_j)}{p_j y_j} + \frac{d\widetilde{G}_i}{p_i y_i} - \frac{\beta_i}{1 + \lambda} \sum_{j=1}^{n} \frac{d\widetilde{G}_j}{p_i y_i} \end{aligned}$$

where $\widetilde{G}_i = p_i G_i$ and $\hat{a}_{ji} = \frac{x_{ji}}{y_i} = a_{ji} \frac{p_j y_j}{p_i y_i}$. Because prices are constant $\frac{d(p_i y_i)}{p_i y_i} = d \ln y_i$, then we have:

$$a_{ij} = \frac{p_j x_{ij}}{p_i y_i} \tag{14}$$

$$d \ln y_i = \sum_{j=1}^{n} \hat{a}_{ji} \cdot d \ln y_j + \frac{d\widetilde{G}_i}{p_i y_i} - \frac{\beta_i}{1 + \lambda} \cdot \sum_{j=1}^{n} \frac{d\widetilde{G}_j}{p_i y_i}. \tag{15}$$

Introducing matrix $\hat{A}$, which is a transformation of the input output matrix A

and setting

$$\mathbf{\Lambda} = \begin{bmatrix} (1-\dfrac{\beta_1}{1+\lambda})\cdot\dfrac{1}{p_1\cdot y_1} & -\dfrac{\beta_1}{1+\lambda}\cdot\dfrac{1}{p_1\cdot y_1} & \cdots & -\dfrac{\beta_1}{1+\lambda}\cdot\dfrac{1}{p_1\cdot y_1} \\ -\dfrac{\beta_2}{1+\lambda}\cdot\dfrac{1}{p_2\cdot y_2} & (1-\dfrac{\beta_2}{1+\lambda})\cdot\dfrac{1}{p_2\cdot y_2} & \cdots & -\dfrac{\beta_2}{1+\lambda}\cdot\dfrac{1}{p_2\cdot y_2} \\ \vdots & \vdots & \ddots & \vdots \\ -\dfrac{\beta_n}{1+\lambda}\cdot\dfrac{1}{p_n\cdot y_n} & (1-\dfrac{\beta_n}{1+\lambda})\cdot\dfrac{1}{p_n\cdot y_n} & \cdots & -\dfrac{\beta_n}{1+\lambda}\cdot\dfrac{1}{p_n\cdot y_n} \end{bmatrix},$$

allows us to rewrite equation (15) in matrix notation:

$$\underset{n\times 1}{d\ln\mathbf{y}} = \underset{n\times n}{\hat{A}'}\cdot\underset{n\times 1}{d\ln\mathbf{y}} + \underset{n\times n}{\mathbf{\Lambda}}\cdot\underset{n\times 1}{d\tilde{\mathbf{G}}}, \tag{16}$$

Equation (16) illustrates that, as the equilibrium price is not affected by the demand side shocks, directly hit sectors adjust the demand of their inputs in absence of price adjustments and shocks propagate upstream ($d\ln\mathbf{y}^{up} = \hat{A}'\cdot d\ln\mathbf{y}$). The sectoral propagation of an expenditure adjustment that determines its global impact is driven by the elements in the columns of a transformed input-output matrix $\hat{A}$, that describes sectoral linkages in the economy.

3 From Theory to Empirics

Imagine that one could identify mutually exclusive tax-based (TB) and expenditure-based (EB) fiscal adjustments e_t exogenous for the estimation on their effect on output growth, then equations (11) and (15) from the previous section can naturally be nested in the following panel specification to model the effect of fiscal adjustments on value added growth in each industry i:

$$\begin{aligned}\Delta y_{i,t} = c_i + \left(\delta\cdot e_t + \beta^{down}\cdot\sum_{j\neq i}^{n} a_{ij}\cdot\Delta y_{j,t}\right)\cdot TB_t + \\ + \left(\gamma\cdot e_t + \beta^{up}\cdot\sum_{j\neq i}^{n}\hat{a}_{ji}\cdot\Delta y_{j,t}\right)\cdot EB_t + \epsilon_{it}\end{aligned} \tag{17}$$

The TB adjustments, being mainly supply shocks, have a network effect that goes through the connection of industry i with its supplier industries (changes in suppliers' output flows down to customer industry i: downstream propagation). This is captured by including in the specification a spatial variable which is a weighted average of value added growth in all other sectors; weights are given by the elements of the rows of the input-output matrix A.

Symmetrically, the EB adjustments, being mainly demand shocks, have a network effect that goes through the connection of industry i with its customer industries (changes in customers' output flows up to supplier industry i: upstream propagation). This is captured by including in the specification another spatial variable, which is a weighted average of value added growth in all other sectors. Weights are now given by the elements of the columns of the transformed input-output matrix $\hat{A}$.

This empirical framework combines the Spatial Autoregressions (SARs) (Ord (1975) , LeSage & Pace (2009)) or more precisely spatial autoregressive panel data models with fixed effects and the GVAR or global vector autoregression (Chudik & Pesaran (2016)) approach to identify direct and indirect effects of fiscal adjustments. Note that, consistently with the GVAR literature and, differently from the Spatial Autoregressions literature, the spatial variables are industry specific and are defined by excluding the value added growth of the sector modelled in each equation. In practice this is carried out by removing the main diagonal from the input-output matrix A and its transformation $\hat{A}$; these new matrices are denoted by adding a 0 subscript to the original ones: A_0 and $\hat{A}_0$.

To interpret the output effects of fiscal stabilization in each industry and in the economy described by equation (17), we have to take into account the role of the effects in related industries. Following LeSage & Parent (2007) we define three scalars to measure the average total, direct and indirect effect. Using vector notation we rewrite equation (17) as follows:

$$\begin{aligned} \Delta\mathbf{y}_t = \mathbf{c} + \left(\mathbf{1}_n \cdot \delta \cdot e_t + \beta^{down} \cdot A_0 \cdot \Delta\mathbf{y}_t\right) \cdot TB_t + \\ + \left(\mathbf{1}_n \cdot \gamma \cdot e_t + \beta^{up} \cdot \hat{A}_0' \cdot \Delta\mathbf{y}_t\right) \cdot EB_t + \epsilon_{it} \end{aligned} \tag{18}$$

