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The Changing Structure of Government Spending*

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Abstract

We document that advanced economies experience a secular increase in the share of purchases from the private sector in total government spending, implying that over time governments purchase relatively more private-sector goods, and rely less on own production of value added. We build a calibrated general equilibrium model to show that this secular process can be accounted for by investment-specific technological change. We then use the model to measure the effect of this secular process on the transmission of fiscal policy, and find that (i) it shifts the stimulative effects of government spending towards private economic activity and (ii) it dampens the response of hours - but not of output - to fiscal shocks.

Key Words: Government Gross Output, 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. Instead, in national accounts, government consumption spending equals government gross output, which sums government value added to the purchases of private-sector goods by the government. The first contribution of this paper is to document a novel stylized fact: in most advanced economies the share of purchases from the private-sector in total government consumption spending rises over time. For instance, in the U.S. this share accounts for 22% of government gross output in 1960, while in 2017 it peaks to 32%. Thus, government spending changes in such a way that governments rely more on goods from the private sector, and less on the in-house production of value added.

A change in the structure of government spending can have important implications for the transmission of fiscal policy. Typically, in models in which government spending shocks consist only of purchases of private-sector goods, fiscal policy has an expansionary effect on output through a crowding-in of labor. Following an expansion in government spending, households suffer a negative wealth shock, and increase their supply of labor to smooth the consumption of the private-sector good. Instead, when government shocks consist also in spending on wage bills and capital rents, fiscal policy may have a contractionary effect on output because, following an expansion in government spending, the rise in public labor dampens the crowding-in of labor in the private sector. As a result, when the composition of public spending changes over time, these countervailing effects might also be time-varying, thus affecting the effects of fiscal policy shocks on the economy.

The second contribution of this paper is to build a model that endogenously generates a changing structure of government spending over time. To do this, we assume that the government produces gross output by means of a constant returns

to scale production function in capital, labor, and intermediate goods, with the latter coming from purchases from the private sector. Also, we posit that, while the government gross output evolves exogenously over time, the production of this amount is achieved optimally: given the desired level of gross output, the production function, and factor prices, the government chooses the combination of capital, labor, and intermediate goods that minimizes the total cost of production.

We then introduce the above characterization of the government sector into a New-Keynesian model with investment-specific technological change (ISTC), which is modelled as an exogenous drop in the relative price of investment in terms of the price of consumption. Our choice is motivated by the following facts: (i) ISTC is a primer driver of aggregate productivity in the U.S. economy (Greenwood et al., 1997; Ngai and Samaniego, 2009); (ii) the effect of ISTC on productivity is larger in sectors with higher capital intensity; (iii) the private sector is more capital intensive than the government sector. These observations suggest that, although ISTC drives aggregate growth, it also creates a productivity asymmetry between the government and the private sector. As a result, ISTC can potentially trigger a change in the structure of government spending towards a higher use of the goods produced by the more productive private-sector.

We formally test the relationship between the relative price of investment and the share of government purchases from the private sector by constructing an unbalanced panel across countries that combines data from the World KLEMS project, the Penn World Tables, and the World Development Indicators. By exploiting cross-country variation, we estimate a panel regression between the two variables and find a negative correlation coefficient which is highly statistically significant and robust to the inclusion of country and year fixed effects. Importantly, the statistical significance of the relationship between the relative price of investment and the share of government purchases from the private sector keeps holding even after controlling for the share of military spending in total government spending and for the entire

structure of taxes. This result highlights that the changes in the spending side of the government do not hinge on the variation in the financing side.

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 production function from the increasingly expensive in-house production of value added to the cheaper intermediate inputs produced by the private sector. We show that both conditions do hold in the data. By using World KLEMS data we first show that across countries the capital share in private sector value added roughly doubles the capital share in government value added. Second, using the same data we estimate an elasticity of substitution between government value added and intermediate inputs well above one.

In the quantitative analysis, we calibrate the model to match a set of targets for the U.S. economy, including the share of intermediate inputs in government spending in 1960. Then, we compare the structure of government spending in 1960 and 2017. When the calibrated model is fed with the observed decline in the investment price between 1960 and 2017, it accounts for 89% of increase in the government intermediate inputs share. This result suggests that the calibrated model reproduces fairly well the changing structure of government spending over time, thus representing a useful tool to study how this secular process affects the transmission of fiscal policy.

