Optimal Monetary and Fiscal Policies in Disaggregated Economies

Lydia Cox, Jiacheng Feng, Gernot J. Müller,
Ernesto Pasten, Raphael Schoenle, and Michael Weber*

August 2024

Abstract

The jointly optimal monetary and fiscal policy mix in a multi-sector New Keynesian model with sectoral government spending and productivity shocks entails a separation of roles: Sectoral government spending optimally adjusts to sectoral output gaps and inflation rates—a policy supported by evidence from sectoral federal procurement data. Monetary policy optimally focuses on aggregate stabilization, but deviates from a zero-inflation target; in a model calibration to the U.S., however, it effectively approximates a zero-inflation target. Because monetary policy is a blunt instrument and government spending trades off stabilization against the optimal-level public good provision, the first best is not achieved.

Keywords: Optimal monetary and fiscal policy, government spending, sectoral heterogeneity, fiscal rules

JEL Classification: E62, E32

*Cox: University of Wisconsin-Madison and NBER. e-Mail: lydia.cox@wisc.edu; Feng: Jane Street Capital. e-Mail: jackfeng6@hotmail.com; Müller: University of Tübingen and CEPR. e-Mail: gernot.mueller@uni-tuebingen.de; Pasten: Central Bank of Chile. e-Mail: epasten@bcentral.cl; Schoenle: Brandeis University, and CEPR. e-Mail: schoenle@brandeis.edu; Weber: Booth School of Business, University of Chicago and NBER. e-Mail: michael.weber@chicagobooth.edu. Schoenle and Weber gratefully acknowledge support from the National Science Foundation under grant number 1756997. We thank participants in conferences and seminars in several institutions for comments and discussions. The views expressed herein are those of the authors and do not necessarily reflect the views of the Central Bank of Chile.

1 Introduction

Business cycle fluctuations are not perfectly synchronized across sectors. Sectors may be hit differently by shocks, as the COVID-19 pandemic so forcefully illustrated (Guerrieri et al., 2022; Baqaee and Farhi, 2022), or they have distinct characteristics that determine their responsiveness even to identical shocks.[1] These features raise challenges for stabilization policy. If productivity shocks are perfectly correlated across and propagate in the same way in all sectors, a zero-inflation policy attains the first best by closing the output gap; the so-called "divine coincidence." But when these conditions are not met, monetary policy is too blunt of a tool. Then, central banks must target a second-best inflation index that gives higher weight to sectors in which shocks manifest in larger output deviations from efficient levels. This policy closes the aggregate output gap but tolerates suboptimal inflation volatility and levels of sectoral output.

Goodfriend and King (1997) articulate this challenge, Aoki (2001) formally shows it, Benigno (2004) apply these insights in a monetary union, Eusepi et al. (2011) explore this issue quantitatively, and La'O and Tahbaz-Salehi (2022) and Rubbo (2023) extend it to production networks. We revisit this policy prescription in light of the fact that monetary policy interacts with sectoral government demand in shaping economic fluctuations. Our analysis builds on and leverages insights from earlier work in Cox et al. (2024). They use the universe of federal procurement contracts in the U.S. to show that government demand is not a monolithic aggregate—big G—but is the sum of rich, disaggregated policy decisions, giving rise to challenges but also opportunities for stabilization policy.

Against this background we shift the focus of fiscal stabilization from the aggregate to the sectoral level and ask: What is the optimal policy mix if monetary policy and sectoral fiscal policy are jointly determined? Moreover, we derive predictions for sectoral government spending under optimal policy and find suggestive evidence that they are borne out in U.S. data. Thus, the stabilization role of disaggregated fiscal policy is not just a theoretical possibility and we can contrast it empirically with an optimal benchmark. We then trace out the implications for monetary policy, in particular, the optimality of a zero-inflation policy to deal with

[1] See, among others, Pastén et al. (2020, 2024) and Bouakez et al. (2023).

disaggregated productivity shocks, and the desirability of the acyclical aggregate fiscal policy observed in U.S. data.

We derive our insights in a New Keynesian multi-sector setup in which, building on the multi-country model of Galí and Monacelli (2008), the government demands goods that contribute to welfare. The optimal, time-consistent mix of monetary and fiscal policy prescribes a separation of roles: monetary policy takes care of aggregate stabilization, whereas fiscal policy focuses on the sectoral level. We obtain an intuitive rule for optimal sectoral fiscal policy: government demand should be expansionary relative to the first-best in sectors with negative inflation and output gaps, that is, those sectors which experience positive productivity shocks.