The sectoral effects of EB and TB adjustments can now be computed as:

$$\left(\frac{\partial \Delta \mathbf{y}}{\partial e_t} \mid TB_t = 1\right) = (I_n - \beta^{down} \cdot A_0)^{-1} \cdot \mathbf{1}_n \cdot \delta = \mathbf{S}^{TB}\left(\beta^{down}, A_0\right) \cdot \mathbf{1}_n \cdot \delta,$$
$$\left(\frac{\partial \Delta \mathbf{y}}{\partial e_t} \mid EB_t = 1\right) = (I_n - \beta^{up} \cdot \hat{A}_0')^{-1} \cdot \mathbf{1}_n \cdot \gamma = \mathbf{S}^{EB}\left(\beta^{up}, \hat{A}_0'\right) \cdot \mathbf{1}_n \cdot \gamma.$$

Given estimates for $\gamma, \beta^{down}, \delta, \beta^{up}$ the matrices $\mathbf{S}^{EB}\left(\beta^{down}, A_0\right)$ and $\mathbf{S}^{TB}\left(\beta^{up}, \hat{A}_0'\right)$ become observable, and therefore the average total, direct and indirect effect of fiscal stabilization can be computed as follows:

- *Average direct effect:* the weighted average of the diagonal elements of $\mathbf{S}^{EB}$ and $\mathbf{S}^{TB}$ with weights given by the sectoral contribution to total value added.
- *Average total effect:* the sum across the ith row of $\mathbf{S}^{EB}$ and $\mathbf{S}^{TB}$ represents the total impact of expenditure-based and tax-based adjustments on value added of industry i. We obtain the average total effect on total value added by taking the weighted average of these effects with weights defined as in the computation of the average direct effect.
- *Average indirect effect*: the difference between the average total effect and the average direct effect.

To illustrate the procedure consider a simple example with three industries for which the relevant adjustment is exclusively a tax based one.

$$\underbrace{\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \end{bmatrix}}_{\Delta \mathbf{y}} = \underbrace{\begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}}_{\mathbf{c}} + \underbrace{\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}}_{\mathbf{1}_3} \cdot \delta \cdot e_t + \underbrace{\begin{bmatrix} 0 & a_{12} \cdot \beta & a_{13} \cdot \beta \\ a_{21} \cdot \beta & 0 & a_{23} \cdot \beta \\ a_{31} \cdot \beta & a_{32} \cdot \beta & 0 \end{bmatrix}}_{A_0} \cdot \underbrace{\begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta y_{3t} \end{bmatrix}}_{\Delta \mathbf{y}}$$

$$\begin{aligned} \frac{\partial \Delta \mathbf{y}}{\partial e_t} &= \begin{bmatrix} 1 & -a_{12} \cdot \beta & -a_{13} \cdot \beta \\ -a_{21} \cdot \beta & 1 & -a_{23} \cdot \beta \\ -a_{31} \cdot \beta & -a_{32} \cdot \beta & 1 \end{bmatrix}^{-1} \cdot \mathbf{1}_3 \cdot \delta \\ &= \begin{bmatrix} 1 - \beta^2 \cdot a_{23}a_{32} & \beta \cdot a_{12} + \beta^2 \cdot a_{32}a_{13} & \beta \cdot a_{13} + \beta^2 \cdot a_{12}a_{23} \\ \beta \cdot a_{21} + \beta^2 \cdot a_{23}a_{31} & 1 - \beta^2 \cdot a_{31}a_{13} & \beta \cdot a_{23} + \beta^2 \cdot a_{21}a_{13} \\ \beta \cdot a_{31} + \beta^2 \cdot a_{21}a_{32} & \beta \cdot a_{32} + \beta^2 \cdot a_{31}a_{12} & 1 - \beta^2 \cdot a_{21}a_{12} \end{bmatrix} \cdot \mathbf{1}_3 \cdot \frac{\delta}{d}, \end{aligned}$$

where, d is the determinant of matrix $(I_3 - \beta \cdot A_0)$:

$$d = 1 - \beta^2 \cdot (a_{12}a_{21} + a_{13}a_{31} + a_{32}a_{23}) - \beta^3 \cdot (a_{12}a_{23}a_{31} + a_{21}a_{13}a_{32}).$$

Given the above result, we provide the analytic form for the total, direct and indirect effect of a tax shock of sector 1:

- $\frac{1-\beta^2 \cdot a_{23}a_{32}}{d} \cdot \delta = \left[1 + \frac{\beta^2 \cdot (a_{13}a_{31}+a_{12}a_{21})+\beta^3 \cdot (a_{12}a_{23}a_{31}+a_{21}a_{13}a_{32})}{d}\right] \cdot \delta$ gives the response of value added in industry 1 to the TB adjustment if this industry were the only one affected by it, and it represents the tax shock "*direct effect*" on sector 1. Notice that it can be interpreted as the summation of the tax coefficient δ plus the network effect triggered by a tax shock which hits only sector 1 itself, called *feedback loop* by LeSage & Pace (2009). We call the former "*instantaneous effect*", while the latter, "*network direct effect*".
Furthermore, the average of the direct effects on all sectors of a tax shock, provides the Average Direct Effect of a tax shock.

- $\frac{\beta \cdot a_{12}+\beta^2 \cdot a_{32}a_{13}}{d}$ gives the response of value added in industry 1 to the TB adjustment if industry 2 were the only one one affected by it.

- $\frac{\beta \cdot a_{13}+\beta^2 \cdot a_{12}a_{23}}{d}$ gives the response of value added in industry 1 to the TB adjustment if industry 3 were the only one affected by it.

- The summation of the previous two effects represent the "*(network) indirect effect*" of industry 1; that is, the effect on industry 1 of a shock which hits all the industries except for industry 1 itself.
The average of the (network) indirect effects of every industry accounts for the Average Indirect Effect.

- The summation of all the direct and indirect effects is the "*total effect*" of a tax shock for sector 1. The average of all the total shocks, represent the Average Total Effect.

4 Data

4.1 Database of Exogenous Fiscal Adjustment Plans for US

Measuring the output effect of fiscal consolidations requires a sample of shifts in fiscal stance exogenous for the estimation of their output effect. Fiscal foresight makes it very difficult to identify unobservables exogenous shifts in fiscal policy by imposing restrictions on reduced form dynamic specifications of macroeconomic and fiscal variables. The narrative method proposed by Romer & Romer (2010) (R&R (2010))is a possible solution to this problem. R&R (2010) refer to presidential speeches, congressional debates, budget documents, congressional reports, to identify the size, timing, and principal motivation for all major postwar tax policy actions. They then classify legislated changes into endogenous (those induced by short-run countercyclical concerns and those taken because of change in government spending) and exogenous (those that are responses to the state of government debt or to concerns about long-run economic growth).

Note that deficit-driven tax adjustments are almost always positive, while the long-run growth driven tax adjustments are both positive and negative.

