The Changing Structure of Government Consumption Spending*

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Abstract

We document a secular increase in the share of purchases from the private sector in government consumption spending: over time the government purchases relatively more private-sector goods, and relies less on its own production of value added. We build a general equilibrium model in which investment-specific technological change accounts for the changing structure of government spending. The model predicts that this secular process alters the transmission of government spending shocks by raising the response of private value added, while dampening the response of hours. We validate these results with novel empirical evidence on the effects of government spending across countries.

Key Words: Government Gross Output, Government Wage Bill, Fiscal Multiplier.

JEL Classification Codes: E62, H10, O41.

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1 Introduction

Macroeconomic models typically consider government consumption spending as consisting only of purchases of goods produced by the private sector (e.g., Baxter and King, 1993; Christiano et al., 2011; Woodford, 2011). Instead, in national accounts, government consumption spending equals government gross output, which sums government value added to the purchase of private-sector goods. The first contribution of this paper is to document a novel stylized fact: the share of purchases from the private-sector in total government consumption spending rises over time in advanced economies. For instance, in the U.S. this share rose from a value of 22% in 1960 to 32% in 2017. Thus, government spending changes such that the government relies more on private-sector goods, and less on its own production of value added.

Since the aggregate effects of public expenditure depend on its composition,[1] the second contribution of this paper is to provide a quantitative theory for the changing structure of government spending, and then use it for measuring how this secular trend alters the transmission of government spending shocks. Our theory grounds on the premise that although government gross output evolves exogenously, the production of this amount is achieved optimally by means of a constant-returns-to-scale production function in capital, labor, and intermediate goods, with the latter consisting of purchases from the private sector. In this way, the government chooses the combination of inputs that minimizes the total cost of production given factor prices and the desired level of gross output.

To generate endogenously the secular change in the structure of government spending, we focus on a main determinant of long-run growth in the U.S.: investment-specific technological change (ISTC). Following Greenwood et al. (1997, 2000) and Ngai and Samaniego (2009), we model ISTC as an exogenous drop in the relative

[1] Finn (1998), Cavallo (2005) and Ramey (2012) show that when public consumption spending includes also public employment, the increase in public employment dampens the crowding-in of labor in the private sector. Thus, increases in government purchases raise public value added, whereas private value added could even drop.

price of investment in terms of the price of consumption. In the model, ISTC induces the government to increase the share of intermediate inputs and reduce that of capital and labor when (*i*) private-sector value added is more intense in capital than government value added, and (*ii*) government value added and intermediate inputs are imperfect substitutes. The first condition implies that ISTC raises the relative productivity of private firms vis-à-vis the government. When the second condition holds, as the private sector becomes more efficient, the government optimally switches its input choice from the increasingly expensive own production of value added to the cheaper intermediate goods produced by the private sector.

We then show that the conditions that allow ISTC to affect the structure of government spending hold in the data. First, we measure the capital share in private and government value added using data of the U.S. Bureau of Economic Analysis. We explicitly take into consideration the fact that national accounts measure differently private and government value added, as the latter is derived by assuming a zero-return on capital. Accordingly, we build a series of private value added which abstracts from proprietors' income and corporate profits. This approach yields a capital share in private-sector value added which roughly doubles the one in government value added.[2] Second, we provide evidence for an elasticity of substitution between government value added and intermediate inputs well above one. Third, we find a strong correlation across countries between the relative price of investment and the share of government purchases from the private sector.

In the quantitative analysis, we calibrate the model to match the share of intermediate inputs in government spending for the U.S. economy in 1960. Then, we compare the structure of government spending in 1960 and 2017. When we feed the model with the observed decline in the investment price between 1960 and 2017, it accounts for 89% of the increase in government purchases of private-sector goods.

[2]This finding is further empirically supported by the fact that (*i*) public firms are more labor intensive than private firms even within sectors, and (*ii*) following a privatization the labor share of public firms shrinks by roughly 40% (e.g., La Porta and Lopez-de-Silanes, 1999; Dewenter and Malatesta, 2001).

Since the calibrated economy reproduces fairly well the changing structure of government spending, we use the model as a laboratory to study the effects of this secular trend on the transmission of government spending shocks. In particular, we compare fiscal multipliers around two steady-states – representing the years 1960 and 2017 – that differ in the exogenous level of the investment price (i.e., the level of ISTC). This distinction makes the two equilibria to differ endogenously in the share of government purchases from the private sector, so that we can ask to what extent the rise of this share alters the transmission of fiscal shocks.

We identify the changes in the propagation of government spending through the lenses of the government production function in the model, which allows us to disentangle the overall output effect in the private value-added and government value-added multipliers. We show that the responses of private and government value added depend crucially on the share of government purchases from the private sector, as the rise in this share shifts the stimulative effects of government spending shocks towards private economic activity. Indeed, in the 1960 steady-state the level of the output fiscal multiplier hinges entirely on a positive government value-added multiplier, which is 0.75, while the private value-added multiplier is zero. Instead, in the 2017 steady-state the government value-added multiplier decreases to 0.65, but the private value-added multiplier becomes positive and equals 0.11. These changes alter the composition of the total output multiplier but not its level, as it equals 0.75 and 0.76 across the two steady-states.

The model also predicts a dramatic effect of the change in the share of government purchases from the private sector on the response of hours to government spending shocks. The total hours multiplier drops from 1.68 in the first steady-state to 0.68 in the second steady-state. This decline – which is due to a reduction in the response of hours in both the private and the public sector – depends on the higher productivity of the economy in 2017 and the asymmetric productivity gains between the two sectors.[3] Importantly, a model with an *exogenously* changing structure of government spending cannot generate the drop in the responsiveness of hours.

Finally, we validate the implications of the model in the data, with a particular focus on the response of hours to understand whether the empirical results are consistent with either an endogenous or exogenous changing structure of government spending. We follow the strategy of Ilzetki et al. (2013) by estimating the response of total value added, public value added, and hours to government spending shocks in two panels of countries – each one consisting of fourteen economies – which differ in the share of government purchases from the private sector. In each panel, we identify government spending shocks with sign restrictions as in Pappa (2009). The results of our panel SVAR corroborate the implications of the model: although the size of the total value-added multiplier does not vary across the two panels, the responses of public value added and total hours are significantly smaller in countries with higher shares of government purchases from the private sector.

Overall, our results highlight the existence of a process of disconnect between the responses of output and hours to government spending: over time the effects of government spending of total output may not change, but fiscal policy is becoming less effective in boosting employment. Moreover, the empirical findings confirm the importance of modeling an endogenous changing structure of government spending, as the process of disconnect between output and hours is absent in the model with an exogenous changing structure.

1.1 Related Literature

This paper adds to the literature on causes and business-cycle implications of the secular changes in the production structure of advanced economies.[4] We contribute

[3]First, the higher productivity of the economy allows to produce output with less hours. Second, this pattern is amplified as government spending tilts towards the private sector, which is less intensive in labor and has also increased its productivity relative to the public sector.

[4]Karabarnounis and Neiman (2014) show the decline in the labor share in private value added, and Duarte and Restuccia (2010) and Herrendorf et al. (2013) document the reallocation of economic activity to services.

to this literature by highlighting that advanced economies are also experiencing a change in the way the government operates and supplies public goods. Da-Rocha and Restuccia (2006), Moro (2012, 2015) and Galesi and Rachedi (2018) show that changes in the sectoral composition have first-order effects on business cycle fluctuations. Similarly, we emphasize how the changes in the government gross-output production function shapes the propagation of government spending shocks.

This paper also builds on the literature on ISTC. Greenwood et al. (1997, 2000) and Ngai and Samaniego (2009) show that the decline in the relative price of investment goods in terms of consumption goods is a primary source of long-run growth and business cycles. Debortoli and Gomes (2015) show that ISTC generates a downward trend in government public investment. Although also Debortoli and Gomes (2015) study a secular change in the government behavior, associate it to changes the relative price of investment goods, and uncover the implications for fiscal policy, our focus is different. First, Debortoli and Gomes (2015) document a decline in government public investment. Instead, our emphasis is only on government consumption spending - and its production function - as we abstract entirely from public investment. Second, Debortoli and Gomes (2015) study the implications for labor and corporate income taxation, whereas we mainly focus on fiscal multipliers.

The literature on fiscal multipliers tend to study the output effect of government spending shocks intended as exogenous hikes in purchases of private-sector goods (e.g., Barro, 1981; Baxter and King, 1993; Christiano et al., 2011; Woodford, 2011; Ramey, 2011a). Starting from Rotemberg and Woodford (1992), a strand of the literature has incorporated the role of changes in the government wage bill (e.g., Finn, 1998; Cavallo, 2005; Pappa, 2009; Ramey, 2012; Bermperoglou et al., 2017; Bandeira et al., 2018).[5] We contribute to this literature by showing that the response of private economic activity to government spending depends crucially on

[5] There is also a strand of the literature that studies how public employment affects private employment and the business cycle (e.g., Quadrini and Trigari, 2007; Gomes, 2015).

the government intermediate inputs share. Finally, this paper adds to the literature on the determinants of government spending multipliers,[6] by providing a novel channel that generates low-frequency movements in the effectiveness of fiscal policy.

2 Empirical Evidence

2.1 Government Spending in the National Accounts

In the National Income and Product Accounts (NIPAs) of the U.S. Bureau of Economic Analysis, government consumption spending[7] equals the nominal value of government gross output $P_{G,t}G_t$, which sums the nominal values of government value added $P_{Y_g,t}Y_{g,t}$ and government purchases of private-sector goods $P_{M_g,t}M_{g,t}$[8]

$$P_{G,t}G_t = P_{Y_g,t}Y_{g,t} + P_{M_g,t}M_{g,t}. \quad (1)$$

The NIPAs treat government spending slightly differently from the private economic activity for the fact that government gross output is measured on the cost side, by valuing output in terms of the input costs incurred in production. This approach implies that the value of gross output equals the sum of the wage bill of employees (both military and civilians), capital services, and the purchase from the private sector.[9] Moreover, the NIPAs posit that the contribution of capital services to the

[6]E.g., slack in the economy in Auerbach and Gorodnichenko (2012), the level of government debt in Ilzetki et al. (2013), the share of public debt held by foreigners in Broner et al. (2018) and Priftis and Zimic (2018), the age structure of the population in Basso and Rachedi (2018)

[7]In the NIPAs, the contribution of the government sector to total GDP is measured as the sum of government investment expenditure (i.e, the value of investment in structures, equipment, and software carried out by both the federal and the local government) and government consumption expenditure. Throughout this paper, we focus solely on government consumption expenditure and abstract from government investment expenditure.

[8]In the NIPAs, government consumption spending equals government gross output *minus* sales to other sectors and own-account investment. Yet, sales to other sectors refer to the transfer of resources within the federal and local governments. Instead, own-account investment accounts for only 2.8% of government gross output. For these reasons, we consider that government consumption spending equals government gross output.

[9]While this cost-side methodology requires some caution in the interpretation of an aggregate defined gross output, similar measurement issues (i.e., the absence of a well defined quantity of output) arise in the measurement of several type of market services. Moreover, in this paper we only use nominal aggregates when dealing with the components of government spending in the data. All predictions about real aggregates and prices are derived from the model.

government value added consists only in the depreciation of the government-owned fixed capital. This condition implicitly assumes that the net return for the fixed assets of the government is zero, which creates a discrepancy with the definition of private value added, as in the latter the capital services yield a positive net return.[10]

Then, the definition of the total GDP of the economy in the NIPAs sums the contribution of the nominal values of nominal values of consumption $P_{C,t}C_t$ and investment $P_{I,t}I_t$ to government gross output $P_{G,t}G_t$, such as

$$GDP_t = P_{Y_p,t}Y_{p,t} + P_{Y_g,t}Y_{g,t} = P_{C,t}C_t + P_{I,t}I_t + P_{G,t}G_t. \tag{2}$$

This equation yields two different ways to define the GDP of the economy. On the one hand, nominal GDP equals the sum of the nominal values of private-sector $P_{Y_p,t}Y_{p,t}$ and government value added. On the other hand, GDP equals the sum of the nominal values of consumption, investment, and government gross output.