The separation of roles hinges on the key trade-off in the design of joint monetary and sectoral fiscal policies: Monetary policy is superior as a stabilization tool to deal with productivity shocks, but government demand can be fine tuned at any required disaggregated level, contrary to monetary policy. The intuition holds in a single-sector model: A positive productivity shock decreases prices and the output gap. If monetary policy engineers a demand stimulus, the output gap can be closed exactly when prices do not respond—a "divine coincidence". The same conclusion does not hold if government demand engineers the stimulus, because it additionally crowds out consumption and thus affects labor supply. In addition, monetary policy *per se* does not enter in welfare, whereas government demand does by providing goods valued by households. Hence, even if a "divine coincidence" were to exist for fiscal policy, it might be suboptimal to fully exploit it.[2]

In our model, optimal monetary policy deviates from a zero-inflation target. Both monetary and sectoral fiscal policy give higher weight to sectors with stickier prices, that is, those in which a given shock yields larger output gaps. However, numerical exercises suggest that the deviation of optimal monetary policy from a zero-inflation target is quantitatively small relative to a case when monetary policy is the only stabilization tool. Yet, the first best is never attained.

Complementary to these theoretical results, the following question naturally arises: Is the disaggregated stabilization role of fiscal policy just a theoretical possibility or can we find empirical support for it in U.S. data? First, as Cox et al. (2024)

[2]"Divine coincidence" may exist for fiscal policy but requires assuming a suboptimal fiscal rule in a frictionless economy. We discuss this possibility in Appendix D.

argue, government purchases of goods and services are the most volatile component of total government spending and exhibit substantial sectoral reallocation. These facts suggest that government spending is flexible enough to perform such a stabilizing role. Second, the joint correlation of sectoral government demand, sectoral inflation and sectoral output in the data is indeed broadly consistent with the theoretical optimal sectoral fiscal rule, but not with a purely aggregate fiscal stabilization policy. We establish this result based on regression analyses, constructing measures of government demand at the 4-digit NAICS sector level from USAspending.gov, which covers the universe of federal procurement contracts from 2001 onwards, using Compustat sales data, producer price inflation from the BLS, and a sectoral measure of the average frequency of price changes constructed by Pastén et al. (2020, 2024). In particular, consistent with the theoretical optimal fiscal rule, we find that fiscal policy is more active in sectors in which prices are stickier.

We want to stress that we do not argue fiscal policy decisions follow the rules we derive in the model. In reality, the allocation of government demand follows a complicated political process involving Congress, lobbying and stakeholders interacting in many layers, things we all abstract from in the model. A distinct literature studies several aspects of such a process, see, for instance, Bisin et al. (2015) and Halac and Yared (2022). Yet, we consider it useful to contrast the outcome of such a process with an optimal fiscal policy that balances its direct welfare effects with stabilization purposes. Remarkably, the model rules and its empirical counterparts are similar. Given this alignment, we study the implications of optimal fiscal policy on monetary policy and the cyclicality of aggregate government demand.

We also study the implications of our setting through the lens of the aggregate Phillips curve. As stressed by Rubbo (2023), Guerrieri et al. (2021) and Afrouzi and Bhattarai (2023), aggregation of sectoral Phillips curves yields an extra term akin to an "aggregate cost-push shock" in setups with sectoral input-output interconnections and no fiscal policy. Such a result holds in any economy in which aggregation is not trivial, including ours. In numerical exercises, we find the volatility of the "aggregate cost-push shock" is six times larger if monetary policy follows a zero-inflation target instead of its optimal rule. Thus, even if a zero-inflation policy does almost as well as optimal monetary policy when the government follows optimal sectoral fiscal policy, it faces the practical challenge of dealing with highly volatile "aggregate cost-push shocks."