Similarly Pescatori et al. (2011) produce a data set which documents exogenous shifts in fiscal policy (both tax and expenditure) by applying the narrative approach to a set of seventeen OECD countries. Amongst all fiscal actions, these authors have selected those that were designed to reduce a budget deficit and/or to put the public debt on a sustainable path. When long-run growth-driven and deficit-driven adjustments happen simultaneously, a period is considered to be an adjustment period only if the deficit-driven adjustment exceeds long-run growth driven adjustment.

Fiscal consolidation policy is actually implemented through multi-year plans that involve an intertemporal and an intratemporal dimension. The intertemporal dimension depends on the fact that plans involve both measures that are implemented upon announcement (the unanticipated component of the plan) and measures that are announced for the future n years (the anticipated component of the plan); the intratemporal dimension depends on the fact that adjustment plans are implemented with a mix of measure on the expenditure side and on the revenue side. Different mix might generate different effects of plans that is based on the same adjustment in government budget.

We adopt the annual database on fiscal adjustment plans constructed by Alesina et al. (2015) and concentrate on US data only. A detailed description of the data is provided in Web Appendix [1].

As in Alesina et al. (2015), we scale all the measures by GDP on the year prior to the consolidation in order to avoid potential endogeneity issues.

When fiscal policy is conducted through multi-year plans narrative exogenous fiscal adjustments in each year are made of three components: the unexpected adjustments (announced upon implementation at time t), the past announced adjustments (implemented at time t but announced in the previous years) and the future announced corrections

We identify plans as sequences of fiscal corrections announced at time t to be implemented between time t and time $t+k$; we call k the anticipation horizon. We

[1] Web Appendix is available from the authors' websites

define the unanticipated fiscal shocks at time t as the surprise change in the primary surplus at time t:

$$e_t^u = \tau_t^u + g_t^u$$

where τ_t^u is the surprise increase in taxes announced at time t and implemented in the same year, and g_t^u is the surprise reduction in government expenditure also announced at time t and implemented in the same year. We denote instead as $\tau_{t,j}^a$ and $g_{t,j}^a$ the tax and expenditure changes announced by the fiscal authorities at date t with an anticipation horizon of j years (*i.e.* to be implemented in year $t+j$). In the Pescatori et al. (2011) dataset fiscal plans almost never extend beyond a 3-year horizon: thus we take $j = 3$ as the maximum anticipation horizon [2]. We therefore define the observed anticipated shocks in period t as follows

$$\begin{aligned}
&\tau_{t,0}^a = \tau_{t-1,1}^a \\
&\tau_{t,j}^a = \tau_{t-1,j+1}^a + \left(\tau_{t,j}^a - \tau_{t-1,j+1}^a\right) \ \ j \geqslant 1 \\
&g_{t,0}^a = g_{t-1,1}^a \\
&g_{t,j}^a = g_{t-1,j+1}^a + \left(g_{t,j}^a - g_{t-1,j+1}^a\right) \ \ j \geqslant 1 \\
&e_{t,j}^a = \tau_{t,.j}^a + g_{t,.j}^a
\end{aligned}$$

Fiscal corrections in each year can be written as follows

$$f_t = e_t^u + e_{t,t}^a + \sum_{j=1}^{horz} e_{t,t+j}^a$$

Plans are labeled as tax-based or expenditure-based by adopting the following rule:

$$\begin{aligned}
if \quad \left(\tau_t^u + \tau_{t,t}^a + \sum_{j=1}^{horz} \tau_{t,t+j}^a\right) \quad &> \quad \left(g_t^u + g_{t,t}^a + \sum_{j=1}^{horz} g_{t,t+j}^a\right) \\
then\ TB_t \quad &= \quad 1\ and\ \ EB_t = 0, \\
else\ TB_t \quad &= \quad 0\ \ and\ \ EB_t = 1, \forall\ t
\end{aligned} \tag{19}$$

By construction tax-based and expenditure based-plan are mutually exclusive and the labelling is almost never marginal.

[2] In the sample there are a few occurences of policy shifts anticipated four and five years ahead. Their number is too small to allow us to include them in our estimation.

4.2 Industrial Networks

4.2.1 I-O matrices

The generic element of the matrix A is constructed as follows:

$$a_{ij} = \frac{p_j \cdot x_{ij}}{p_i \cdot y_i} = \frac{\text{SALES}_{j \to i}}{\text{SALES}_i}$$

where x_{ij} is the quantity of good employed by sector i and supplied by industry j. We used the industry-by-industry total requirement table of year 1997[3] provided by the Bureau of Economic Analysis (BEA), to construct the empirical counterpart of matrix A. In Web Appendix we dedicate a section to explain thoroughly all the steps required to construct matrix A starting from the raw data. For instance, if the number of sectors, n, is 3, we have:

$$A = \begin{bmatrix} a_{11} = \dfrac{\text{SALES}_{1\to 1}}{\text{SALES}_1} & a_{12} = \dfrac{\text{SALES}_{2\to 1}}{\text{SALES}_1} & a_{13} = \dfrac{\text{SALES}_{3\to 1}}{\text{SALES}_1} \\[2ex] a_{21} = \dfrac{\text{SALES}_{1\to 2}}{\text{SALES}_2} & a_{22} = \dfrac{\text{SALES}_{2\to 2}}{\text{SALES}_2} & a_{23} = \dfrac{\text{SALES}_{3\to 2}}{\text{SALES}_2} \\[2ex] a_{31} = \dfrac{\text{SALES}_{1\to 3}}{\text{SALES}_3} & a_{32} = \dfrac{\text{SALES}_{2\to 3}}{\text{SALES}_3} & a_{33} = \dfrac{\text{SALES}_{3\to 3}}{\text{SALES}_3} \end{bmatrix},$$

The elements of a generic row, i, represent the inputs that industry i employes in its production. Basically, they reflect the transfers from suppliers of inputs to industry i. For this reason it can be described as the downstream matrix: any change which affects the supplying industries, should propagate downward to hit the customer industry i (from suppliers to customers: downstream propagation).
On the contrary, if we take the Hadamard product of matrix A and a scaling matrix

[3] We have chosen to keep coefficients constant at those observed in a central year of our sample as these coeffcients are very stable over time, witnessing stable industrial relationships.