Importantly, the definition of government consumption spending of the NIPAs differs from the one which is usually considered in the theoretical literature on fiscal policy, which tends to posit that government consumption spending consists only of purchases of goods produced by the private sector. In this case, the resource constraint of the economy posits that nominal private value added equals the sum of the nominal values of consumption, investment, and government purchases of private-sector goods, that is

$$P_{Y_p,t}Y_{p,t} = P_{C,t}C_t + P_{I,t}I_t + P_{M_g,t}M_{g,t}. \tag{3}$$

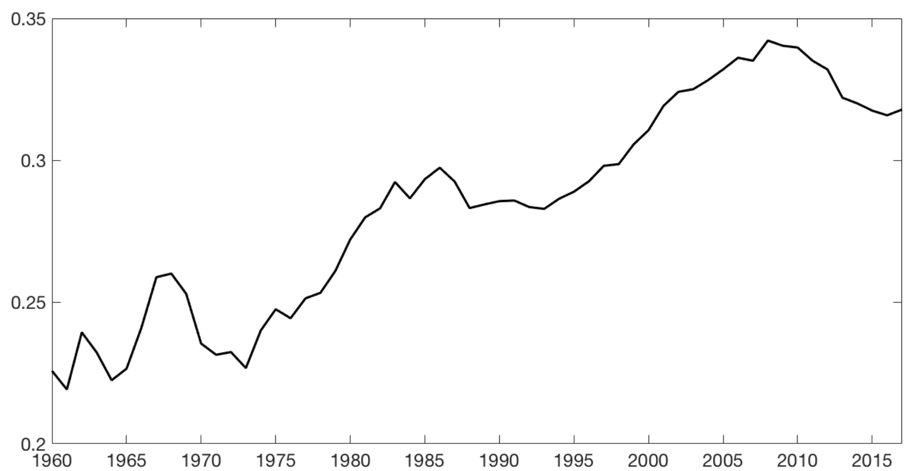
2.2 The Government Intermediate Inputs Share

In this paper we document a novel stylized fact on government consumption spending, namely that the relative size of its two components $P_{Y_g,t}Y_{g,t}$ and $P_{M_g,t}M_{g,t}$

[10]The definitions of government gross output, value added, and intermediate inputs can be explained in the following example. The government gross output associated with the provision of education consists of the wage and non-wage benefits accruing to the employees of public educational institutions, the depreciation of the capital stock, such as offices, buildings, and computers, and the purchase from the private sector, such as stationery, chalks, and blackboards.

changes dramatically over time in industrialized economies. In particular, governments purchase relatively more goods and services from the private sector, and rely less on the in-house production of value added. In Section 3 we interpret these purchases from the private sector as intermediate goods entering the gross-output production of the government, so that the ratio $(P_{M_g,t}M_{g,t})/(P_{G,t}G_t)$ defines the share of intermediate inputs in gross output. Figure 1 reports the share of intermediate inputs in the gross output of the general government in the U.S. from 1960 to 2017, which rises from a value of 22.6% in 1960 up to 31.8% in 2017. We refer to this new stylized fact as *the changing structure of government spending.*

Figure 1: Share of Government Intermediate Inputs.

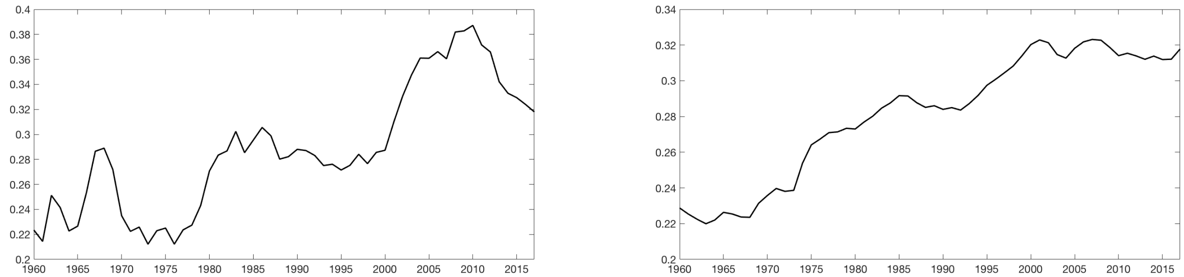


Note: This graph reports the share of intermediate inputs in the gross output of general government. The data is annual from 1960 until 2017. Source: Bureau of Economic Analysis.

The share of intermediate inputs rises even when we disaggregate the gross output of the general government in either the gross output of the federal government or the gross output of the local government. Figure 2 reports the share of intermediate inputs at these different government levels, and shows that the intermediate inputs share of the federal government increased from 22.4% to 31.8%, whereas the intermediate inputs share of the local government rose from 22.9% to 31.8%. Hence, the rise of the government intermediate inputs share is not driven by the behavior of one specific level (or function) of the U.S. government.

Figure 2: Share of Government Intermediate Inputs - Different Government Levels.

(a) Federal Government (b) Local Government



Note: These graphs report the share of intermediate inputs in the gross output of the federal government (Panel a) and the share of intermediate inputs in the gross output of the local government (Panel b). The data is annual from 1960 until 2017. Source: Bureau of Economic Analysis.

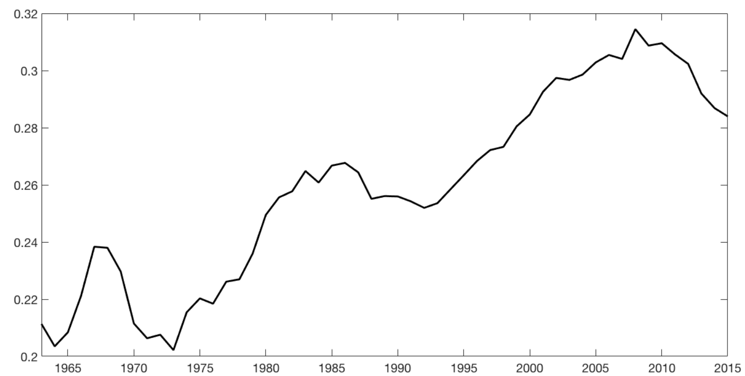
The rise in the government intermediate inputs share could be driven by an outsourcing process through which public workers are displaced and then hired back by private companies, even though they do not change their job tasks. To rule out this hypothesis, we compute the government intermediate inputs share by excluding each time a key sector in the provision of goods and services to the government. Figure 3 shows that even when we exclude either the finance and real estate sector, or the professional and business services sector, or the educational services sector, or the health care services sector, the government intermediate inputs share always displays an upward trend. Thus, the changing structure of government spending does not hinge on a simple outsourcing of labor, but it is rather the result of a complex reallocation of resources from the public sector to the private sector.[11]

The rise of the government intermediate inputs share is not mirrored by an analogous trend in the private sector. Ngai and Samaniego (2009), Moro (2012, 2015), Duarte and Restuccia (2017) have documented that the intermediate inputs shares in private gross output across sectors are constant over time. The evidence of this strand of the literature confirms that the changes in the intermediate inputs

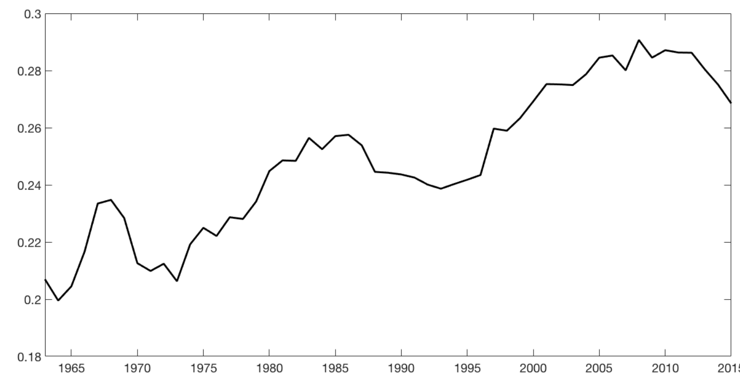
[11]The hypothesis of a simple process of outsourcing of labor from the public to the private sector would generate a raise in the value-added labor share of the private sector, which is inconsistent with the secular decline documented by Karabarnounis and Neiman (2014).

Figure 3: Share of Government Intermediate Inputs - Excluding Specific Sectors.

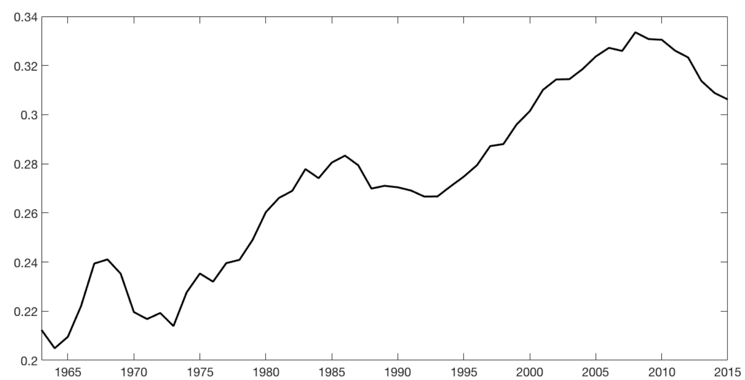
(a) Excluding Financial & Real Estate Services



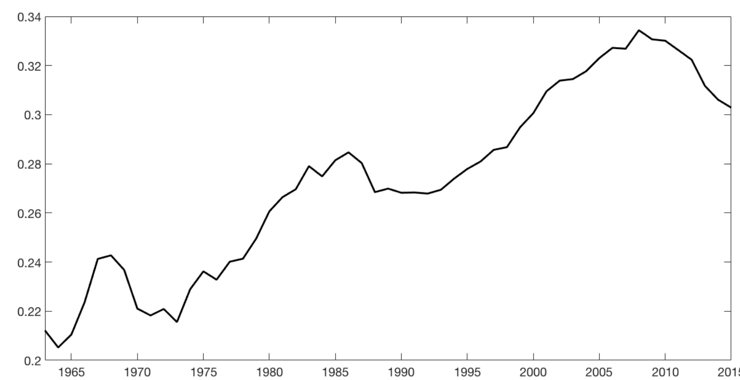
(b) Excluding Professional Services



(c) Excluding Educational Services



(d) Excluding Health Care Services

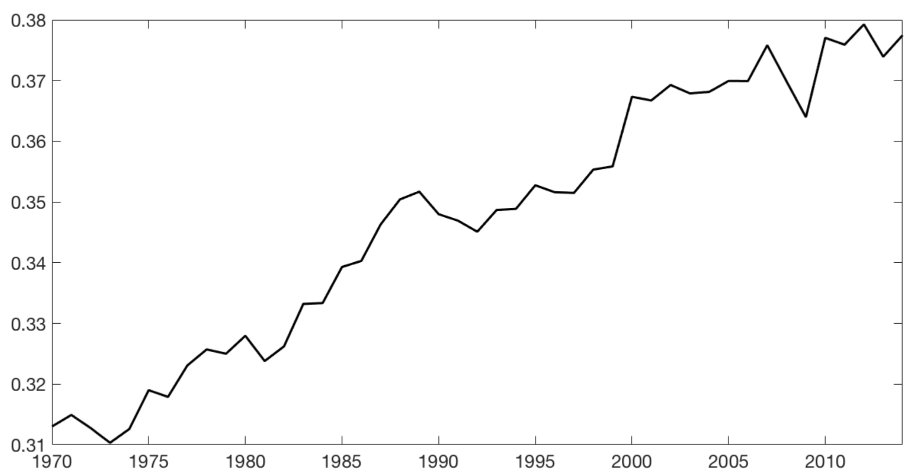


Note: The graphs report the share of intermediate inputs in the gross output of the general government when excluding the inputs provided by either the financial services and real estate sector (Panel a), or the professional and business services sector (Panel b), or the educational services sector (Panel c), or the health care services sector (Panel d). The data is annual from 1960 until 2015. Source: Bureau of Economic Analysis.

share of the government gross-output production function were not accompanied by similar systematic dynamics in the private sector.

Importantly, the rise of the government intermediate inputs share does not characterize only the U.S. economy. Using data from the World KLEMS initiative on an unbalanced panel of twenty countries over the years 1970 - 2014, we uncover the global dimension of the changing structure of government spending.[12] In a similar vein as the analysis of Karabarnounis and Neiman (2014) on the labor share, we estimate a panel regression in which the intermediate inputs share is regressed on country fixed effects and year fixed effects. Figure 4 reports the estimated coefficients on the year fixed effects, which inform on the global dimension of the change in the government intermediate inputs share. The rise in the government intermediate inputs share is indeed a global phenomenon: the average share has been rising from 31% to 38%.