While the structure of government spending changes slowly over time, it generates important implications at the business cycle frequency, in particular for the propagation of fiscal policy. Our third contribution is to use the model as a laboratory to study quantitatively the effect of long-run changes in the structure of gov-

ernment spending on the transmission of government spending shocks. We uncover these facts by comparing fiscal multipliers around two steady-states representing the years 1960 and 2017. The two equilibria differ only in the exogenous level of the price of investment (i.e., the level of ISTC). This unique distinction makes the two equilibria 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. This decomposition is a relevant tool to identify the transmission of fiscal policy, since Ramey (2012) shows that although government spending boosts total economic activity and government employment, it does not necessarily increase private spending and private employment. We show that these dynamics depend crucially on the share of the 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 is due to a reduction in the response of hours in both the private and the public sector. These changes depend on the

higher productivity of the economy in 2017 and the asymmetric productivity gains between the two sectors. First, the higher productivity of the economy allows to produce output with a lower amount of hours. Second, these dynamics are 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.

Overall, these 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. These effects of the changing structure of government spending on fiscal multipliers can also rationalize the fact that in aftermath of the financial crisis the implementation of the Obama fiscal stimulus package was accompanied by a large increase in total output and a very sluggish and slow recovery in employment.

This paper adds to the literature which focuses on the secular changes in the production structure of advanced economies, and their business-cycle implications. Karabarnounis and Neiman (2014) show that the labor share in private value added shrinks over time whereas Duarte and Restuccia (2010) and Herrendorf et al. (2013) document the reallocation of economic activity towards services. We contribute 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) study the business cycle implications of the changes in the sectoral composition of an economy in both RBC and new-Keynesian models, finding first order quantitative effects. Here we build on these results to 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 invest-

ment 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 usually studies the output effects of government spending shocks intended as exogenous hikes in purchases of private-sector goods (e.g., Barro, 1981; Baxter and King, 1993; Blanchard and Perotti, 2002; Barro and Redlick, 2011; Ramey, 2011). 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).¹ We contribute to this literature by showing that the response of private economic activity to government spending depends crucially on the government intermediate inputs share. Finally, this paper adds to the literature that studies the determinants of fiscal multipliers (e.g., Christiano et al., 2011; Woodford, 2011; Auerbach and Gorodnichenko, 2012), by providing a novel channel that generates low-frequency movements in the effectiveness of fiscal policy.

The remainder of the paper is as follows. Section 2 presents the empirical evidence on the structure of government spending in developed economies and its relationship with the relative price of investment. Section 3 presents the model while Section 4 is devoted to the quantitative analysis. Finally, Section 5 concludes.

¹There 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).

2 Empirical Evidence

2.1 The Government Intermediate Inputs Share

Government consumption spending is usually modelled as consisting 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 $P_{Y_p,t}Y_{p,t}$ equals the sum of the nominal values of consumption $P_{C,t}C_t$, investment $P_{I,t}I_t$, and government purchases of private-sector goods $P_{M_g,t}M_{g,t}$

$$P_{Y_p,t}Y_{p,t} = P_{C,t}C_t + P_{I,t}I_t + P_{M_g,t}M_{g,t}. \quad (1)$$

Instead, in national accounts, government consumption spending 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 $P_{M_g,t}M_{g,t}$ ²

$$P_{G,t}G_t = P_{Y_g,t}Y_{g,t} + P_{M_g,t}M_{g,t}. \quad (2)$$

The combination of Equations (1) and (2) yields two different ways to define the nominal GDP of the economy. On the one hand, nominal GDP equals the sum of the nominal values of private sector and government value added. On the other hand, nominal GDP equals the sum of the nominal values of consumption, investment, and government gross output