Σ, we obtain the upstream matrix $\hat{A}$:

$$\hat{A} = A \circ \Sigma = \begin{bmatrix} \frac{\text{SALES}_{1\to1}}{\text{SALES}_1} & \frac{\text{SALES}_{2\to1}}{\text{SALES}_1} & \frac{\text{SALES}_{3\to1}}{\text{SALES}_1} \\ \frac{\text{SALES}_{1\to2}}{\text{SALES}_2} & \frac{\text{SALES}_{2\to2}}{\text{SALES}_2} & \frac{\text{SALES}_{3\to2}}{\text{SALES}_2} \\ \frac{\text{SALES}_{1\to3}}{\text{SALES}_3} & \frac{\text{SALES}_{2\to3}}{\text{SALES}_3} & \frac{\text{SALES}_{3\to3}}{\text{SALES}_3} \end{bmatrix} \circ \begin{bmatrix} 1 & \frac{\text{SALES}_1}{\text{SALES}_2} & \frac{\text{SALES}_1}{\text{SALES}_3} \\ \frac{\text{SALES}_2}{\text{SALES}_1} & 1 & \frac{\text{SALES}_2}{\text{SALES}_3} \\ \frac{\text{SALES}_3}{\text{SALES}_1} & \frac{\text{SALES}_3}{\text{SALES}_2} & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{\text{SALES}_{1\to1}}{\text{SALES}_1} & \frac{\text{SALES}_{2\to1}}{\text{SALES}_2} & \frac{\text{SALES}_{3\to1}}{\text{SALES}_3} \\ \frac{\text{SALES}_{1\to2}}{\text{SALES}_1} & \frac{\text{SALES}_{2\to2}}{\text{SALES}_2} & \frac{\text{SALES}_{3\to2}}{\text{SALES}_3} \\ \frac{\text{SALES}_{1\to3}}{\text{SALES}_1} & \frac{\text{SALES}_{2\to3}}{\text{SALES}_2} & \frac{\text{SALES}_{3\to3}}{\text{SALES}_3} \end{bmatrix}.$$

The generic column j of matrix $\hat{A}$ contains the sales of sector j sector by sector . Every column represents the transfers from sector j to its customers. For this reason matrix $\hat{A}$ is said to be the upstream matrix: sector j is now the supplier while the other industries are the customers.

4.2.2 Value Added

In our baseline specification the dependent variable is value added. Value added is the difference between an industry's or an establishment's total output and the cost of its intermediate inputs. It equals gross output (sales or receipts and other operating income, plus inventory change) minus intermediate inputs (consumption of goods and services purchased from other industries or imported). Value added consists of compensation of employees, taxes on production and imports less subsidies (formerly indirect business taxes and non tax payments), and gross operating surplus (formerly "other value added").
We employ annual data from the BEA website, in particular we choose the industry value added at the disaggregation level of 15 sectors.

4.2.3 Spatial variables

The combination of value added and the I-O matrices allows us to construct two spatial variables: the ΔY^{up} - the upstream spatial variable, which captures the propagation of shocks from customers up to their suppliers - and the ΔY^{down} - the downstream spatial variable, which captures the propagation of shocks from suppliers down to their customers. Analytically we have:

$$
\begin{aligned}
\Delta y^d_{i,t} &= \sum_{j \neq i}^{n} a_{ij} \cdot \Delta y_{j,t} \\
\underset{n\times 1}{\Delta \mathbf{y}^d_t} &= \underset{n\times n}{\begin{bmatrix} 0 & a_{12} & \dots & a_{1n} \\ a_{21} & 0 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 0 \end{bmatrix}} \cdot \underset{n\times 1}{\begin{bmatrix} \Delta y_{1,t} \\ \Delta y_{2,t} \\ \vdots \\ \Delta y_{n,t} \end{bmatrix}} \\
\Delta \mathbf{y}^d_t &= A_0 \cdot \Delta \mathbf{y}_t,
\end{aligned}
$$

where $\Delta y_{j,t}$ is the value added percent change of sector j in year t and A_0 corresponds to matrix A with zeros on its main diagonal.
As anticipated in the Section 3, we exclude the main diagonal when constructing spatial variables: this strategy is typically implemented to avoid endogeneity in the Spatial framework.
The spatial upstream variable is constructed as follows:

$$
\begin{aligned}
\Delta y^{up}_{i,t} &= \sum_{j \neq i}^{n} \hat{a}_{ji} \cdot \Delta y_{j,t} \\
\underset{n\times 1}{\Delta \mathbf{y}^{up}_t} &= \underset{n\times n}{\begin{bmatrix} 0 & \hat{a}_{21} & \dots & \hat{a}_{n1} \\ \hat{a}_{12} & 0 & \dots & \hat{a}_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{a}_{1n} & \hat{a}_{2n} & \dots & 0 \end{bmatrix}} \cdot \underset{n\times 1}{\begin{bmatrix} \Delta y_{1,t} \\ \Delta y_{2,t} \\ \vdots \\ \Delta y_{n,t} \end{bmatrix}} \\
\Delta \mathbf{y}^{up}_t &= \hat{A}'_0 \cdot \Delta \mathbf{y}_t,
\end{aligned}
$$

where $\hat{A}'_0$ corresponds to the transposed upstream matrix $\hat{A}$ with zeros on its main diagonal.
We also follow the SAR literature and we row-normalize both the downstream and upstream weight-matrices. [4]

[4] Results with non-row-normalized data are robust and available in the web appendix

5 Empirical Results

We bring the following empirical model to the data:

$$\Delta y_{i,t} = c_i + \left(\beta^{down} \cdot \Delta y^d_{i,t} + \delta^u \cdot e^u_t + \delta^a \cdot e^a_{t,t} + \delta^f \cdot e^f_t\right) \cdot TB_t +$$
$$+ \left(\beta^{up} \cdot \Delta y^u_{i,t} + \gamma^u \cdot e^u_{i,t} + \gamma^a \cdot e^a_{i,t,t} + \gamma^f \cdot e^f_{i,t}\right) \cdot EB_T. \quad (20)$$

equation (20) is a panel specification that allows to track the effect on output growth of EB and TB based fiscal plans. We model the multiperiod structure of fiscal plans by allowing separate coefficients on the unexpected, announced and future components of the fiscal adjustments. Total adjustments are separated into their three components and each component is allowed to a have a different impact on output growth. To keep the specification parsimonious the future announced component is identified as the sum of future announcements at all horizons:

$$e_t = e^u_t + e^a_{t,t} + e^f_t,$$

with

$$e^f_t = \sum_{j=1}^{horz} e^a_{t,t+j}.$$

TB adjustments do not have by construction an heterogenous effect by sector while EB adjustments do as the as the purchases of government goods and services differ across sectors. Such a heterogeneity is modelled following Acemoglu et al. (2016) who weight the spending adjustments using the input-output matrix to construct industry specific spending shocks.

In particular, we premultiply each spending shock by the elements of the last row of matrix $\hat{A}_0$, as the n^{th} row of the transformed input-output matrix corresponds to government sector.