Figure 4: The Global Rise of the Government Intermediate Inputs Share.



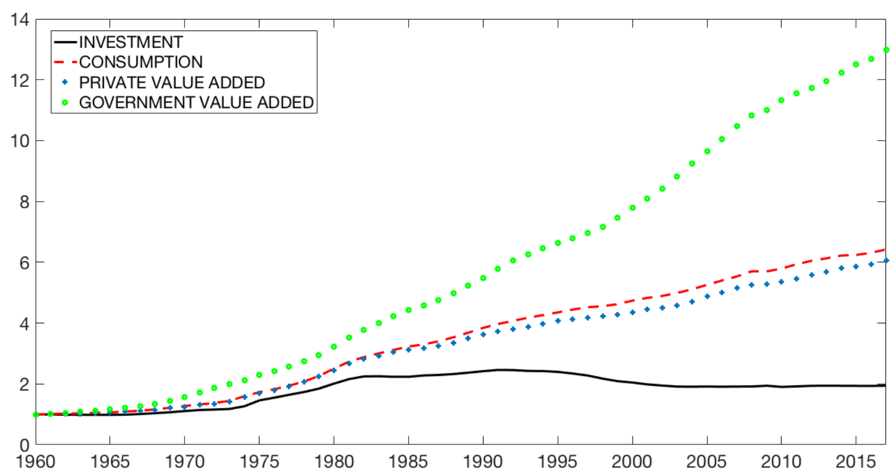
Note: The graph plots the estimated coefficient of year fixed effects in a panel regression across twenty countries in which the government intermediate inputs share is regressed on country and year fixed effects. Source: World KLEMS Initiative.

[12]The countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States.

2.3 The Price of Investment Goods

The rise in the government intermediate inputs share is highly correlated with the decline of the relative price of investment goods in terms of the price of consumption goods. Figure 5 shows that the price of investment goods increases over time much less than the price of consumption goods, and this relative decline takes place contemporaneously to the rise in the share of government intermediate inputs. In addition, as the relative price of investment goods declines, the prices of the government and private value added diverge more and more. The dramatic increase in the price of government value added relative to the price of the value added of the private sector suggests that over time the private sector is progressively becoming more productive than the government.

Figure 5: The Relative Price of Investment.



Note: The graph plots the price of investment goods (continuous line), the price of consumption goods (dashed lined), the price of private value added (crossed line), and the price of government value added (squared line). All prices range from 1960 to 2017, and are normalized to equal one in 1960. Source: Bureau of Economic Analysis.

As in the U.S. the empirical evidence is suggestive of a negative correlation between the relative price of investment and the government intermediate inputs share, we extend the analysis to a cross-country dimension, to test the robustness of this relationship. By exploiting data from the World KLEMS project, the Penn World Tables, and the World Development Indicators, we construct a panel on the government intermediate inputs share and the relative price of investment across 20 industrialized countries at a yearly frequency during the 1975-2010 period. We use these data to estimate the following panel regression

$$\log\left(\frac{P_{M_g,i,t}M_{g,i,t}}{P_{G,i,t}G_{i,t}}\right) = \alpha_i + \delta_t + \beta \log\left(\frac{P_{I,i,t}}{P_{i,t}}\right) + \gamma X_{i,t} + \epsilon_{i,t}$$

where $\frac{P_{M_g,i,t}M_{g,i,t}}{P_{G,i,t}G_{i,t}}$ denotes the share of government intermediate inputs in country i at time t, defined as the ratio of the nominal value of public purchases from the private sector $P_{M_g,i,t}M_{g,i,t}$ over the nominal value of the gross output of the government $P_{G,i,t}G_{i,t}$, α_i and δ_t are country and time fixed effects, $\frac{P_{I,i,t}}{P_{i,t}}$ denotes the relative price of investment, defined as the ratio between the price of investment $P_{I,i,t}$ and the price of consumption $P_{i,t}$, and $X_{i,t}$ is a vector of control variables, which include the share of military spending in total government spending, and the proceeds from corporate income taxation, personal income taxation, social security contributions, value added taxation, and personal property taxation, all measured as a percentage of GDP.

We report the results of the panel regression in Table 1, in which Panel (a) refers to the case in which the relative price of investment is derived from information of the Penn World Tables, whereas Panel (b) refers to the case in which the relative price of investment is derived from information of the World Development Indicators.

In both Panels, column (1) reports the estimated coefficient of relationship between the government intermediate inputs share and the relative price of investment in a simple panel regression, column (2) reports the estimated coefficient in a regression which includes country fixed effects, column (3) reports the estimated coefficient in a regression which includes year fixed effects, which control for common time-variation across countries in the government intermediate inputs share, column (4) reports the estimated coefficient in a regression with country and time fixed effects, and column (5) reports the estimated coefficient in a regression with not only country and time fixed effects, but also the set of key country-specific characteristics that controls for the structure of government spending and financing.

Table 1: Panel Regressions: Share of Government Purchases and the Price of Investment

Dependent Variable: Share of Government Purchases from Private Sector in Government Spending					
	(1)	(2)	(3)	(4)	(5)
Panel (a): PWT Relative Price of Investment					
Price Investment	-0.66***	-0.32***	-0.79***	-0.31**	-0.40***
	(0.06)	(0.05)	(0.07)	(0.14)	(0.14)
Controls	No	No	No	No	Yes
Country Fixed Effects	No	Yes	No	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes
R^2	0.19	0.82	0.22	0.83	0.88
N. Obs.	535	535	535	535	502
Panel (b): WDI Relative Price of Investment					
Price Investment	-0.86***	-0.40***	-0.96***	-0.37***	-0.32***
	(0.07)	(0.06)	(0.08)	(0.13)	(0.12)
Controls	No	No	No	No	Yes
Country Fixed Effects	No	Yes	No	Yes	Yes
Year Fixed Effects	No	No	Yes	Yes	Yes
R^2	0.23	0.82	0.26	0.83	0.88
N. Observations	535	535	535	535	502

Note: The panel covers 20 countries from 1975 to 2010. The dependent variable in all the regressions is the log of the share of government purchases from the private sector over total government spending. *Price of Investment* indicates the log of the relative price of investment in terms of the price of consumption, which either comes from the Penn World Tables (PWT Relative Investment Price) in Panel (a) or from the World Development Indicators (WDI Relative Investment Price) in Panel (b). The control variables are the amount of military government spending over total government spending, the amount of proceeds from corporate income taxation over total GDP, the amount of proceeds from personal income taxation over total GDP, the amount of proceeds from goods taxation - which consists mainly in the proceeds of the value added taxation - over total GDP, the amount of proceeds from personal property taxation over total GDP, the amount of proceeds from social security contributions over total GDP. Robust standard errors are reported in brackets. ** and *** indicate statistical significance at the 5% and 1%, respectively.

Table 1 shows that the estimated elasticity between the structure of government spending and investment-specific technological change is always negative and highly statistically significant, independently on the specification of the regression. Also the introduction of the regressors that control for changes in the entire set of taxes of the government does not alter our main finding. Hence, the relationship between the changes in the structure of government spending and the relative price of investment does not hinge on changes in the financing side of the government. Although these results have to be interpreted as simple correlations, in the next section we rationalize this evidence through the lenses of a model in which ISTC is the only exogenous driver of the changes in the structure of governments spending.

3 The Model

We build a model that can endogenously generate a changing structure of government consumption spending, and then we use it to evaluate the implications of this secular process on the size of fiscal multipliers.

The economy consists of a representative household, a final good private-sector firm, a continuum of monopolistically competitive private-sector firms, an investment-good producer, and the government. The government produces public goods using labor, capital, and intermediate inputs produced by the private-sector firm.

The model has a set of features that are intended to generate the long-run changes in the structure of government spending: the production function of government gross output with a non-unitary elasticity of substitution between value added and intermediate inputs, the differences in the value-added capital share between the private sector and the government, and ISTC, such that the relative price of investment goods in terms of consumption goods falls exogenously over time.

In addition, the model has a set of features which are intended to generate short-run dynamics following government spending shocks that are quantitatively in line with the empirical evidence on fiscal multipliers: the New Keynesian set up of the economy (i.e., monopolistic competition and Calvo (1983) staggered price setting in the private sector), a GHH utility function, and the presence of intermediate inputs in the production function of the private sector.[13]

3.1 Household

The economy is populated by an infinitely-lived representative household that has preferences over consumption C_t and labor N_t, such that the lifetime utility is

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\sigma} \left(C_t - \theta \frac{N_t^{1+\eta}}{1+\eta} \right)^{1-\sigma} \right], \tag{4}$$

where β is the time discount factor, σ denotes the risk aversion, θ captures the disutility from working, and η is the inverse of the Frisch elasticity. We consider a GHH utility as in Greenwood et al. (1988) because CRRA preferences generate counterfactually low fiscal multipliers when government spending consists also of government value added.[14]

The household maximizes life-time utility (4) subject to the budget constraint

$$P_t C_t + P_{I,t} I_t + T_t + B_{t+1} = W_t N_t + R_{k,t} K_t + R_t B_t + \Pi_t. \tag{5}$$

The household buys the consumption goods C_t at the nominal price P_t, investment goods I_t at the nominal price $P_{I,t}$ and incur in lump-sum nominal taxes T_t. The household also invests in a one-period bond B_t which yields a nominal gross interest rate R_t. The household earns a nominal labor income $W_t N_t$, a nominal capital income $R_{k,t} K_t$, and receives the profits of private-sector firms Π_t. Physical capital accumulates following the law of motion

[13] Section C of the Appendix studies the relevance of each of these features on the effects of the changing structure of government spending on the size of fiscal multipliers.

[14] Bilbiie (2011) shows that the consumption-labor complementarities generated by GHH preferences can trigger a positive response of consumption to government spending where prices are not flexible. Gnocchi et al. (2016) study time use data to provide empirical evidence on the relevance on the consumption-labor complementarities in the transmission of government spending.

$$K_{t+1} = (1-\delta) K_t + I_t \left[1 - \frac{\Omega}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right], \tag{6}$$

where δ is the depreciation rate and Ω captures investment adjustment costs.

The household provides labor and capital to both the private-sector firms and the government, such that

$$N_t = N_{p,t} + N_{g,t}, \qquad \text{and} \qquad K_t = K_{p,t} + K_{g,t}. \tag{7}$$

The perfect mobility of capital and labor across sectors implies that both the wage W_t and the rental rate of capital $R_{k,t}$ equalize across sectors in equilibrium.

3.2 Investment-Good Producer

The investment-good producer purchases consumption goods X_t at the nominal price P_t, transform them into investment goods I_t, which are then sold to the households at the the nominal price $P_{I,t}$. The investment-good producer uses a linear technology that turns one unit of consumption good X_t into q_t units of investment good I_t. Hence, the maximization problem of the investment-good producer reads

$$\max_{X_t} P_{I,t} I_t - P_t X_t \tag{8}$$

$$\text{s.t.} \quad I_t = q_t X_t. \tag{9}$$

The variable q_t denotes the current state of ISTC: it determines the amount of investment that can be produced for one unit of consumption goods. The variable q_t moves exogenously over time following the motion

$$q_t = (1+\lambda) q_{t-1}, \tag{10}$$

where λ is the growth rate of ISTC.

The first-order condition associated with the problem (8)-(9) defines that the nominal price of the investment good equals

$$P_{I,t} = \frac{P_t}{q_t}. \tag{11}$$

In Equation (11) , the level of ISTC q_t pins down the relative price of investment goods in terms of the consumption goods. As the variable q_t increases, the production of the investment good requires less units of the consumption goods, and the relative price of investment shrinks over time.

3.3 Government-Sector Firm

The total amount of public goods G_t produced by the government moves over time following the realizations of government consumption spending shocks, as

$$\log G_t = (1-\rho_g)\, G_s + \rho_g \log G_{t-1} + \epsilon_{g,t}, \tag{12}$$

where the parameter ρ_g denotes the persistence of changes in government spending, $\epsilon_{g,t}$ is a spending shocks such that $\epsilon_{g,t} \sim N(0, \sigma_g)$, and G_s is the steady-state level of public goods. In the quantitative analysis, we set G_s to be a constant fraction of total GDP, as it is in the data. In this way, in the model there is no change in the total amount of government spending relative to GDP, but only in its composition.