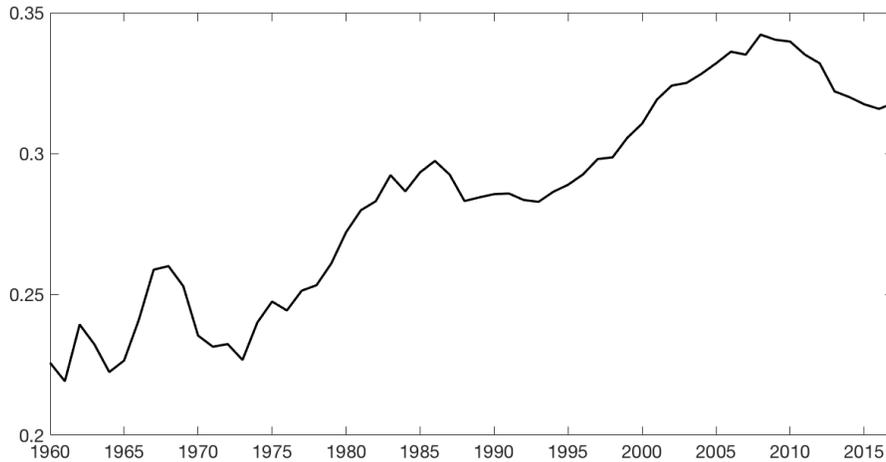
$$GDP_t = P_{Y_p,t}Y_{p,t} + P_{Y_g,t}Y_{g,t} = P_{C,t}C_t + P_{I,t}I_t + P_{G,t}G_t. \quad (3)$$

In this paper we document a novel stylized fact on government spending, namely

²In the national accounts, 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 government and the local government. 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.

that the relative size of its two components $P_{Y_g,t}Y_{g,t}$ and $P_{M_g,t}M_{g,t}$ 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.³ 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.



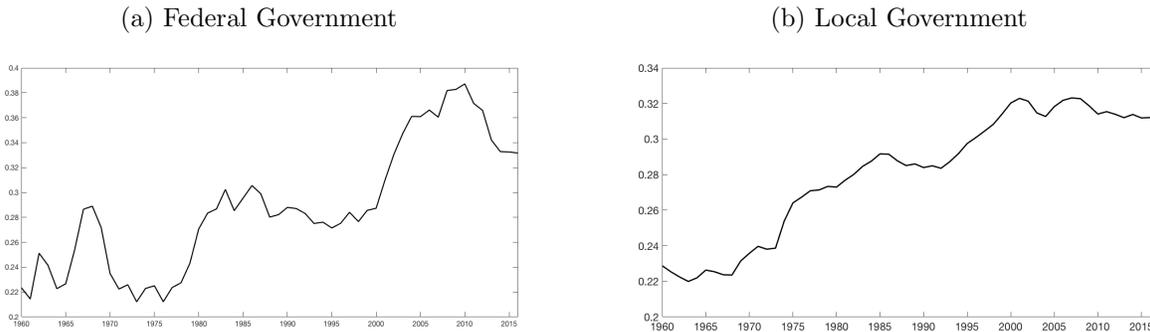
Note: This graph reports the share of intermediate inputs in the gross output of general government. The data is annual from 1960 until 2017. Source: Bureau of Economic Analysis.

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

³Technically, government gross output is measured on the cost side as the sum of the wage bill of employees (both military and civilians), the consumption of government capital (mainly the deterioration of the stock of fixed assets), and the purchases from the private sector. While this 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. Note also, that 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.

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.



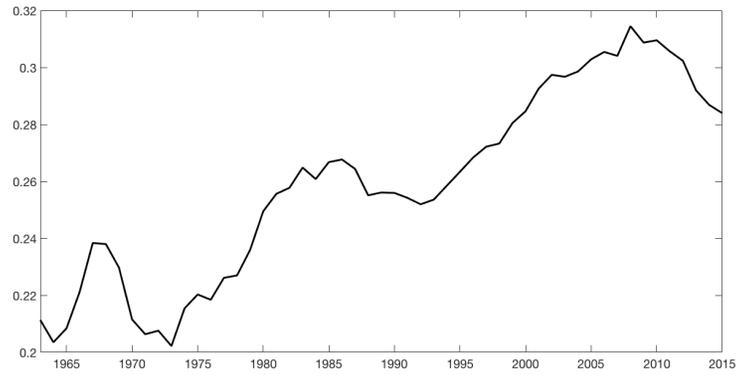
Note: These graphs report the share of intermediate inputs in the gross output of the federal government (Panel a) and the share of intermediate inputs in the gross output of the local government (Panel b). The data is annual from 1960 until 2017. Source: Bureau of Economic Analysis.