The generic element of the n^{th} row of matrix $\hat{A}_0$, indicated with ω_j, is:

$$\omega_j = \frac{Sales_{j \to G}}{Sales_j}, \quad j \neq n$$

which is used to scale the EB adjustments to find their sectoral counterpart:

$$e^u_{j,t} = \omega_j \cdot e^u_t$$

$$e^a_{j,t,t} = \omega_j \cdot e^a_{t,t}$$

$$e^f_{j,t} = \omega_j \cdot e^f_t$$

After estimation we compute the output effect of fiscal policy by simulating a combination of the unexpected and future component of a fiscal adjustment that replicates the average TB and EB fiscal plans in US data of the size of 1% of GDP. For TB plans the unexpected component is 11.5% and the future component is 88.5%. For EB plans the unexpected component is 19.8% and the future component is 80.2%.

Maximum Likelihood estimates for the relevant coefficients[5] are shown in Table I:

Insert Table I here

While Table II reports estimates of the core coefficients via Bayesian MCMC.[6] Since the posterior distribution of the spatial coefficients is unknown and non-normal, we report the mean, the standard deviation and a t-statistics (even if these should be treated with care , because of slight non-normal shape [7]) and quantiles:

Insert Table II here

Note that the two estimation methods deliver almost identical results. Moreover, Maximum Likelihood delivers slightly more efficient estimates for the spatial coefficients than Bayesian MCMC; while the opposite is true for all the remaining parameters. Therefore, we have a partial confirmation of the result obtained by LeSage (1997) in the homoscedastic standard SAR case.

5.1 The Effect of Tax Based Adjustments

We report in Table III the results of the Monte Carlo simulation of the output effects of TB adjustments. On the left part of the Table III, the results obtained using maximum likelihood estimates, while on the right part of the Table III the results obtained by drawing parameters from the posterior distributions obtained by Bayesian MCMC estimation:

Insert Table III here

[5]We do not report fixed effects and variances in this Table, whose estimates are reported in the Web Appendix

[6]See Web Appendix for a detailed description of the estimation and simulation procedures.

[7]Histograms of the posteriors are reported in Web Appendix

Note that maximum likelihood MC simulation delivers again similar results to Bayesian MCMC simulation. The average total effect of TB adjustment, is estimated at -1.9%.
The average total effect can be decomposed into the instantaneous, the network-direct and network-indirect effects. The instantaneous effect is a combination of the estimated coefficients on unexpected and future components of a TB plan, with weights of 11.5 per cent and 88.5 per cent:

$$\phi_\delta = 11.5\% \cdot \delta^u + 88.5\% \cdot \delta^f.$$

The Average Total Effect (ATE) is the sum of the instantaneous effect, the average network direct effect (NDE) and the average network indirect effect (NIE). Table IV reports the sub-components of the TB adjustment effects, both in absolute and relative (to the average total effect) terms:

Insert Table IV here

Note that the network effect contributes for about 50 per cent of the total output effect of the TB fiscal plan.

5.2 The Effect of Expenditure Based Adjustments

We report in Table V the results of the simulated effects of EB adjustments.

Insert Table V here

Again, the two alternative methodologies deliver similar results.
The magnitude of the effect is definitely smaller than the one of TB adjustments: -0.71% against -1.95%. The effect is also slightly less statistically significant (0.08 per cent versus 0.02 per cent).
As in the case of TB adjustments, the total effect is decomposed into instantaneous (now with weights 19.8 and 80.2 respectively), network-direct and network indirect. The results are reported in Table VI, which shows a significantly lesser importance of the network channel for EB adjustments.

Insert Table VI here

6 Robustness

6.1 Inverted propagation channels

So far we have brought theoretical mechanism to the data by considering TB adjustments as supply adjustments and EB adjustments as demand adjustments. An obvious way to assess the validity of the theoretical model is to conduct robustness analysis by putting the theoretically "wrong" labels to EB and TB adjustments. What happens empirically when a model is estimated in which TB adjustments propagate "wrongly" upstream and EB adjustments propagate "wrongly" downstream ? We conducted this experiment by adopting the following specification:

$$\Delta y_{i,t} = c_i + \left(\beta^{up} \cdot \Delta y_{i,t}^{up} + \delta^u \cdot e_t^u + \delta^a \cdot e_{t,t}^a + \delta^f \cdot e_t^f\right) \cdot TB_t +$$

$$+ \left(\beta^{down} \cdot \Delta y_{i,t}^{down} + \gamma^u \cdot e_t^u + \gamma^a \cdot e_{t,t}^a + \gamma^f \cdot e_t^f\right) \cdot EB_t. \tag{21}$$

Estimated the parameters from (21), are reported in Table VII-VIII.

Insert Table VII-VIII here

As before, maximum likelihood and Bayesian MCMC yield same results, but the significance of the two spatial coefficients is switched. Tables IX-X report the simulated output effect of a TB adjustment using the "inverted" model

Insert Table IX-X here

Table IX and X show that the share of the effect of a TB adjustment attributable to the network does not change (still around 53%), but the magnitude of the effect is now reduced: from an average total effect of almost -2%, we move to -1.5%. The statistical significance of the effect is also reduced. Moving to the effect of EB plans Tables XI-XII show that the share of total network effect decreases from 27% to 18%, and the magnitude of the total effect changes from -0.71% to -0.57%, while the statical significance is slightly lower

Insert Table XI-XII here

Overall the results confirms the superiority of the theory based specification over the "inverted" specification.

6.2 Placebo

Several Placebo test have been conducted to test whether our results are not capturing a spurious correlation. In particular, we simulated several new spatial matrices by: permutating the elements of the rows of the original one; permutating the elements of its columns; reshuffling all its elements; drawing new components from a uniform with support 0-0.4 in two different ways.[8] For each simulated spatial matrix, we carried out a separate analysis, as we had done with the original data. We overall collected 500 placebo experiments, whose results have been summarized by a pair: the mean and the asymptotic t-statistic of the average effect of the simulated fiscal plan distributions. In this way we have been able to compare every Placebo experiment with the original one, through a scatter plot, with the mean on the horizontal axis and the asymptotic t-stat in the vertical axis, as shown in Figure 1.

Insert Figure 1 here

If the original spatial matrix is capturing a structural network effect , we expect the original results to have a stronger effect both in absolute terms (strongly negative mean) and statistical terms (strongly negative asymptotic t-statistic). Notice, that in Figure 1, the red dot, which accounts for the original data simulation, always stands in the bottom-left part of the panel, that is, it delivers the stronger results both in terms of mean and asymptotic t-statistic. In particular, the average indirect effect is located in the most south-west position on the graphs.