Although the total amount of public goods G_t moves exogenously over time, the inputs required to produce such a level of government consumption spending are endogenously determined according to the gross-output production function[15]

$$G_t = \left[\omega_{m,g}^{\frac{1}{\nu_{m,g}}} M_{g,t}^{\frac{\nu_{m,g}-1}{\nu_{m,g}}} + (1-\omega_{m,g})^{\frac{1}{\nu_{m,g}}} Y_{g,t}^{\frac{\nu_{m,g}-1}{\nu_{m,g}}} \right]^{\frac{\nu_{m,g}}{\nu_{m,g}-1}}, \tag{13}$$

where $M_{g,t}$ denotes the intermediate inputs purchased from the private sector, $Y_{g,t}$ is the in-house production of government value added, $\omega_{m,g}$ is the weight of intermediate inputs in the government gross output, and $\nu_{m,g}$ denotes the elasticity of substitution between government value added and intermediate inputs. The production function (13) implies that the price of the government gross output is

$$P_{G,t} = \left[\omega_{m,g} P_t^{1-\nu_{m,g}} + (1-\omega_{m,g})\, P_{Y_g,t}^{1-\nu_{m,g}} \right]^{\frac{1}{1-\nu_{m,g}}}, \tag{14}$$

[15] This modeling approach is observationally equivalent to positing that the government chooses optimally both the production inputs *and* the level of gross output to meet an exogenously given households' demand for public goods.

where P_t is the price of the intermediate inputs provided by the private sector and $P_{Y_g,t}$ is the price of government value added. The first-order condition on the optimal amount of government intermediate inputs implies that the government intermediate inputs share equals

$$\frac{P_t M_{g,t}}{P_{G,t} G_t} = \omega_{m,g} \left(\frac{P_t}{P_{G,t}} \right)^{1-\nu_{m,g}}. \tag{15}$$

This condition states that when government value added and intermediate inputs are imperfect substitutes (i.e., $\nu_{m,g} > 1$), an increase in the price of government value added relative to the price of private-sector goods induces the government to raise the share of intermediate inputs.

The government value added $Y_{g,t}$ is produced with a Cobb-Douglas function

$$Y_{g,t} = K_{g,t}^{\alpha_{k,g}} \, N_{g,t}^{1-\alpha_{k,g}}, \tag{16}$$

where $\alpha_{k,g}$ denotes the capital share of the government value added. The production function (16) implies that the price of government value added is

$$P_{Y_g,t} = \frac{R_{k,t}^{\alpha_{k,g}} \; W_t^{1-\alpha_{k,g}}}{{\alpha_{k,g}}^{\alpha_{k,g}} \left(1-\alpha_{k,g}\right)^{1-\alpha_{k,g}}}. \tag{17}$$

Finally, the balanced budget constraint of the government implies $P_{G,t}G_t = T_t$, such that

$$T_t = W_t N_{g,t} + R_{k,t} K_{g,t} + P_t M_{g,t}. \tag{18}$$

The government levies a lump-sum nominal tax T_t to finance its wage bill $W_t N_{g,t}$, the cost of renting capital $R_{k,t} K_{g,t}$, and the purchase of private-sector goods $P_t M_{g,t}$. In this way, the financing side of the model does not vary over time, and we can isolate the role of changes in the structure of government spending. This modeling choice is consistent with our empirical evidence in Section 2.3, in which we show that the relationship across countries between the relative price of investment and the share of government purchases from the private sector holds above and beyond any heterogeneity in the financing structure of the government.

3.4 Monopolistically Competitive Private-Sector Firms

As in standard New Keynesian models, the production structure of the private sector is split in two levels: a continuum of monopolistically competitive producers indexed by $i \in [0, 1]$ and a final goods firm.

Each monopolistically competitive firm i produces the gross-output variety $GO^i_{p,t}$ with a Cobb-Douglas value-added production function

$$GO^i_{p,t} = \left[{K^i_{p,t}}^{\alpha_{k,p}} \, {N^i_{p,t}}^{1-\alpha_{k,p}} \right]^{1-\alpha_{m,p}} {M^i_{p,t}}^{\alpha_{m,p}}, \qquad (19)$$

where $K^i_{p,t}$ and $N^i_{p,t}$ are the amounts of capital and labor hired by firm i. In equilibrium, the market clearing conditions imply that $\int_0^1 N^i_{p,t} \, di = N_{p,t}$ and $\int_0^1 K^i_{p,t} \, di = K_{p,t}$. Then, $M^i_{p,t}$ denotes the intermediate inputs, $\alpha_{m,p}$ is the share of intermediate inputs in the private-sector gross output[16], and $\alpha_{k,p}$ is the capital share of the private-sector value added. Importantly, we allow the capital share in private value added $\alpha_{k,p}$ to differ from the capital share in government value added $\alpha_{k,g}$. In the calibration, we set these parameters to match the shares observed in WorldKLEMS and BEA data and find that the capital share of private value added doubles the one in the government.

Finally, firms face a Calvo staggered price setting mechanism such that prices can be reset with a probability $1 - \phi$. This probability is independent and identically distributed across firms, and constant over time. As a result, in each period a

[16]The Cobb-Douglas specification of the gross output of the private sector implies that in the model the share of intermediate inputs in gross output is constant over time. Importantly, the constancy of the share of intermediate inputs in private gross output does not depend on the elasticity of substitution between value added and intermediate inputs. This is due to the fact that the price of gross output and intermediate inputs is always the same in the private sector. Section A of the Appendix shows that in the model the share of intermediate inputs in the gross output of the private sector is constant over time, independently on the value of the elasticity of substitution between private value added and private intermediate inputs. Rather, the choice of a unitary elasticity of substitution is motivated by the empirical evidence on this parameter provided by Atalay (2017), who finds that the elasticity of substitution estimated over a panel of 30 U.S. sectors from 1997 to 2013 is not statistically different from one.

fraction ϕ of firms cannot change their prices and maintain the prices of the previous period, whereas the remaining fraction $1-\phi$ of firms can set freely their prices. The optimal reset price $P_t^{i,\star}$ is chosen to maximize the expected discounted stream of real dividends

$$\max_{P_t^{i,\star}} \mathbb{E}_t \sum_{s=t}^{\infty} (\beta\phi)^s \Lambda_{t,s} \left[\frac{P_t^i}{P_s} - \varphi_s\right] GO_{p,s}^i,$$

where φ_t denotes the real marginal cost, and $\Lambda_{t,s}$ is the stochastic discount factor of the household between period t and s.

3.5 Final Goods Private-Sector Firm

The perfectly competitive final goods firm aggregates the different gross-output varieties $GO_{p,t}^i$ produced by the continuum of monopolistically competitive firms using the CES function

$$GO_{p,t} = \left(\int_0^1 GO_{p,t}^{i\;\frac{\epsilon-1}{\epsilon}} \, di\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{20}$$

where ϵ denotes the elasticity of substitution across varieties.

The market clearing condition of the private sector posits that the production of final goods is split into the consumption goods demanded by the households, the investment goods demanded by the investment goods producer firm, the intermediate inputs demanded by the private sector, and the intermediate inputs demanded by the government:

$$GO_{p,t} = C_t + X_t + M_{p,t} + M_{g,t}. \tag{21}$$

where the market clearing for intermediate inputs used by the private-sector firms imply that $M_{p,t} = \int_0^1 M_{p,t}^i \, di$.

Finally, we define the value added of the private sector $Y_{p,t}$ as the difference between the nominal value of private-sector gross output and the nominal value of private-sector intermediate inputs, that is

$$P_{Y_p,t} Y_{p,t} = P_t GO_{p,t} - P_t M_{p,t}. \tag{22}$$

3.6 Closing the Model

We consider the consumption price as the numeraire of the economy. Accordingly, we can define the real aggregate GDP as the sum of the value added of the private sector multiplied by the relative price of the private-sector value added in terms of the consumption price and the value added of the government multiplied by the relative price of the government value added in terms of the consumption price, that is

$$Y_t = \frac{P_{Y_p,t}}{P_t} Y_{p,t} + \frac{P_{Y_g,t}}{P_t} Y_{g,t}. \tag{23}$$

In the economy there is a monetary authority that sets the nominal interest rate R_t following the Taylor rule

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}}\right)^{\rho_r} \left[(1+\pi_t)^{\phi_\pi} x_t^{\phi_y}\right]^{1-\rho_r}, \tag{24}$$

where $1+\pi_t = \frac{P_t}{P_{t-1}}$ is the consumer price inflation, and $x_t = \log\left(\frac{Y_t}{Y_t^{FLEX}}\right)$ defines the output gap, that is, the difference between the log real GDP of the economy Y_t and the corresponding variable Y_t^{FLEX} for an economy with fully flexible prices. R_{ss} is the steady-state interest rate, ρ_r denotes the degree of interest rate inertia, ϕ_π and ϕ_y capture the elasticities at which the monetary authority moves the nominal interest rate following a change in inflation and the output gap, respectively.

3.7 The Structure of Government Spending

This section characterizes analytically the equilibrium steady-state structure of government spending. We provide a closed-form formula that highlights the conditions through which ISTC induces a switch of the government production function towards the purchase of intermediate inputs.

In the steady-state the equilibrium government intermediate inputs share equals

$$\frac{P_{ss}M_{g,ss}}{P_{G,ss}G_{ss}} = \frac{\omega_{m,g}}{\omega_{m,g} + \Phi\left(1-\omega_{m,g}\right) q_{ss}^{\frac{\alpha_{k,g}-\alpha_{k,p}}{1-\alpha_{k,p}}\left(\nu_{m,g}-1\right)}} \tag{25}$$

where

$$\Phi = \left(\frac{\left[\alpha_{m,p}^{\alpha_{m,p}}\left(1-\alpha_{m,p}\right)^{\left(1-\alpha_{m,p}\right)}\right]^{\frac{1-\alpha_{k,g}}{\left(1-\alpha_{k,p}\right)\left(1-\alpha_{k,g}\right)}}\left[\alpha_{k,p}^{\alpha_{k,p}}\left(1-\alpha_{k,p}\right)^{\left(1-\alpha_{k,p}\right)}\right]^{\frac{1-\alpha_{k,g}}{1-\alpha_{k,p}}}}{\alpha_{k,g}^{\alpha_{k,g}}\left(1-\alpha_{k,g}\right)^{\left(1-\alpha_{k,g}\right)}}\right)^{1-\nu_{m,g}} > 0.$$

How does the level of ISTC q_{ss} affect the equilibrium government intermediate inputs share? Equation (26) defines the derivative of the government intermediate inputs share with respect to q_{ss}:

$$\frac{\partial \frac{P_{ss}M_{g,ss}}{P_{G,ss}G_{ss}}}{\partial q_{ss}} = \frac{\Phi\left(1-\omega_{m,g}\right)^{\left(\nu_{m,g}-1\right)\left(\frac{\alpha_{k,p}-\alpha_{k,g}}{1-\alpha_{k,p}}\right)} q_{ss}^{\left[\frac{\alpha_{k,g}-\alpha_{k,p}}{1-\alpha_{k,p}}\left(\nu_{m,g}-1\right)\right]-1}}{\left[\omega_{m,g} + \Phi\left(1-\omega_{m,g}\right) q_{ss}^{\frac{\alpha_{k,g}-\alpha_{k,p}}{1-\alpha_{k,p}}\left(\nu_{m,g}-1\right)}\right]^2}. \tag{26}$$

The sign of the derivative depends on the sign of the numerator, as the denominator is always positive. Since $\Phi > 0$ and $0 < \omega_{m,g} < 1$, the numerator is positive under two conditions that have to hold jointly:

(*i*) $\alpha_{k,p} > \alpha_{k,g}$, such that private-sector value added is more intensive in capital then government value added;

(*ii*) $\nu_{m,g} > 1$, such that government value added and intermediate inputs are imperfect substitutes within the government gross-output production function.