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.⁴

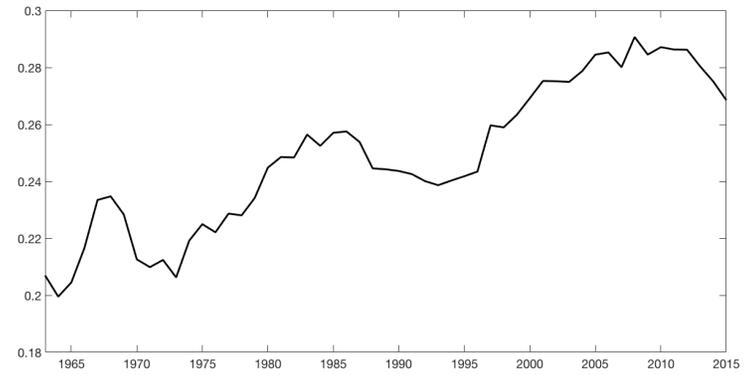
⁴The hypothesis of a simple process of outsourcing of labor from the public to the private sector would generate a raise in the value-added labor share of the private sector, which is inconsistent with the secular decline documented by Karabarnounis and Neiman (2014).

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

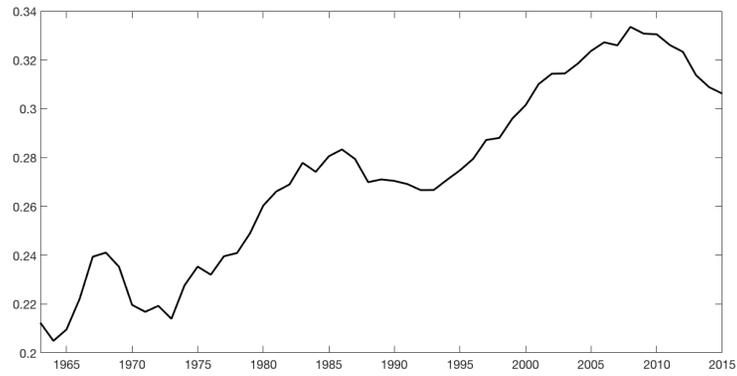
(a) Excluding Financial & Real Estate Services



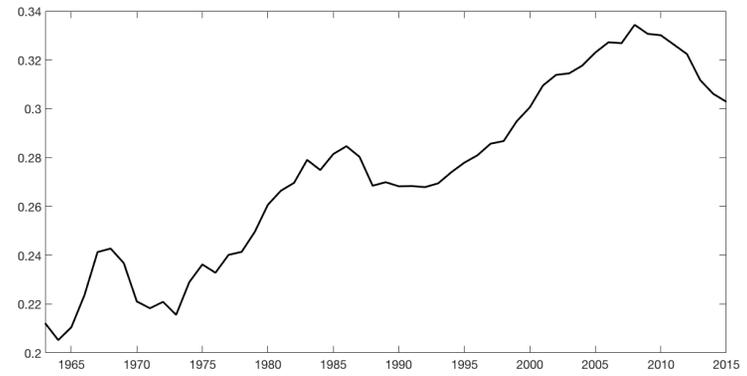
(b) Excluding Professional Services



(c) Excluding Educational Services



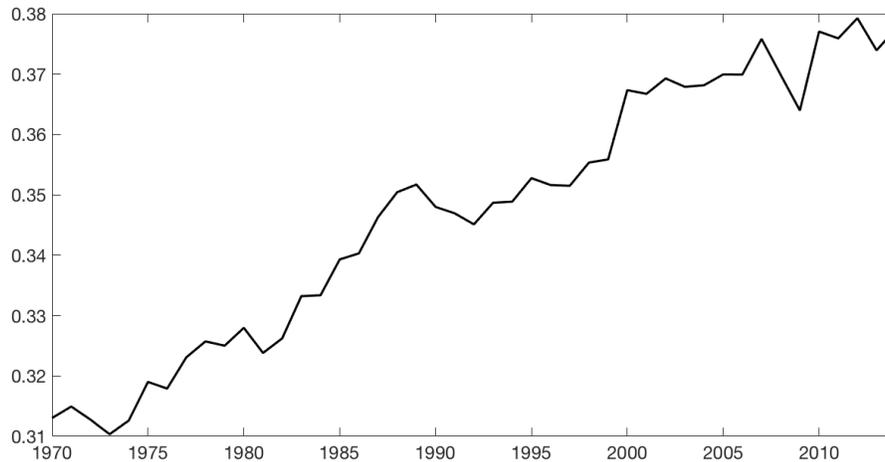
(d) Excluding Health Care Services



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.