[8]see the Web Appendix for details.

7 Conclusions

We have investigated how fiscal plans propagate through the industrial network in the US economy, to find a stronger output effect of TB adjustment plans than EB adjustment plans. In particular, the average total effect of a 1% of GDP Tax Based adjustment plan is estimated to an average contraction of 2% in GDP while an EB plan is estimated to lead to a much lesser contraction of 0.77% in GDP. These estimates are very close to those found in a multi-country study of OECD economies by Alesina et al. (2015). The different network transmission mechanism of EB and TB adjustments offers an interesting new explanations for their estimated heterogenous effects. Interestingly the industrial propagation network effect accounts for half of the total impact of TB based adjustment on output while in case of EB adjustments the share of the propagation through the industrial network is of about half of that observed for TB plans.

Our robustness analysis shows that forcing the TB adjustment to flow upstream rather than downstream as predicted by the theory on the network effects of supply-side adjustments produces a statistically weaker empirical model. Even stronger evidence in the same direction is obtained when EB adjustments are forced to flow downstream in the industrial network. Overall our results on the US economy illustrate that the heterogenous impact of TB and EB adjustments on output growth could be explained theoretically and empirically by the different network propagation mechanism of demand and supply adjustments.

8 Tables

Table I: ML estimates for the baseline model.

	MLE	Std Dev	Tstat*	Pvalue
β^{down}	0.499	0.075	6.676	0.000
β^{up}	0.259	0.083	3.135	0.001
δ_u	-0.241	1.617	-0.149	0.441
γ_u	-1.463	1.871	-0.782	0.217
δ_a	-1.938	1.270	-1.526	0.064
γ_a	0.195	1.037	0.188	0.426
δ_f	-1.063	0.544	-1.954	0.025
γ_f	-0.283	0.468	-0.605	0.273

*: The t-statistics can be interpreted as an asymptotic t-statistics. In fact, keep in mind that the normality of the ML estimator is an asymptotic result.

Table II: Bayesian MCMC estimates for the baseline model.

	Mean	Std Dev	Tstat	1%	5%	10%	16%	50%	84%	90%	95%	99%
β^{down}	0.495	0.088	5.600	0.281	0.345	0.380	0.407	0.497	0.584	0.607	0.635	0.687
β^{up}	0.279	0.090	3.105	0.072	0.131	0.163	0.189	0.280	0.369	0.395	0.426	0.483
δ^u	-0.235	1.543	-0.152	-3.807	-2.751	-2.207	-1.776	-0.232	1.300	1.742	2.309	3.357
γ^u	-1.384	1.744	-0.794	-5.456	-4.252	-3.629	-3.112	-1.374	0.334	0.842	1.477	2.680
δ^a	-1.926	1.264	-1.524	-4.830	-4.009	-3.547	-3.180	-1.921	-0.676	-0.305	0.161	1.019
γ^a	0.241	0.997	0.242	-2.065	-1.388	-1.037	-0.754	0.241	1.223	1.512	1.868	2.575
δ^f	-1.016	0.565	-1.800	-2.311	-1.936	-1.738	-1.578	-1.020	-0.455	-0.290	-0.077	0.310
γ^f	-0.306	0.433	-0.705	-1.328	-1.017	-0.860	-0.737	-0.306	0.128	0.250	0.401	0.702

Table III: The Output Effects of TB plan

	ML			Bayesian MCMC		
	Tax Tot	Tax Dir	Tax Ind	Tax Tot	Tax Dir	Tax Ind
Point Estim.	-1.959	-1.018	-0.941	-	-	-
Mean	-2.046	-1.014	-1.032	-1.919	-0.971	-0.948
Std Dev	1.145	0.490	0.689	1.079	0.503	0.630
$Pr(x < 0)$	98.08%	98.08%	98.08%	97.41%	97.41%	97.41%
1%	-5.361	-2.191	-3.237	-4.850	-2.158	-2.942
5%	-4.095	-1.823	-2.328	-3.765	-1.793	-2.086
10%	-3.522	-1.644	-1.907	-3.283	-1.607	-1.745
16%	-3.121	-1.496	-1.643	-2.933	-1.468	-1.506
50%	-1.937	-1.011	-0.917	-1.856	-0.969	-0.858
84%	-0.941	-0.522	-0.404	-0.886	-0.469	-0.382
90%	-0.685	-0.385	-0.283	-0.617	-0.330	-0.267
95%	-0.371	-0.212	-0.151	-0.276	-0.147	-0.122
99%	0.182	0.110	0.071	0.387	0.205	0.185

Table IV: The Output Effect of TB plans: a Decomposition

ML - MC			Bayesian MCMC		
Direct		NIE	Direct		NIE
-1.014 (49.56%)		-1.032 (50.44%)	-0.971 (50.59%)		-0.948 (49.41%)
ϕ_δ	NDE	-	ϕ_δ	NDE	-
-0.968 (47.31%)	-0.045 (2.20%)	-	-0.926 (48.25%)	-0.045 (2.34%)	-
-	NTE		-	NTE	
-	-1.077 (52.64%)		-	-0.993 (51.75%)	

Table V: The Output Effect of BB plans

	ML			Bayesian MCMC		
	Exp Tot	Exp Dir	Exp Ind	Exp Tot	Exp Dir	Exp Ind
Point Estim.	-0.772	-0.582	-0.190	-	-	-
Mean	-0.711	-0.523	-0.188	-0.716	-0.519	-0.198
Std Dev	0.519	0.369	0.170	0.478	0.337	0.166
$Pr(x < 0)$	92.36%	92.36%	92.35%	94.06%	94.06%	94.06%
1%	-2.025	-1.370	-0.742	-1.907	-1.310	-0.722
5%	-1.594	-1.131	-0.513	-1.520	-1.076	-0.502
10%	-1.383	-1.001	-0.405	-1.331	-0.955	-0.413
16%	-1.220	-0.896	-0.339	-1.186	-0.857	-0.349
50%	-0.690	-0.520	-0.157	-0.700	-0.515	-0.169
84%	-0.195	-0.149	-0.036	-0.247	-0.182	-0.050
90%	-0.068	-0.054	-0.012	-0.121	-0.089	-0.024
95%	0.102	0.081	0.020	0.038	0.028	0.008
99%	0.424	0.324	0.092	0.354	0.260	0.096