Condition (*i*) guarantees that ISTC raises more the efficiency of the private-sector firm than the efficiency of the government. In this way, the private sector becomes relatively more productive over time. Instead, condition (*ii*) governs how the relative increase in the efficiency of the private sector affects the government production function. Since government value added and intermediate inputs are imperfect substitutes, the government finds it optimal to switch partially from the in-house production of value added to the purchase of intermediate inputs produced by the private-sector firm as the latter becomes more productive.[17]

4 Quantitative Analysis

4.1 Empirical Strategy

In general, multi-sector models with a changing production structure do not follow a balanced growth path.[18] This feature characterizes also our model. We then study the performance of the model in explaining the variation in the structure of government consumption spending by comparing two steady-states which differ in the level of ISTC q_t. First, we normalize the level of ISTC in 1960 such that $q_{1960} = 1$, and calibrate the model to match the share of government purchases from the private sector as of 1960. Next, we compute the change in the relative price of investment between 1960 and 2017 and feed the model with the observed value of ISTC in 2017, q_{2017}. Finally, we evaluate the quantitative performance of the model in explaining the changing structure of government spending by comparing the share of intermediate inputs in gross output of the government in the two steady-states.

Then, we analyze the implications of the changing structure of government spending on fiscal multipliers by studying the effects of government spending shocks around the 1960 and 2017 steady-states. These equilibria differ in the exogenous level of ISCT and therefore in the endogenous structure of government consumption spending. Throughout our analysis, we keep fixed all the other parameters, so we can ask to what extent the variation in the structure of government consumption

[17]The derivate is also positive in the counterfactual case in which the private sector is less intensive in capital than the government (i.e., $\alpha_{k,p} < \alpha_{k,g}$) and government value added and intermediate inputs are complements (i.e., $\nu_{m,g} < 1$).

[18]In the structural change literature, balanced growth path exists only in very particular cases. See Kongsamut, Rebelo and Xie (2001), Ngai and Pissarides (2007) and Boppart (2014).

spending alone can alter the transmission of government spending shocks.[19]

4.2 Calibration

Section 3.7 has established that in the model the change in the government intermediate inputs share depends on three key elements: the overall change in the relative price of investment, the value added capital share of both the private-sector firm and the government, and the elasticity of substitution between government value added and intermediate inputs. To properly evaluate the quantitative performance of the model, we discipline these three elements with the data. Throughout the calibration, we set one period of the model to equal a quarter, as it is standard in the literature on fiscal multipiers.

We follow Greenwood et al. (1997, 2000) and Debortoli and Gomes (2015) by disciplining the amount of ISTC using data on investment prices (excluding residential investment). We take the price of equipment investment, divide it by the price of non-durable consumption, and normalize it to be 1 in 1960. We find that from 1960 to 2017 the price of equipment has been declining at an annual rate of -1.8%. Following Cummins and Violante (2002), we add a further -2.5% annual decline to adjust for the quality bias of the raw equipment price series. This adjustment implies that the price of equipment has actually been declining at an overall annual rate of -4.3%. We apply the same procedure to the price of non-residential structure (without the quality-bias adjustment), and find that the price of structures has been increasing from 1960 to 2017 at an annual rate of 1.48%. Then, we use a Tornquist procedure to weight the changes in the prices of equipment and structures, by taking into account that from 1960 to 2017 the investment in equipment accounts for around 65% of the total non-residential investment. This procedure yields an aver-

[19]Strictly speaking, we also allow the disutility of labor in the utility function to be time varying, to keep a labor supply of $N_{ss} = 0.33$ in both steady-states. This choice alters the aggregate steady-state equilibrium of the model, but not its dynamics around the steady-state. See the next subsection for details.

age annual growth rate of the price of investment that equals -2.3%, which implies that the variable q_t has been increasing at a quarterly rate of $\lambda = 0.57\%$.

Our mechanism hinges on different value-added capital shares between the private sector and the government. Nevertheless, recovering these shares from the national accounts is not straightforward as the definition of value added differs across sectors, as we have already mentioned in Section 2.1. In the private sector, value added equals the sum of the compensation of employees, taxes of production and imports less subsidies, the depreciation of fixed capital, proprietors' income, and corporate profits. Instead, government value added equals just the sum of the compensation of employees and the depreciation of fixed capital. The discrepancy between the definitions of value added is also due to the fact that the Bureau of Economic Analysis assumes a zero-return on public capital (i.e. the gross operating surplus equals the depreciation of fixed capital and does not include any extra source of income and profit). For this reason, we compute the capital shares by harmonizing the definition of value added across sectors. Namely, we consider that value added in either sector equals the sum of the compensation of employees and the depreciation of fixed capital. This assumption washes out the role of taxes of production and imports less subsidies from the private-sector value added, and extends the assumption of zero-return to private-sector capital. Once we have the same definition of value added, we proceed in computing the average capital shares between 1960 and 2016. We find that the average labor share of government value added is 0.78, which implies that the government capital share is $\alpha_{k,g} = 0.22$. Instead, the private-sector value-added labor share equals 0.59, such that the capital share of the private sector is $\alpha_{k,p} = 0.41$. Hence, condition (i) of the characterization of Section 3.7 does hold in the data as private-sector value added is more intensive in capital than government value added.[20]

[20] Public firms have a higher labor intensity than private firms even within a sector, as documented by Dewenter and Malatesta (2001). Moreover, La Porta and Lopez-de-Silanes (1999) and Dewenter and Malatesta (2001) find that following a privatization the labor intensity of public firms shrinks by roughly 40%. Hence, the higher

We estimate the elasticity of substitution between government value added and government intermediate inputs using cross-country data. To back-up from the data a model-consistent estimate of this key parameter, we estimate the first-order condition of intermediate inputs of Equation (15), controlling for time and fixed effects. Namely, we estimate the regression

$$\log\left(\frac{P_{i,t}M_{g,i,t}}{P_{G,i,t}G_{i,t}}\right) = \log\omega_{m,g} - (1-\nu_{m,g})\log\left(\frac{P_{i,t}}{P_{G,i,t}}\right) + \delta_i + \alpha_t + \epsilon_{i,t}$$

where $P_{i,t}M_{g,i,t}$ denotes the nominal value of government intermediate inputs of country i at time t, $P_{G,i,t}G_{i,t}$ is the nominal value of government gross output, $\log\omega_{m,g}$ is a constant, $P_{i,t}$ is the price deflator of government intermediate inputs, $P_{G,i,t}$ is the price deflator of government gross output, δ_i is a country fixed effect, and α_t is a time fixed effect. The object of interest is the coefficient $1-\nu_{m,g}$, which yields a direct estimate of the elasticity of substitution between government value added and intermediate inputs. The identification of the elasticity $\nu_{m,g}$ comes from the cross-country variation in trends in the government intermediate inputs shares.

Table 2 reports the results of the regression on the unbalanced panel of twenty countries from 1975 to 2010, at the yearly frequency. We estimate an elasticity of substitution that ranges between 1.90 and 1.97, which confirms that condition (ii) of the analytical characterization of Section 3.7 holds in the data, as government value added and intermediate inputs are imperfect substitutes. Accordingly, we set $\nu_{m,g} = 2$.

labor intensity is intrinsically linked to the ownership by the government. This difference between private and public firms could be driven by different managerial practices (see Bloom and Van Reenen, 2010) or non-market incentives (see Lippi and Schivardi, 2014). The scope of the paper is not to micro-found the differential in the capital share across public and private sector, and all the potential factors that can rationalize the distinct value-added capital shares are captured in a reduced form by wedge between the parameters $\alpha_{k,p}$ and $\alpha_{k,g}$. We study the implications of this differential in the capital shares across public and private sector on the changing structure of government spending, implicitly assuming that this differential remains constant over time. Section B of the Appendix reports that the differential between the private-sector and government capital shares has mildly increased over time. We show that in our model even the capital shares of both sectors vary over time as a function of ISTC if we consider a CES aggregator for the value-added production functions. This feature not only captures the rising differential between the private-sector and government capital shares but also improves the quantitative performance of the model in explaining the changing structure of government spending.

Table 2: Estimation of the Elasticity ν_m.

	OLS	OLS	Weighted OLS	Weighted OLS
	(1)	(2)	(3)	(4)
$\hat{\nu}_m$	1.97*** (0.32)	1.91*** (0.36)	1.95*** (0.33)	1.90*** (0.36)
Year FE	Yes	No	Yes	No
Country FE	Yes	Yes	Yes	Yes

Note: This table reports the estimate of the parameter ν_m carried out using an unbalanced panel of data on the nominal value of government intermediate inputs, the nominal value of government gross output, the price of government intermediate inputs, and the price of government gross output across twenty countries from 1975 to 2010, at the yearly frequency. The regression (1) includes year and country fixed effects. The regression (2) includes only country fixed effects. The regression (3) includes year and country fixed effects, and each observation is weighted with countries' log GDP. The regression (4) includes only country fixed effects, and each observation is weighted with countries' log GDP.

We set the steady-state level of government spending to equals 20% of the steady-state level of total GDP, to match the average government spending to GDP ratio from 1960 to 2017. For the persistence and the volatility of the government spending shocks, we choose the standard values of $\rho_g = 0.9$ and $\sigma_g = 0.1$. Then, we calibrate the time discount parameter to the standard value of $\beta = 0.99$, which implies an annual steady-state interest rate of 4%. For the utility function, we set the risk aversion to $\sigma = 2$, and we calibrate $\eta = 2$ such that the Frisch elasticity equals 0.5, the value estimated by Chetty et al. (2013) in a meta-analysis of studies on the intensive labor supply elasticity. Finally, note that GHH preferences imply that the amount of labor supply in the steady-state increases with the level of investment-specific technological change. Thus, for the model to display an amount of labor $N_{ss} = 0.33$ in both steady-states we follow Moro (2012) and Galesi and Rachedi (2018) and allow for a time varying disutility of labor.[21] Accordingly, we set θ to

[21]With a constant parameter of the disutility the model would counterfactually imply a 60% rise in the steady-state amount of labor between 1960 and 2017.

Table 3: Calibration.

Parameter	**Value**	**Target/Source**
Level ISTC	$\lambda = 0.0057$	Data
Elasticity Govt. Gross Output	$\nu_m = 2$	Data
Share Inputs in Govt. Gross Output	$\omega_{m,g} = 0.428$	Share Intermediate Inputs 1960
Capital Share Govt.	$\alpha_{k,g} = 0.22$	Data
Capital Share Private Sector	$\alpha_{k,p} = 0.41$	Data
Persistence Govt. Spending	$\rho_g = 0.9$	Standard Value
Std. Deviation Govt. Spending Shocks	$\sigma_{\epsilon_g} = 0.1$	Standard Value
Time discount	$\beta = 0.99$	Steady-State Annual Interest Rate = 0.04
Risk Aversion	$\sigma = 2$	Standard Value
Disutility Labor	$\theta_{1960} = 3.586$	1960 Steady-State Labor = 0.33
Disutility Labor	$\theta_{2016} = 8.968$	2017 Steady-State Labor = 0.33
Inverse Frisch-Elasticity	$\eta = 2$	Chetty et al. (2013)
Depreciation Capital	$\delta = 0.025$	Standard Value
Adjustment Cost	$\Omega = 8.707$	Investment Fiscal Multiplier = -0.48
Elasticity Substitution Varieties	$\epsilon = 6$	Standard Value
Calvo Parameter	$\phi = 0.75$	Standard Value
Interest Rate Inertia	$\rho_i = 0.8$	Clarida et al. (2000)
Taylor Parameter Inflation	$\phi_\pi = 1.5$	Clarida et al. (2000)
Taylor Parameter Output Gap	$\phi_\pi = 0.2$	Clarida et al. (2000)

3.586 in 1960 and to 8.968 in 2017.

In the law of motion of physical capital, we set the depreciation rate to $\delta = 0.025$, and we calibrate the adjustment cost parameter such that a government spending shock in the 1960 steady-state implies a 1-year cumulative investment fiscal multiplier of -0.48, in the range of the estimates of Blanchard and Perotti (2002). This procedure yields a value of $\Omega = 8.707$.