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

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.

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.⁵ 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 coeffi-

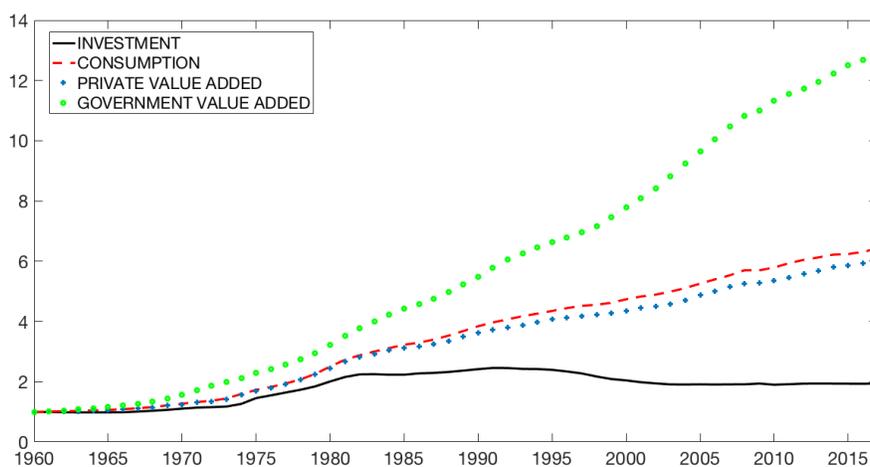
⁵The countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States.

cients 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%.

2.2 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 a panel regression between the log-share of government intermediate inputs and the log-relative price of investment. We report the results 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 a set of key country-specific characteristics that controls for the structure of government spending and financing, such as, 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.

Table 1 shows that the estimated elasticity between the structure of government

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

Dependent Variable: Share of Government Purchases from Private Sector in Total Government Spending					
	(1)	(2)	(3)	(4)	(5)
Panel (a): PWT Relative Price of Investment					
Price Investment	-0.66*** (0.06)	-0.32*** (0.05)	-0.79*** (0.07)	-0.31** (0.14)	-0.40*** (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*** (0.07)	-0.40*** (0.06)	-0.96*** (0.08)	-0.37*** (0.13)	-0.32*** (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. Obs.	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 Investment* indicates the log of the relative price of investment in terms of the price of investment, 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 *** indicates statistical significance at the 5% and 1%, respectively.

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. Following these results, in the next section we build a model where ISTC is the only exogenous driver of the changes in the structure of governments spending.

3 The Model

The economy extends a standard cashless Calvo (1983) staggered price setting New Keynesian model with an explicit production function for government gross output. The economy consists of a representative household, a final good private sector firm, a continuum of intermediate private sector firms, an investment goods producer firm, and the government. The government produces public goods using labor, capital, and intermediate inputs produced by the private sector firm. The final good private sector firm, the investment goods producer firm, and the government act as in perfect competition, while the intermediate private sector firms act in monopolistic competition and set prices à la Calvo. The total amount of public goods is determined by government consumption spending shocks. The model features ISTC, such that the relative price of investment goods in terms of consumption goods falls exogenously over time.

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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \tag{4}$$

where β is the time discount factor, and the instantaneous utility function $U(\cdot)$ is increasing in C_t and decreasing in N_t . The household maximizes life-time utility (4) subject to the budget constraint

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

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 taxes T_t . The household also invests in a one-period bond B_t which yields a nominal 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

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

where δ_k 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

$$N_t = N_{p,t} + N_{g,t}, \quad (7)$$

$$K_t = K_{p,t} + K_{g,t}, \quad (8)$$

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

3.2 Investment Goods Producer Firm

The investment goods producer firm 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 goods producer firm 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 goods producer firm reads

$$\max_{X_t} P_{I,t} I_t - P_t X_t \quad (9)$$

$$\text{s.t. } I_t = q_t X_t \quad (10)$$

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

$$q_t = (1 + \lambda) q_{t-1} \quad (11)$$

where λ is the growth rate of ISTC. Equation (12) posits that over time the production of the investment good requires less units of the consumption goods.