Table VI: The Output Effect of EB plans: a Decomposition

<table>
<tr><td colspan="3">ML - MC</td><td colspan="3">Bayesian MCMC</td></tr>
<tr><td colspan="2">Direct</td><td>NIE</td><td colspan="2">Direct</td><td>NIE</td></tr>
<tr><td colspan="2">-0.523 (73.56%)</td><td>-0.188 (26.44%)</td><td colspan="2">-0.519 (72.49%)</td><td>-0.198 (27.51%)</td></tr>
<tr><td>ϕ_γ</td><td>NDE</td><td>-</td><td>ϕ_γ</td><td>NDE</td><td>-</td></tr>
<tr><td>-0.517 (72.71%)</td><td>-0.006 (0.85%)</td><td>-</td><td>-0.519 (72.49%)</td><td>-0.000 (0.00%)</td><td>-</td></tr>
<tr><td>-</td><td colspan="2">NTE</td><td>-</td><td colspan="2">NTE</td></tr>
<tr><td>-</td><td colspan="2">-0.189 (27.29%)</td><td>-</td><td colspan="2">-0.198 (27.51%)</td></tr>
</table>

Table VII: Robustness: ML Estimates of "Inverted" Model

	MLE	Std Dev	Tstat	Pvalue
β^{down}	0.146	0.082	1.782	0.037
β^{up}	0.499	0.084	5.928	0.000
δ_u	-0.090	1.625	-0.056	0.478
γ_u	-1.105	1.871	-0.591	0.277
δ_a	-1.355	1.297	-1.045	0.148
γ_a	0.683	1.044	0.654	0.257
δ_f	-0.854	0.554	-1.540	0.062
γ_f	-0.297	0.468	-0.636	0.262

Table VIII: Robustness:Bayesian MCMC Estimates of "inverted" model

	Mean	Std Dev	Tstat	1 %	5%	10%	16%	50 %	84%	9 %	95%	99%
β^{down}	0.179	0.080	2.211	0.013	0.048	0.074	0.097	0.175	0.261	0.284	0.317	0.376
β^{up}	0.504	0.083	6.040	0.305	0.364	0.394	0.420	0.504	0.587	0.610	0.639	0.693
δ^u	-0.130	1.551	-0.084	-3.768	-2.682	-2.117	-1.676	-0.117	1.399	1.850	2.403	3.472
γ^u	-1.070	1.733	-0.617	-5.095	-3.923	-3.288	-2.794	-1.063	0.643	1.128	1.771	3.029
δ^a	-1.325	1.210	-1.094	-4.141	-3.319	-2.862	-2.525	-1.327	-0.130	0.218	0.660	1.516
γ^a	0.671	0.979	0.685	-1.599	-0.944	-0.584	-0.300	0.676	1.644	1.919	2.284	2.955
δ^f	-0.819	0.542	-1.510	-2.083	-1.710	-1.515	-1.360	-0.821	-0.279	-0.123	0.073	0.444
γ^f	-0.315	0.434	-0.726	-1.340	-1.027	-0.870	-0.745	-0.314	0.114	0.238	0.394	0.690

Table IX: The Output Effect of TB plans in the Inverted Model

	ML			Bayesian MCMC		
	Tax Total	Tax Direct	Tax Indirect	Tax Total	Tax Direct	Tax Indirect
Point Estim.	-1.528	-0.711	-0.817	-	-	-
Mean	-1.652	-0.797	-0.855	-1.537	-0.768	-0.769
Std Dev	1.184	0.497	0.722	1.014	0.478	0.573
$Pr(x < 0)$	94.80%	94.80%	94.80%	94.60%	94.60%	94.60%
1%	-5.159	-1.980	-3.285	-4.185	-1.881	-2.493
5%	-3.797	-1.627	-2.222	-3.267	-1.553	-1.806
10%	-3.189	-1.440	-1.765	-2.832	-1.382	-1.498
16%	-2.733	-1.287	-1.473	-2.513	-1.247	-1.288
50%	-1.516	-0.788	-0.711	-1.487	-0.766	-0.694
84%	-0.545	-0.305	-0.228	-0.559	-0.289	-0.252
90%	-0.287	-0.166	-0.118	-0.301	-0.154	-0.133
95%	0.019	0.011	0.009	0.036	0.019	0.016
99%	0.574	0.334	0.233	0.673	0.340	0.329

Table X: The Output Effect of TB plans in the Inverted Model: a Deconmposition

<table>
<tr><th colspan="3">ML - MC</th><th colspan="3">Bayesian MCMC</th></tr>
<tr><th colspan="2">Direct</th><th>Network Indirect</th><th colspan="2">Direct</th><th>Network Indirect</th></tr>
<tr><td colspan="2">-0.797 (48.25%)</td><td>-0.855 (51.75%)</td><td colspan="2">-0.768 (49.97%)</td><td>-0.769 (50.03%)</td></tr>
<tr><td>Instantaneous</td><td>Network Direct</td><td>-</td><td>Instantaneous</td><td>Network Direct</td><td>-</td></tr>
<tr><td>-0.766 (96.11%)</td><td>-0.031 (3.89%)</td><td>-</td><td>-0.740 (96.23%)</td><td>-0.029 (3.77%)</td><td>-</td></tr>
<tr><td>-</td><td colspan="2">Total Network Effect</td><td>-</td><td colspan="2">Total Network Effect</td></tr>
<tr><td>-</td><td colspan="2">-0.886 (53.63%)</td><td>-</td><td colspan="2">-0.798 (51.92%)</td></tr>
</table>