The share of intermediate inputs in the gross output of the private sector is set to 0.45 to capture the average share observed in the data from 1960 to 2017. The elasticity of substitution across the varieties of the intermediate goods in the private sector is set to the standard parameter of $\epsilon = 6$. Then, we calibrate the Calvo parameter to $\phi = 0.75$, such that prices last on average 12 months, and we choose the values for the parameters of the Taylor rule following the estimates of Clarida et al. (2000): the inertia of the nominal interest rate equals $\rho_r = 0.8$, the sensitivity to changes in inflation is $\phi_\pi = 1.5$, and the sensitivity to changes in the output gap is $\phi_y = 0.2$.

Finally, we set the parameter $\omega_{m,g} = 0.428$ such that, given all the other parameters, the model matches the government intermediate inputs share as of 1960.

4.3 The Changing Structure of Government Spending in the Model

We have calibrated the model to match the share of government intermediate inputs as of 1960 in the non-stochastic steady-state. Yet, the prediction of the model on how ISTC drives the change in the share between 1960 and 2017 is left completely unrestricted, and hence informs on the quantitative appeal of the model in explaining the changes in the structure of government spending. In particular, we are interested in the value of the government intermediate inputs shares implied by the model in the non-stochastic steady-state of 2017, where the only difference with respect to the 1960 steady-state is the level of ISTC (i.e., the level of the relative price of investment).

Panel (a) of Table 4 reports the comparison between the two years in the model and the data. The model accounts for 89% of the changes in the structure of government spending between 1960 and 2017, as it predicts an increase in the government intermediate inputs share from 22.6% to 30.8%, compared to one in the data from 22.6% to 31.8%.

Table 4: Results on the Changing Structure of Government Spending.

Variables	**1960**		**2017**	
	Model	Data	Model	Data
	Panel (a): $\nu_m = 2$			
Government Intermediate Inputs Share	22.6%	22.6%	30.8%	31.8%
Government Value Added Relative Price	1	1	1.53	2.39
	Panel (b): $\nu_m = 1.75$			
Government Intermediate Inputs Share	22.6%	22.6%	28.6%	31.8%
Government Value Added Relative Price	1	1	1.53	2.39
	Panel (c): $\nu_m = 2.25$			
Government Intermediate Inputs Share	22.6%	22.6%	33.1%	31.8%
Government Value Added Relative Price	1	1	1.53	2.39

The Table reports the model implications on the share of government intermediate inputs and the relative price of government value added in the 1960 steady-state and the 2017 steady-state vis-à-vis the values of these variables observed in the data. Panel (a) considers the implications of the benchmark model in which $\nu_m = 2$. Panel (b) considers the case of a lower elasticity such that $\nu_m = 1.75$. Panel (c) considers the case of a higher elasticity such that $\nu_m = 2.25$.

How does ISTC raises the government intermediate inputs share? The characterization of Section 3.7 shows that if private-sector value added is more intensive in capital than government value added, a decline in the price of investment raises the relative productivity of the private sector. This pattern can be observed by the implications of the model on the relative price of government value added. The model predicts that the relative price has increased from 1 in 1960 to 1.53 in 2017. This change accounts for 38% of the actual increase observed in the data. Then, if government value added and intermediate inputs are imperfect substitutes, the higher productivity of the private sector induces the government to purchase relatively more goods from the private sector, and rely less on the in-house production of value added. Basically, the government manages to contain the productivity slowdown of its own value added by increasing the share of intermediate inputs in its gross output.

Table 4 reports the implications of the model on the changes of the government intermediate inputs share for different values of the elasticity of substitution between government value added and intermediate inputs. Panel (b) considers the case of a lower elasticity such that $\nu_{m,g} = 1.75$ and Panel (c) considers the case of a higher elasticity such that $\nu_{m,g} = 2.25$. The results point out that even with a lower elasticity, the model still accounts for 65% of the observed change in the government intermediate inputs share. Instead, with a higher elasticity the model slightly overshoots by predicting that in 2017 the intermediate inputs share equals 33.1%.

Panel (b) and (c) also show that the productivity slowdown of the government value added is insensitive to the value of the elasticity of substitution between government value added and intermediate inputs, as the increase in the relative price of government value added does not vary with the value of $\nu_{m,g}$.

4.4 Fiscal Multipliers

This section shows that the secular change in the structure of government spending alters the transmission of government spending shocks. We uncover this fact by comparing the fiscal multipliers in the 1960 and 2017 steady-states. As discussed above, the two equilibria differ only in the level of the exogenous price of investment, and therefore also in the endogenous structure of government spending. Throughout the exercise, we keep all the other parameters fixed, so we can ask to what extent the rise of the government intermediate inputs share alone can alter the transmission of fiscal shocks.

The first two columns of Table 5 report the 1 year cumulative fiscal multipliers implied by the "Benchmark Economy" in the 1960 steady-state and in the 2017 steady state. The model predicts an output fiscal multiplier in the 1960 steady-state which equals 0.75. The response of investment has been calibrated to deliver a multiplier of -0.48, which implies that the consumption multiplier is positive and amounts to 0.23. Moving from the 1960 steady-state to the 2017 one does not alter the size of the output fiscal multiplier, which remains virtually unchanged at a value of 0.76. Hence, the model delivers an output fiscal multiplier which is at the lower bound of the empirical estimates in the literature.[22]

The constancy of the total output fiscal multiplier hides offsetting changes in the multipliers of the private and public sectors: the private value-added fiscal multiplier rises from zero to 0.11, whereas the public value-added fiscal multiplier drops from 0.75 to 0.65. Thus, although the changing structure of government spending does not alter the total output fiscal multiplier, it implies a dramatic change in the composition of the transmission mechanism of fiscal policy: over time government spending becomes more effective in spurring the economic activity of the private sector. This result sheds a new light on the findings of Ramey (2012) on

[22]Ramey (2011b) reviews the empirical evidence on output fiscal multipliers and argues the multiplier of a temporary increases in government purchases ranges between 0.5 and 2.

Table 5: 1 Year Cumulative Fiscal Multipliers.

	Benchmark Economy		Exogenous Changing Structure Economy		No Government Gross-Output Production Function			
					Private-Sector Purchases		Value Added	
	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017
Y_t	0.75	0.76	0.68	0.69	0.47	0.47	0.52	0.52
C_t	0.23	0.23	0.16	0.17	-0.06	-0.06	0.00	0.00
I_t	-0.48	-0.47	-0.48	-0.48	-0.47	-0.47	-0.48	-0.48
$Y_{p,t}$	0.00	0.11	-0.09	-0.00	0.38	0.38	-0.48	-0.48
$Y_{g,t}$	0.75	0.65	0.77	0.69	0.09	0.09	1.00	1.00
N_t	1.68	0.68	1.45	1.44	1.13	1.13	1.27	1.27
$N_{p,t}$	0.42	0.24	0.46	0.59	1.13	1.13	-0.55	-0.55
$N_{g,t}$	1.26	0.41	0.99	0.85	0.00	0.00	1.82	1.82

The Table reports the 1-year cumulative fiscal multipliers of the "Benchmark Economy", the "Exogenous Changing Structure Economy" in which there is no change in the relative price of investment and the structure of government spending changes exogenously over time, and the "No Government Gross-Output Production Function" in which government purchases from the private sector and government value added are both exogenously determined by different government spending shocks, such as there is no production technology for government gross output that endogenously determines those inputs. In this economy, we consider both the effects of government spending that consist in an exogenous increase of the purchase from the private sector (i.e., the "Private-Sector Purchases" case) and the effects of government spending that consist in an exogenous increase of government value added (i.e., the "Value Added" case). "Model 1960" refers to the steady-state calibrated to match the share of government purchases from the private sector as of 1960. "Model 2017" refers to the steady-state in which either the relative price of investment goods or the share of government purchases from the private sector is set as of 2017.

the contractionary effect of government spending on private activity. In the model, the response of private economic activity to government spending shocks depends crucially on the government intermediate inputs share: government spending shocks trigger a negative response of private economic activity only at low levels of the government intermediate inputs share.

Interestingly, the changing structure of government spending generates a dramatic decline in the response of hours to a government spending shock: the total hours fiscal multiplier drops from 1.68 to 0.68. This decline is due to a substantial reduction of the response of hours both in the private sector, from 0.42 to 0.24, and in the public sector, from 1.26 to 0.41. This difference between the output multiplier and the hours multiplier allows to disentangle the transmission mechanism of fiscal shocks in our model. First, a government spending shock generates a negative wealth effect for the consumers. Since the model features price rigidity, the government spending shock raises labor demand by reducing markups. As a result, labor is crowded-in. Since in our setting productivity raises following the process of ISTC, the increase in the amount of hours needed to increase output by one unit declines over time. Second, this mechanism is amplified by the changing structure of government spending. In the 2017 the government purchases a larger share (in gross output) of goods and services from the private sector. As the private sector is relatively more productive and displays a smaller labor share than the public sector, the response of hours in both sectors is substantially dampened in the 2017 steady-state.

Although few papers have higlighted that the effectiveness of government spending in stimulating economy activity has been decreasing over the recent decades (e.g., Blanchard and Perotti, 2002; Bilbiie et al., 2008; Basso and Rachedi, 2018), our results point towards a disconnect in the response of output and hours to government spending. As government spending shifts towards the purchase of private-sector goods, fiscal policy maintains its effectiveness in stimulating total output, but loses the ability in triggering a large surge of employment. This novel prediction on the disconnect between the response of output and hours to government spending is very relevant for policy-makers, as usually job creation is considered one of the main goals of fiscal stimulus plans.

Would we observe any different behavior in the fiscal multipliers if the changing structure of government spending were to be *exogenous* rather than endogenous? We address this question by studying the fiscal multipliers in an alternative specification of the model, the "Exogenous Changing Structure Economy", which abstracts from ISTC and features an exogenous increase in the share of government purchases in total spending. We implement this case by keeping the level of ISTC to $q_{ss} = 1$ in both the 1960 and 2017 steady-states, and calibrating the parameter $\omega_{m,g}$ in each steady-state such that we can match the variation in the structure of government spending. The results in Table 5 show that although an exogenous changing structure can still explain the shift in the stimulus effect of government spending towards the private economic activity, this version of the model cannot generate a drop in the responsiveness of hours to government spending shocks. This exercise highlights that a model with an exogenous change in the government spending structure not only cannot provide an explanation to this phenomenon by construction, but it also generates different implications of the changing structure of spending on the effects of fiscal policy.

We also report the fiscal multipliers in the "No Government Gross-Output Production Function" economy, in which the composition of government gross output is not determined endogenously by the presence of a production function, as both government purchases from the private-sector and government value added follow AR(1) processes, and the government spending shocks are orthogonal across these two processes. We calibrate the steady-state values of this economy such that it can match exogenously the rise in the share of government purchases from the private sector between 1960 and 2017. In this economy without a government gross-output production function, exogenous increases in the purchase from the private sector increase private value added and have barely any effect on government value added. This shock raises hours, whose increase is fully concentrated in the private sector. Instead, exogenous increases in government value added generate a unitary multiplier of government value added by construction, and have a very large negative effect on private value added. This shock generates an even larger response of hours, which is concentrated in the public sectors, as hours in the private sectors actually drop. This exercise highlights that the absence of a government production function makes the changing structure of government spending not to affect the transmission of fiscal policy across the two steady-states.

5 Empirical Validation

In this section we evaluate whether the implications of the model on the effects of the changing structure of government consumption spending on the transmission of public expenditure shocks hold in the data. Moreover, by looking at the response of hours we can evaluate whether the empirical evidence is more consistent with either an endogenous or exogenous changing structure of government spending. Indeed, only the model with an endogenous structure creates a disconnect between the responses of output and hours.

A challenge of this empirical validation consists in the fact that we want to evaluate how a secular process – such as the changing structure of government consumption spending – alters the transmission of monetary policy. As the rise of the government intermediate inputs share is a slow-moving process, we look at the transmission of government spending shocks *across countries* so that we can exploit the variations in the structure of government consumption spending among different economies at each point of time. This approach follows the same strategy of Galesi and Rachedi (2018), which connects the transmission of monetary policy shocks to a secular change in the sectoral composition of intermediate inputs by exploiting cross-country variation.

We build a data set on total value added, government value added, government gross output, government deficit, and total hours across twenty-eight countries by merging information from the OECD and WorldKLEMS data.[23] Since our variables of interest – government value added and total hours worked – comes at an annual frequency when looking at cross-country data, we define an unbalanced panel across these twenty-eight countries that ranges from 1970 to 2015.