The first-order condition associated with the problem (9)-(10) defines that the nominal price of the investment good equals

$$P_{I,t} = \frac{P_t}{q_t}. \quad (12)$$

Then, 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 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

$$\log G_t = (1 - \rho_g) G_s + \rho_g \log G_{t-1} + \epsilon_{g,t} \quad (13)$$

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, 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

$$G_t = \left[\omega_{m,g}^{\frac{1}{\nu_{m,g}}} M_{g,t}^{\frac{\nu_{m,g}-1}{\nu_{m,g}}} + (1 - \omega_{m,g})^{\frac{1}{\nu_{m,g}}} Y_{g,t}^{\frac{\nu_{m,g}-1}{\nu_{m,g}}} \right]^{\frac{\nu_{m,g}}{\nu_{m,g}-1}} \quad (14)$$

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 (14) implies that the price of the government gross output is

$$P_{G,t} = \left[\omega_{m,g} P_t^{1-\nu_{m,g}} + (1 - \omega_{m,g}) P_{Y_{g,t}}^{1-\nu_{m,g}} \right]^{\frac{1}{1-\nu_{m,g}}} \quad (15)$$

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

$$\frac{P_t M_{g,t}}{P_{G,t} G_t} = \omega_{m,g} \left(\frac{P_t}{P_{G,t}} \right)^{1-\nu_{m,g}}. \quad (16)$$

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 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

$$Y_{g,t} = K_{g,t}^{\alpha_{k,g}} N_{g,t}^{1-\alpha_{k,g}} \quad (17)$$

where $\alpha_{k,g}$ denotes the capital share of the government value added.⁶ The production function (17) implies that the price of government value added is

$$P_{Y_{g,t}} = \frac{R_{k,t}^{\alpha_{k,g}} W_t^{1-\alpha_{k,g}}}{\alpha_{k,g}^{\alpha_{k,g}} (1 - \alpha_{k,g})^{1-\alpha_{k,g}}}. \quad (18)$$

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

so

$$P_t T_t = W_t N_{g,t} + R_{k,t} K_{g,t} + P_t M_{g,t}. \quad (19)$$

The government levies a lump-sum tax $P_t T_t$ to finance its wage bill $W_t N_{g,t}$, the cost of renting capital $R_{k,t} K_{g,t}$, and the purchases of private-sector goods $P_t M_{g,t}$.

⁶The assumption that the value added production function of both the government and the private sector is a Cobb-Douglas implies that the share of labor in value added is constant over time. Appendix B relaxes this assumption by considering a CES aggregator for the value added production function such that the labor share in value added varies over time as a function of the process of investment specific technological change.

3.4 Intermediate Good Private Sector Firm

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

Each intermediate good firm i produces the gross-output variety $GO_{p,t}^i$ with a Cobb-Douglas value added production function

$$GO_{p,t}^i = \left[K_{p,t}^i{}^{\alpha_{k,p}} N_{p,t}^i{}^{1-\alpha_{k,p}} \right]^{1-\alpha_{m,p}} M_{p,t}^i{}^{\alpha_{m,p}} \quad (20)$$

where $K_{p,t}^i$ and $N_{p,t}^i$ are the amounts of capital and labor hired by firm i . In equilibrium, the market clearing conditions imply that $\int_0^1 N_{p,t}^i di = N_{p,t}$ and $\int_0^1 K_{p,t}^i di = K_{p,t}$. Then, $M_{p,t}^i$ denotes the intermediate inputs, $\alpha_{k,p}$ is the capital share of the private sector value added, and $\alpha_{m,p}$ is the share of intermediate inputs in the private sector gross output.⁷

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 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 $P_t^{i,*}$ is chosen to maximize the expected discounted stream of real dividends

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

⁷The 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. Appendix A 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), which 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.

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

$$GO_{p,t} = \left(\int_0^1 GO_{p,t}^i \frac{\epsilon-1}{\epsilon} \right)^{\frac{\epsilon}{\epsilon-1}} \quad (21)$$

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:

$$GO_{p,t} = C_t + X_t + M_{p,t} + M_{g,t}. \quad (22)$$

where the market clearing conditions of the market of 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

$$P_{Y_{p,t}} Y_{p,t} = P_t GO_{p,t} - P_t M_{p,t}. \quad (23)$$

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

$$Y_t = \frac{P_{Y_p,t}}{P_t} Y_{p,t} + \frac{P_{Y_g,t}}{P_t} Y_{g,t} \quad (24)$$