Table XI: The Output Effect of EB plans in the Inverted Model

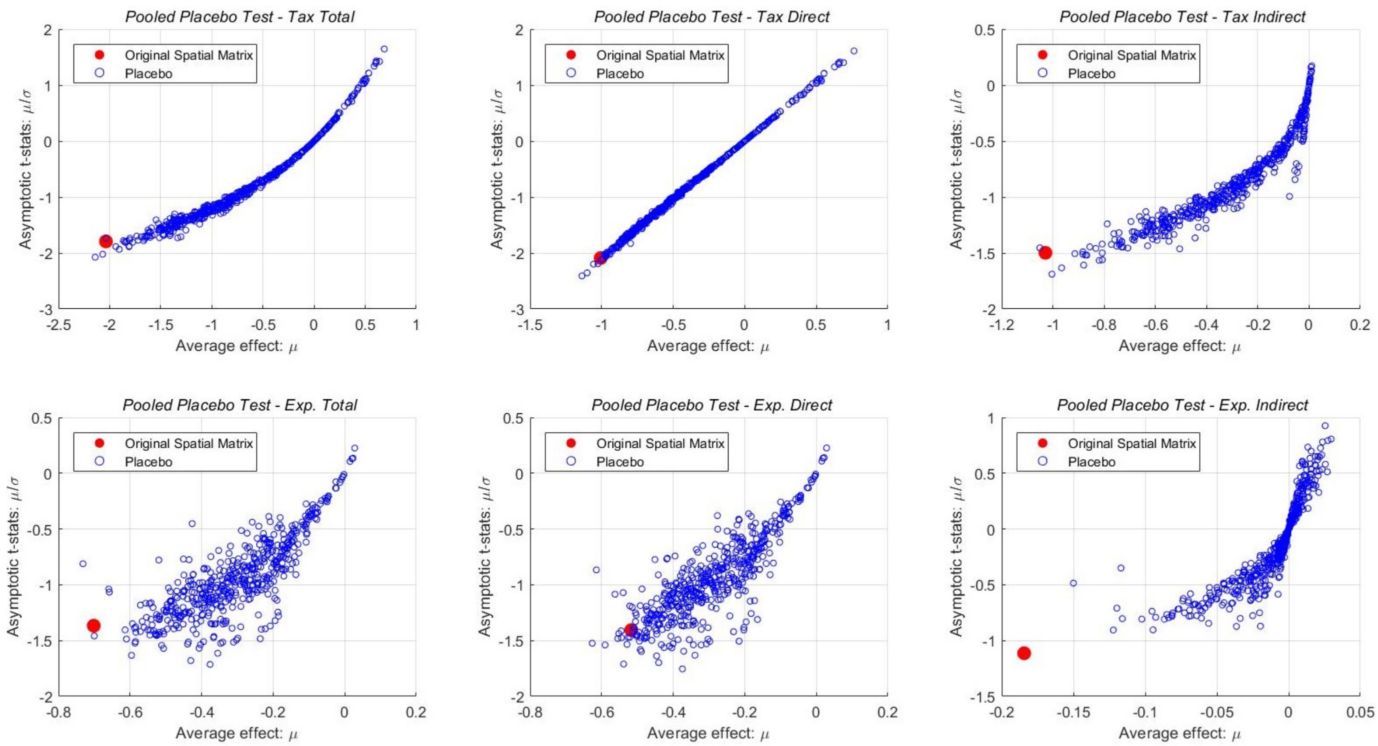
	ML			Bayesian MCMC		
	Exp Total	Exp Direct	Exp Indirect	Exp Total	Exp Direct	Exp Indirect
Point Estim.	-0.548	-0.458	-0.089	-	-	-
Mean	-0.564	-0.462	-0.101	-0.588	-0.466	-0.122
Std Dev	0.455	0.364	0.114	0.429	0.333	0.120
$Pr(x < 0)$	89.77%	89.77%	87.14%	91.9 %	91.9%	91.9%
1%	-1.711	-1.290	-0.474	-1.655	-1.255	-0.520
5%	-1.326	-1.063	-0.319	-1.310	-1.019	-0.347
10%	-1.147	-0.925	-0.252	-1.140	-0.893	-0.276
16%	-1.014	-0.820	-0.202	-1.006	-0.798	-0.227
50%	-0.555	-0.466	-0.073	-0.577	-0.467	-0.098
84%	-0.111	-0.095	-0.005	-0.170	-0.137	-0.020
90%	0.006	0.005	0.005	-0.051	-0.041	-0.005
95%	0.158	0.141	0.024	0.104	0.081	0.016
99%	0.449	0.382	0.074	0.396	0.318	0.081

Table XII: The Output Effect of EB plans in the Inverted Model: a Decomposition

ML - MC			Bayesian MCMC		
Direct		Network Indirect	Direct		Network Indirect
-0.462 (81.91%)		-0.101 (18.09%)	-0.466 (79.25%)		-0.122 (20.75%)
Instantaneous	Network Direct	-	Instantaneous	Network Direct	-
-0.457 (98.92%)	-0.005 (1.08%)	-	-0.464 (99.57%)	-0.002 (0.43%)	-
-	Total Network Effect		-	Total Network Effect	
-	-0.106 (18.79%)		-	-0.124 (21.09%)	

9 Figures

Figure 1: Pooled Placebo Test (500 simulations)



Bibliography

Acemoglu, D., Akcigit, U. & Kerr, W. (2016), 'Networks and the macroeconomy: An empirical exploration', *NBER Macroeconomics Annual* **30**(1), 273–335.

Acemoglu, D., Carvalho, V. M., Ozdaglar, A. & Tahbaz-Salehi, A. (2012), 'The network origins of aggregate fluctuations', *Econometrica* **80**(5), 1977–2016.

Alesina, A., Barbiero, O., Favero, C., Giavazzi, F. & Paradisi, M. (2017), The effects of fiscal consolidations: Theory and evidence, Technical report, National Bureau of Economic Research.

Alesina, A., Favero, C. & Giavazzi, F. (2015), 'The output effect of fiscal consolidation plans', *Journal of International Economics* **96**, S19–S42.

Christiano, L., Eichenbaum, M. & Rebelo, S. (2011), 'When is the government spending multiplier large?', *Journal of Political Economy* **119**(1), 78–121.

Chudik, A. & Pesaran, M. H. (2016), 'Theory and practice of gvar modelling', *Journal of Economic Surveys* **30**(1), 165–197.

Diamond, P. A. (1982), 'Aggregate demand management in search equilibrium', *Journal of political Economy* **90**(5), 881–894.

Guajardo, J., Leigh, D. & Pescatori, A. (2014), 'Expansionary austerity? international evidence', *Journal of the European Economic Association* **12**(4), 949–968.

LeSage, J. P. (1997), 'Bayesian estimation of spatial autoregressive models', *International Regional Science Review* **20**(1-2), 113–129.

LeSage, J. P. & Parent, O. (2007), 'Bayesian model averaging for spatial econometric models', *Geographical Analysis* **39**(3), 241–267.

LeSage, J. & Pace, R. K. (2009), *Introduction to spatial econometrics*, Chapman and Hall/CRC.

Long Jr, J. B. & Plosser, C. I. (1983), 'Real business cycles', *Journal of political Economy* **91**(1), 39–69.

Ord, K. (1975), 'Estimation methods for models of spatial interaction', *Journal of the American Statistical Association* **70**(349), 120–126.

Ozdagli, A. & Weber, M. (2017), Monetary policy through production networks: Evidence from the stock market, Technical report, National Bureau of Economic Research.

Pescatori, A., Leigh, M. D., Guajardo, J. & Devries, M. P. (2011), *A new action-based dataset of fiscal consolidation*, number 11-128, International Monetary Fund.

Romer, C. D. & Romer, D. H. (2010), 'The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks', *American Economic Review* **100**(3), 763–801.