Then, we follow the strategy of Ilzetki et al. (2013) and group the countries in two different panels, each one consisting of fourteen countries: one set of economies with high government intermediate inputs shares ($g \equiv H$), and one set of economies with low government intermediate inputs shares ($g \equiv L$). The split is carried out by looking for each country at its average government intermediate inputs share over 1970 to 2015. In this way, we can evaluate whether the estimated effects of the government spending shocks differ across the two panels, corroborating the idea the the structure of government spending shapes the transmission of fiscal policy. Hence, for each group of countries $g \in \{L, H\}$, we have the following system

$$Y_{i,t}^g = A^g Y_{i,t-1}^g + B^g u_{i,t}^g, \qquad g \in \{L, H\}$$

where $Y_{i,t}^g$ is the vector of the logarithm of real total value added per capita, the logarithm of real government value added per capita, the logarithm of real government gross output per capita, government deficit as a percentage of total value added, and total hours per capita for each country i at year t in the group $g \in \{L, H\}$, and $u_{i,t}^g$ denotes the reduced-form innovations to the system. The matrices A^g and B^g are invariant across countries, groups, and time.

The fact that the data are defined at the annual frequency defines yet another

[23]The countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, United Kingdom, and the United States.

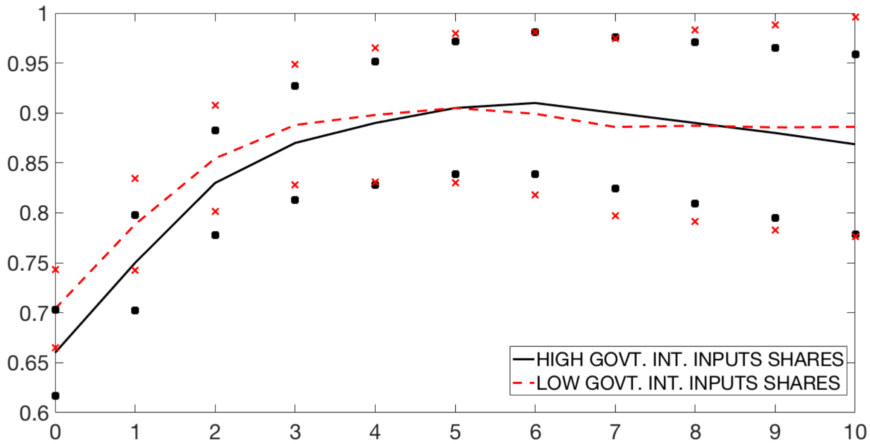
challenge in the identification of government consumption spending shocks. Indeed, the ordering restriction of Blanchard and Perotti (2002), which assumes that fiscal authorities cannot contemporaneously react to variations in economic activity, hinges on the use of quarterly data for its validity. Hence, we follow an alternative identification scheme, by appealing to the sign restriction proposed in Pappa (2009). The use of sign restriction in the identification of government spending shocks is rather common in the literature (e.g., Canova and Pappa, 2007; Mountford and Uhlig, 2009; Bruckner and Pappa, 2012; Pappa et al., 2014; Bermperoglou et al., 2017), and consists in identifying shocks by restricting only the sign of the responses of the variables in our system. Namely, we identify as a positive government spending shock what leads to a rise in government gross output (i.e., a rise in government consumption spending), total value added, and government deficit, both on impact and in the following year.[24] Hence, a government spending shock generates a positive value-added spending multiplier and an increase in government deficit. These restrictions are derived in Pappa (2009) by looking at the responses to government spending shocks in both Real Business Cycle and New Keynesian models for the overwhelming majority of the different possible parameter combinations.

Two comments are due on our identification strategy. First, we are just imposing a sign restriction on the fact that the government consumption spending multiplier should be positive, but then we leave completely unrestricted the actual value that the multiplier can take. Hence, a-priori the data could deliver either a very low multiplier close to zero, or a multiplier well above one. This sign restriction is consistent with the empirical evidence on fiscal multipliers. For instance, Ramey (2011b) reviews this literature and concludes that the U.S. aggregate multiplier ranges between 0.5 and 2. Second, our sign restrictions is completely agnostic about how the transmission of government consumption spending varies across the two

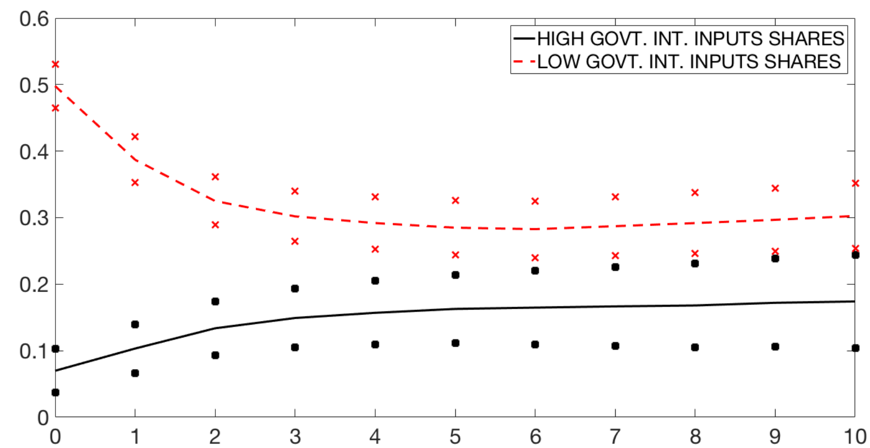
[24]The implementation of the sign restriction follows the algorithm of Rubio-Ramirez et al. (2010), with 5000 draws from the posterior distribution of the reduced form parameters with 5000 rotations each.

Figure 6: Share of Government Intermediate Inputs and Fiscal Multipliers.

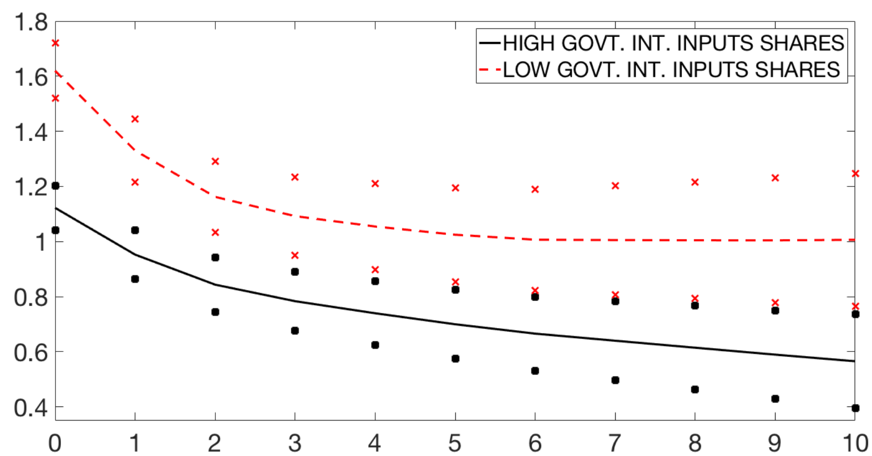
(a) Response of Total Value Added



(b) Response of Government Value Added



(c) Response of Total Hours



Note: The graphs report the the cumulative government consumption spending multipliers over different horizons of total value added (Panel a), government value added (Panel b), and total hours (Panel c) in a panel of countries with high shares of government intermediate inputs (continuous) and a panel of countries with low shares of government intermediate inputs (dashed line). The graph reports one standard deviation error bands.

panels with different government intermediate inputs shares. Thus, the way through which the changing structure of government spending shapes the effects of fiscal policy is left completely unrestricted.

Once we have identified the government spending shocks for each country in either panel, we can compute the responses of our variables of interest. Figure 6 reports the cumulative government consumption spending multipliers over different horizons of total value added (in Panel a), government value added (in Panel b), and total hours (in Panel c) in both the panel of countries with high shares of government intermediate inputs (depicted by the continuous lines) and the panel of countries with low shares of of government intermediate inputs (depicted by the dashed lines). We also report one standard deviation error bands. The figure shows that the implications of the model do hold in the data: although the size of the total value-added multiplier does not vary across the two panels, the responses of public value added and total hours are significantly smaller in countries with high shares of government intermediate inputs. Importantly, the difference in the responses of government value added and total hours across the two panels of countries are always statistically significant.

This novel evidence on the effects of public expenditure across countries corroborates the fact that changes in the structure of government consumption spending alters the transmission of fiscal policy. The results highlight the existence of a process of disconnect between the responses of output and hours to government spending: over time the effects of government spending on total output may not change, but fiscal policy is becoming less effective in boosting employment. Moreover, the empirical findings confirm the importance of modeling an endogenous changing structure of government spending, as the process of disconnect between output and hours is absent in the model with an exogenous changing structure.

6 Concluding Remarks

This paper documents that the structure of government spending in advanced economies changes continuously over time. In particular, the government purchases relatively more goods from the private sector, and relies less on the in-house production of value added. We refer to this novel stylized fact as the rise of the government intermediate inputs share.

We build a general equilibrium model and show that the process of investment-specific technological change can account for the bulk of the change in the structure of government spending. We extend a standard New Keynesian model with an explicit production function for government gross output, and find that a decline in the price of investment goods boosts the share of government intermediate inputs. This prediction of the model hinges on two specific conditions which we find to hold in the data: (*i*) the fact that private-sector value added is more intensive in capital than government value added, and (*ii*) the imperfect substitution between government value added and intermediate inputs.

Although the change in the structure of government spending occurs slowly over time, it alters the transmission of government spending shocks in two main aspects. On the one hand, it increases the effect of fiscal stimulus on the private sectors, while dampening that on the public sector. On the other hand, while the total output multiplier is unaffected by this secular change, the multiplier on total hours is substantially reduced, generating a disconnect in the response of output and hours to government spending. Importantly, these implications are validated empirically in a panel SVAR analysis.

Overall, our results point to a substantial role of the structure of government spending in shaping the sectoral effects of fiscal policy, and highlights that fiscal stimulus may not be able to overturn the emergence of jobless recoveries, as over time government spending become less effective in boosting hours worked.

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A The Private-Sector Intermediate Inputs Share

This section shows that in the model the share of the intermediate inputs in the gross output of private sector is constant over time, independently on the value of the elasticity of substitution between private value added and private intermediate inputs.

To do so, we consider a production function for the gross-output monopolistically competitive private-sector firms which has a non-unitary elasticity of substitution between private value added and private intermediate inputs:

$$GO_{p,t}^{i} = \left[\omega_{m,p}^{\frac{1}{\nu_{m,p}}} {M_{p,t}^{i}}^{\frac{\nu_{m,p}-1}{\nu_{m,p}}} + (1-\omega_{m,p})^{\frac{1}{\nu_{m,p}}} \left({K_{p,t}^{i}}^{\alpha_{k,p}} {N_{p,t}^{i}}^{1-\alpha_{k,p}}\right)^{\frac{\nu_{m,p}-1}{\nu_{m,p}}}\right]^{\frac{\nu_{m,p}}{\nu_{m,p}-1}} \tag{A.1}$$

where $\omega_{m,p}$ captures the weight of intermediate inputs in the private-sector gross output, whereas $\nu_{m,p}$ is the elasticity of substitution between intermediate inputs and value added.

The first-order condition of this problem reads

$$M_{p,t}^{i} = \omega_{m,p} \left(\frac{P_t}{\varphi_t^i}\right)^{-\nu_{m,p}} GO_{p,t}^{i} \tag{A.2}$$

where φ_t^i denotes the marginal costs. Since in the equilibrium steady-state the price of consumption equals the marginal costs, the share of intermediate inputs in the gross output of the private sector is

$$\frac{P_{ss} M_{p,ss}}{P_{ss} GO_{p,ss}} = \omega_{m,p} \tag{A.3}$$

so that the share of intermediate inputs is constant over time and does not depend on the elasticity of substitution between private value added and private intermediate inputs.

B The Variation in the Value-Added Capital Share

This section relaxes the assumption of the benchmark model on the unitary elasticity substitution between labor and capital in the value-added production function of both the private sector and the government. We relax this condition by substituting the Cobb-Douglas technologies with CES production functions. In this way, the process of investment specific technological change can alter the equilibrium capital share in value added of both the private sector and the government. Instead, in the benchmark model the value-added capital shares are constant over time.