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

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}} \right)^{\rho_r} \left[(1 + \pi_t)^{\phi_\pi} x_t^{\phi_y} \right]^{1-\rho_r} \quad (25)$$

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

$$\frac{P_{ss}M_{g,ss}}{P_{G,ss}G_{ss}} = \frac{\omega_{m,g}}{\omega_{m,g} + \Phi (1 - \omega_{m,g}) q_{ss}^{\frac{\alpha_{k,g} - \alpha_{k,p}}{1 - \alpha_{k,p}} (\nu_{m,g} - 1)}} \quad (26)$$

where

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

How does the level of ISTC q_{ss} affect the equilibrium government intermediate inputs share? Equation (27) defines the derivative of the government intermediate inputs share with respect to q_{ss} :

$$\frac{\partial \frac{P_{ss}M_{g,ss}}{P_{G,ss}G_{ss}}}{\partial q_{ss}} = \frac{\Phi (1 - \omega_{m,g}) (\nu_{m,g} - 1) \left(\frac{\alpha_{k,p} - \alpha_{k,g}}{1 - \alpha_{k,p}} \right) q_{ss}^{\left[\frac{\alpha_{k,g} - \alpha_{k,p}}{1 - \alpha_{k,p}} (\nu_{m,g} - 1) \right] - 1}}{\left[\omega_{m,g} + \Phi (1 - \omega_{m,g}) q_{ss}^{\frac{\alpha_{k,g} - \alpha_{k,p}}{1 - \alpha_{k,p}} (\nu_{m,g} - 1)} \right]^2}. \quad (27)$$

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 than 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.⁸

4 Quantitative Analysis

4.1 Calibration

We calibrate the model to match the share of government intermediate inputs in 1960. Then, we evaluate the quantitative performance of the model in explaining the changing structure of government spending between 1960 and 2017. The previous Section 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.

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.

⁸The derivative is also positive in the counterfactual case in which the private sector is less intensive in capital than the government ($\alpha_{k,p} < \alpha_{k,g}$) and government value added and intermediate inputs are complements ($\nu_{m,g} < 1$).

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 average 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 $\lambda = 0.57\%$.

We set the capital shares using data on labor compensation and value added of World KLEMS and the Bureau of Economic Analysis. The average labor share of government value added between 1960 and 2017 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.

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 (16), controlling for time and fixed effects. Namely, we estimate the regression

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

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 $\nu_{m,g} = 2$.

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 assume the GHH utility of Greenwood et al. (1988), such that

$$U(C_t, N_t) = \frac{1}{1 - \sigma} \left(C_t - \theta \frac{N_t^{1+\eta}}{1 + \eta} \right)^{1-\sigma}$$

where σ denotes the risk aversion, θ captures the disutility from working, and η is the inverse of the Frisch elasticity. We consider a GHH preference because with CRRA preferences the model can generate positive fiscal multipliers only with counterfactually high Frisch elasticities.⁹ We set the risk aversion to $\sigma = 2$, the disutility of labor is $\theta = 3.586$ such that the steady-state labor is $N_{ss} = 0.33$, 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.

In the law of motion of physical capital, we set the depreciation rate to $\delta_k = 0.025$, 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

⁹Bilbiie (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.

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	$\theta = 3.586$	Steady-State Labor = 0.33
Inverse Frisch-Elasticity	$\eta = 2$	Chetty et al. (2013)
Depreciation Capital	$\delta_k = 0.025$	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)

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.

4.2 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%.

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

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 $\nu_m = 2.25$.

implications of the model on the relative price of government value added. The model predicts that the relative prices 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 $\nu_{m,g}$.

4.3 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

Table 5: 1 Year Cumulative Fiscal Multipliers.

	Benchmark Economy		Only Technical Change Economy		Only Changing Structure Economy		CRRA Utility Economy		No Intermediate Inputs Private Sector Economy	
	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017	Model 1960	Model 2017
Y_t	0.75	0.76	0.70	0.70	0.70	0.70	0.35	0.35	0.62	0.63
C_t	0.23	0.23	0.18	0.17	0.18	0.18	-0.17	-0.17	0.10	0.12
I_t	-0.48	-0.47	-0.48	-0.47	-0.48	-0.48	-0.48	-0.48	-0.48	-0.48
$Y_{p,t}$	0.00	0.11	-0.05	-0.05	-0.05	0.04	-0.42	-0.34	-0.11	0.02
$Y_{g,t}$	0.75	0.65	0.75	0.75	0.75	0.66	0.77	0.69	0.72	0.61
N_t	1.68	0.68	1.57	0.63	1.57	1.58	0.95	0.38	0.13	0.05
$N_{p,t}$	0.42	0.24	0.58	0.23	0.58	0.72	-0.58	-0.17	0.01	0.01
$N_{g,t}$	1.26	0.41	0.99	0.40	0.99	0.86	1.54	0.55	0.12	0.04