Government value added $Y_{g,t}$ is produced with the technology

$$Y_{g,t} = \left[\omega_g^{\frac{1}{\nu_g}} N_{g,t}^{\frac{\nu_g-1}{\nu_g}} + (1-\omega_g)^{\frac{1}{\nu_g}} K_{g,t}^{\frac{\nu_g-1}{\nu_g}}\right]^{\frac{\nu_g}{\nu_g-1}} \tag{B.4}$$

where ω_g is the weight of labor in the government value added, and ν_g denotes the elasticity of substitution between labor and capital. The production function (B.4) implies that the price of government value added is

$$P_{Y_g,t} = \left[\omega_g W_t^{1-\nu_g} + (1-\omega_g) R_{k,t}^{1-\nu_g}\right]^{\frac{1}{1-\nu_g}} . \tag{B.5}$$

The first-order condition on the optimal amount of labor implies that the equilibrium labor share in the government value added is

$$\frac{W_t N_{g,t}}{P_{Y_g,t} Y_{g,t}} = \omega_g \left(\frac{W_t}{\left[\omega_g W_t^{1-\nu_g} + (1-\omega_g) R_{k,t}^{1-\nu_g}\right]^{\frac{1}{1-\nu_g}}} \right)^{1-\nu_g} . \tag{B.6}$$

This condition posits that if the rental price of capital drops more than the equilibrium wage, due to the process of investment specific technological change, then the labor share in government value added increases if $\nu_g < 1$, such that labor and capital are imperfect complements. Instead, if $\nu_g > 1$ and labor and capital are imperfect substitutes, then a relative drop in the price of government value added decreases the labor share.

Analogously, private-sector value added $Y_{p,t}$ is produced with the technology

$$Y_{p,t} = \left[\omega_p^{\frac{1}{\nu_p}} N_{p,t}^{\frac{\nu_p-1}{\nu_p}} + (1-\omega_p)^{\frac{1}{\nu_p}} K_{p,t}^{\frac{\nu_p-1}{\nu_p}}\right]^{\frac{\nu_p}{\nu_p-1}} \tag{B.7}$$

where ω_p is the weight of labor in the private-sector value added, and ν_p denotes the elasticity of substitution between labor and capital. We allow for the elasticity of substitution of labor of private-sector value added ν_p to differ from the one in government value added ν_g. As we discuss later on in the calibration, two different elasticities are required in order to let the process of investment specific technological change to explain contemporaneously the behavior of both the labor share in government value added and the labor share in the private-sector value added. Then, since the price of the value added of the private sector is normalized to one, the CES technology (B.7) implies the following relationship

$$1 = \left[\omega_p W_t^{1-\nu_p} + (1-\omega_p) R_{k,t}^{1-\nu_p}\right]^{\frac{1}{1-\nu_p}}. \tag{B.8}$$

The first-order condition on the optimal amount of labor hired by the private sector implies that the labor share in the value added of the private sector equals

$$\frac{W_t N_{p,t}}{P_{Y_p,t} Y_{p,t}} = \omega_p W_t^{1-\nu_p}. \tag{B.9}$$

As before, this condition implies different behaviors of the labor share following the process of investment specific technological change depending on the value of the elasticity of substitution across labor and capital. If $\nu_p < 1$, then the labor share in the private-sector value added raises following a relative decrease in the price of investment. Instead, if $\nu_p > 1$ and labor and capital are imperfect substitutes, then a relative drop in the price of investment reduces the labor share.

The calibration strategy is similar to the one of the benchmark model with the only difference that now we need to discipline the parameters in the CES production functions of government value added and private-sector value added. Accordingly, we calibrate the parameters of the CES production functions such that the model can match exactly the dynamics of the labor share in government value added and private-sector value added. In this way, we can look at the contribution of the process of investment specific technological change in explaining the dynamics of the government intermediate inputs share once the model accounts for the variation in the value-added production functions of the private sector and the government.

Interestingly, the labor shares in the value added of the private sector and the government display diverging trends. On the one hand, Karabarnounis and Neiman (2014) show that the labor share in private value added has declined by around 5 percentage points over the recent decades. In the WorldKLEMS data, the share has declined from a value of 0.594 in 1960 down to 0.555 in 2014. On the other hand, the labor share in government value added has increased from a value of 0.741 in 1960 up to 0.793 in 2017.

The process of investment specific technological change can jointly explain the diverging trends in the labor shares only if the elasticity of substitution between labor and capital in the value added of the government differs from the analogous elasticity in the value added of the private sector. Furthermore, the elasticity of substitution in government value added should be $\nu_g < 1$ to capture its rising labor share whereas the elasticity of substitution in private-sector value added should be $\nu_g > 1$ to capture its declining labor share, as in Karabarnounis and Neiman (2014).

For the CES function of the private sector, we calibrate the parameters ω_p and ν_p to match the labor share in private-sector value added in 1960 and 2014. This procedure yields the values of $\omega_p = 0.651$ and $\nu_p = 1.072$. The elasticity of substitution implied by our calibration is slightly lower than the value of 1.25 estimated by Karabarnounis and Neiman (2014). Yet, they compute the elasticity on a panel

Table B.1: Calibration - New Parameter Values.

Parameter	**Value**	**Target/Source**
Share Inputs in Govt. Gross Output	$\omega_{m,g} = 0.441$	Share Intermediate Inputs 1960
Elasticity Govt. Value Added	$\nu_g = 0.875$	Share Capital in Govt. Value Added 2017
Share Labor in Govt. Value Added	$\omega_g = 0.653$	Share Capital in Govt. Value Added 1960
Elasticity Pvt. Value Added	$\nu_p = 1.072$	Share Capital in Pvt. Value Added 2014
Share Labor in Pvt. Value Added	$\omega_p = 0.651$	Share Capital in Pvt. Value Added 1960
Disutility Labor	$\theta = 9.36$	Steady-State Labor = 0.33

of countries from 1970 on, whereas we calibrate the elasticity to match the change in the labor share of the U.S. private sector from 1960 on. Analogously, for the CES function of the government, we calibrate the parameters ω_g and ν_g to match the labor share in government value added in 1960 and 2017. This procedure yields the values of $\omega_g = 0.653$ and $\nu_g = 0.875$. In this case, the elasticity of substitution implied by our calibration is close to the value of 0.75 estimated by Herrendorf et al. (2013) for the services industries. Table B.1 reports the values of the new set of calibrated parameters.

What are the implications of this alternative specification of the benchmark model on the dynamics of the government intermediate inputs share over time? Panel (a) of Table B.2 reports the share of intermediate inputs in the government gross output in 1960 and 2017, compared with the values observed in the data. Panel (b) and Panel (c) report similar statistics for the case of a lower elasticity of substitution between government intermediate inputs and value added and a higher elasticity of substitution between government intermediate inputs and value added, respectively.

Overall the results highlight that accounting for the secular changes in the value-added production functions of both the government and the private sector improves the quantitative implications of the model with respect the dynamics of the government intermediate inputs share. Indeed, the share implied by the model in 2017 is 31.3% whereas the benchmark model generates a share of 30.8%.

Table B.2: Results on Changing Structure of Government Spending.

Variables	**1960**		**2017**	
	Model	Data	Model	Data
Panel (a): $\nu_m = 2$				
Government Intermediate Inputs Share	22.6%	22.6%	31.3%	31.8%
Government Value Added Relative Price	1	1	1.56	2.39
Panel (b): $\nu_m = 1.75$				
Government Intermediate Inputs Share	22.6%	22.6%	28.9%	31.8%
Government Value Added Relative Price	1	1	1.56	2.39
Panel (c): $\nu_m = 2.25$				
Government Intermediate Inputs Share	22.6%	22.6%	33.7%	31.8%
Government Value Added Relative Price	1	1	1.56	2.39

The Table reports the model implications on the share of government intermediate inputs and the relative price of government value added in the 1960 steady-state and the 2017 steady-state vis-à-vis the values of these variables observed in the data. Panel (a) considers the implications of the benchmark model in which $\nu_m = 2$. Panel (b) considers the case of a lower elasticity such that $\nu_m = 1.75$. Panel (c) considers the case of a higher elasticity such that $\nu_m = 2.25$.

C Fiscal Multipliers: Robustness Checks

The model incorporates a set of features which are intended to generate short- run dynamics following government spending shocks that are quantitatively in line with the empirical evidence on fiscal multipliers: a GHH utility function, the presence of intermediate inputs in the production function of the private sector, and the New Keynesian set up of the economy (i.e., monopolistic competition and Calvo (1983) staggered price setting in the private sector).

This section shows that the implications of the changing structure of government consumption spending on the dynamics of fiscal multipliers over time does not qualitatively change in case we abstract from the features mentioned above. Indeed, Table C.3 reports the fiscal multipliers in three alternative specifications of the "Benchmark Economy".

In the first alternative specification, the "CRRA Utility Economy", the utility function is a CRRA instead of the GHH of the baseline model. The dynamics of the fiscal multipliers across the 1960 and the 2017 steady-states are similar to those observed in "Benchmark Economy". The only difference relies on the fact that without the consumption-labor complementarity of the GHH preferences, the model with a CRRA utility displays a negative response of consumption, a negative response of private value added, and therefore a much lower level in the total output fiscal multiplier, in line with the results of Biilbie (2011), which show that GHH preferences and sticky prices can rationalize a positive consumption fiscal multiplier. The second alternative specification, the "No Private Intermediate Inputs Economy", abstracts from intermediate inputs in the production functions of the private sector. Again the dynamics of the fiscal multipliers across the 1960 and the 2017 steady-states are similar to those observed in the "Benchmark Economy". Also in this case, abstracting from this feature generates a lower response of total output, and a negative response of private value added in 1960, in line with the results of

Table C.3: 1 Year Cumulative Fiscal Multipliers - Robustness.

	Benchmark Economy		CRRA Utility Economy		No Private Intermediate Inputs Economy		Flexible Prices Economy	
	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017
Y_t	0.75	0.76	0.35	0.35	0.62	0.63	-0.01	-0.02
C_t	0.23	0.23	-0.17	-0.17	0.10	0.12	-0.53	-0.53
I_t	-0.48	-0.47	-0.48	-0.48	-0.48	-0.48	-0.48	-0.49
$Y_{p,t}$	0.00	0.11	-0.42	-0.34	-0.11	0.02	0.77	0.69
$Y_{g,t}$	0.75	0.65	0.77	0.69	0.72	0.61	-0.79	-0.71
N_t	1.68	0.68	0.95	0.38	0.13	0.05	0.12	0.04
$N_{p,t}$	0.42	0.24	-0.58	-0.17	0.01	0.01	-1.41	-0.50
$N_{g,t}$	1.26	0.41	1.54	0.55	0.12	0.04	1.53	0.54

The Table reports the 1-year cumulative fiscal multipliers of the "Benchmark Economy", the "CRRA Utility Economy" in which the utility of the households is a CRRA function and not anymore a GHH function, the "No Private Intermediate Inputs Economy" which abstracts from the presence of intermediate inputs in the production function of the private sector, and the "Flexible Prices Economy" in which prices are fully flexible. "Model 1960" refers to the steady-state calibrated to match the government purchases from the private sector as of 1960. "Model 2017" refers to the steady-state in which the relative price of investment goods is set as of 2017.

Bouakez et al. (2018), which point out how the presence of intermediate inputs in the private-sector production function raises the size of fiscal multipliers.

Finally, the third alternative specifications, the "Flexible Price Economy", abstracts from the price rigidity feature of the New Keynesian setup of the model. In this neoclassical economy, the size of the multiplier is virtually zero, as the output fiscal multiplier equals -0.01 and -0.02 across the two steady-states. These values depend on a very negative private value added multiplier, which for instance equals -0.79 in the first steady-state. These results are in line with the findings of Hall (2009) and Woodford (2011), which point out that the output fiscal multiplier increases in the degree of price rigidity. Nonetheless, even in this case the changing structure of government spending implies a shift of the stimulus effect of government spending from government value added to private value added, and a sharp reduction in the responsiveness of hours.

Overall these exercises highlight that although these three features of the model are required to have quantitative implications on the size of output fiscal multipliers which are in line of the empirical evidence, their presence does not alter our main findings on the relationship between the changing structure of government consumption spending and the transmission of fiscal policy.