The Table reports the 1-year cumulative fiscal multipliers of the “Benchmark Economy”, the “Only Technical Change Economy” in which the share of capital in value added is equalized across sectors such that changes in the relative price of investment do not alter the structure of government spending, the “Only Changing Structure Economy” in which share of capital in value added is equalized across sectors, there is no change in the relative price of investment, and the structure of government spending changes exogenously over time, the “CRRA Utility Economy” in which the utility of the households is a CRRA function and not anymore a GHH function, and the “No Intermediate Inputs Private Sector Economy” which abstracts from the presence of intermediate inputs in the production function of the private sector. “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.

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. Hence, the model generates a positive consumption multiplier which 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.

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 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, who react by raising hours worked in the attempt to smooth consumption. 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 highlighted 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 out 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 response of hours. These effects of the changing structure of government spending on fiscal multipliers can also rationalize the fact that in aftermath of the financial crisis the implementation of the Obama fiscal stimulus package was accompanied by a large increase in total output and a very sluggish and slow recovery in 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.

To provide a better understanding of the mechanisms that alter the effectiveness of government spending in our model, Table 5 reports also the fiscal multipliers in two additional specifications of the “Benchmark Economy”. In the “Only Technical Change Economy” the capital share is equalized across sectors, so that ISTC does not alters the structure of government spending. Hence, this economy highlights the role of the changes in the productivity of the private and public sectors in the effects of government spending. The results point out that in this case ISTC still

generates a drop in the response of hours to government spending, but no change in the transmission of fiscal policy between the value added of the private and the public sector. In the “Only Changing Structure Economy”, the share of capital is equalized across sectors, there is no change in the relative price of investment, and the structure of government spending changes exogenously over time. This case highlights that if the changes in the structure of government spending are not accompanied by the rise in productivity triggered by ISTC, then the model predicts a shift in the transmission channel of government spending from the public sector towards private economic activity, but not drop in the response of hours.

The last two columns of Table 5 reports the fiscal multipliers in two alternative specifications of the “Benchmark Economy”, which study the robustness of our economy to changes in the utility function of the households and the production function of the private sector. In the “CRRA Utility Economy” the utility function is a CRRA instead of the GHH considered in 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. Finally, the “No Intermediate Inputs Private Sector Economy” abstracts from intermediate inputs in the production functions of the private sector. In this case, again the dynamics of the fiscal multipliers across the 1960 and the 2017 steady-states are similar to those observed in 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 the first steady-state.

5 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.

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 Model Robustness: 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 intermediate good private sector firms which has a non-unitary elasticity of substitution between private value added and private intermediate inputs, such as

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

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

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

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

$$\frac{P_{ss} M_{p,ss}}{P_{ss} GO_{p,ss}} = \omega_{m,p} \quad (\text{A.3})$$

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 Model Robustness: The Value Added Labor Share

This Appendix 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 labor share in value added of both the private sector and the government. Instead, in the benchmark model the value added labor shares are constant over time.

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

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

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

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

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

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

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

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

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

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

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

$$\frac{W_t N_{p,t}}{P_{Y_{p,t}} Y_{p,t}} = \omega_p W_t^{1-\nu_p}. \quad (\text{B.9})$$

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 $\nu_p > 1$ 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

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 Labor in Govt. Value Added 2017
Share Labor in Govt. Value Added	$\omega_g = 0.653$	Share Labor in Govt. Value Added 1960
Elasticity Pvt. Value Added	$\nu_p = 1.072$	Share Labor in Pvt. Value Added 2014
Share Labor in Pvt. Value Added	$\omega_p = 0.651$	Share Labor in Pvt. Value Added 1960
Disutility Labor	$\theta = 9.36$	Steady-State Labor = 0.33

by Karabarnounis and Neiman (2014). Yet, they compute the elasticity on a panel 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 $\nu_m = 2.25$.