Finally, we highlight the implications of optimal fiscal policy for the cyclicality of aggregate government demand. A well-established fact for advanced economies, including the U.S., is that fiscal spending is largely acyclical (for instance, Talvi and Vegh, 2005). This feature has been regarded as suggestive that fiscal policy does not play a stabilization role (Chari et al., 2007). We find a muted cyclicality is not inconsistent with government demand playing a stabilization role; it just does it at a disaggregated level. In our setup, if sectors were symmetric and the economy were efficient, optimal fiscal policy is perfectly cyclical. However, a milder cyclicality arises when the economy is inefficient and the composition of private and public demand differs across sectors, as in the U.S., with public demand tilted towards stickier sectors (Cox et al., 2024). Cyclicality is even lower if monetary policy follows standard inflation targeting as fiscal policy is even more active in this case.

The paper is structured as follows. The remainder of this introduction discusses the related literature and our contribution. Section 2 lays out the model. Section 3 discusses the trade-offs which govern optimal policy, its objective function, and the optimal fiscal and monetary policy rules we obtain. Section 4 presents the data and empirical results supporting the idea that sectoral government demand does play a disaggregated stabilization role. Section 5 studies its implications for monetary policy and aggregate government demand. Section 6 concludes.

Related Literature. In addition to work cited above, our analysis relates to four strands of the literature. First, a line of work conducts a positive analysis on the importance of sectors in fiscal policy transmission, notably the influential study of Ramey and Shapiro (1998) and more recent work by Proebsting (2022), Flynn et al. (2022) and Bouakez et al. (2022). Bouakez et al. (2023) develop richer multi-sector models with input-output structures to shed light on the fiscal transmission mechanism. In contrast to these papers, we offer a normative perspective.

Second, to do so, our analysis builds on work about the optimal adjustment of government spending in aggregate economies if monetary policy is constrained by the zero lower bound, or an exchange-rate target. Bianchi et al. (2023) study the optimal adjustment of government spending in the presence of nominal rigidities and sovereign risk in a open economy with an exchange rate peg. Such a setting calls for a modified Samuelson rule which, absent frictions, requires optimal policy to equate the marginal benefits of higher government spending to the marginal costs of reduced private consumption. Hettig and Müller (2018) study the optimal response of country-level government spending in a model of a monetary union in which monetary policy is constrained by the effective lower bound. Bilbiie et al. (2024) revisit the trade-offs for monetary and fiscal policy in a model that emphasizes household heterogeneity and inequality. Our analysis, instead, considers a multi-sector closed-economy model and is focused on heterogeneities along the production side of the economy.

Third, several papers show how taxes should adjust when monetary policy is constrained by the zero lower bound (Eggertsson et al., 2004; Correia et al., 2013); as well as the possibility of "non-conventional" fiscal policy to replicate a first-best when monetary policy is constrained by the zero lower bound as well as empirical evidence (Correia et al., 2013; D'Acunto et al., 2018, 2022; Bachmann et al., 2021). Farhi et al. (2014), in turn, consider a monetary union and study the optimal tax policy which brings about a "fiscal devaluation" in response to country-specific shocks; and Antonova and Müller (2024) study the optimal tax response to sectoral shocks in the New Keynesian model with network structure. Woodford (2022) studies transfers as a way to stabilize effective demand in a multi-sector model. We focus instead on government spending financed through lump-sum taxes to isolate its optimal stabilization role.

Our analysis relates to earlier and recent work on fiscal rules. Galí and Perotti (2003), in particular, study how various fiscal instruments adjust to the cycle based on a sample of European countries. Kliem and Kriwoluzky (2014) offer a normative model-based assessment of alternative fiscal rules, Halac and Yared (2018) study international coordination of fiscal rules, and Hatchondo et al. (2022) focus on the performance of fiscal rules in a model of sovereign risk. In contrast, assuming optimal policy, we establish a link between sectoral government spending, sectoral output gaps and sectoral inflation and show that granular data for federal purchases is largely consistent with this relationship. Finally, we focus on discretionary optimal monetary and fiscal policy. A large literature exists studying policy without commitment in more complex environments, with Afrouzi et al. (2023) being a recent example. We leave such extensions for future research.

2 A New Keynesian multi-sector model

We model the optimal allocation of government sectoral demand building on the multi-country setup of Galí and Monacelli (2008). In our model, though, the sectoral composition of private and public demand is flexible in line with the evidence in Cox et al. (2024) and we consider time-consistent policies. Our model has K sectors with a continuum of monopolistic competitive firms operating in each of them. Prices are adjusted infrequently. A representative household provides labor in competitive sectoral markets. Government purchases are financed via lump-sum taxes with its budget balanced at all times. Finally, monetary policy adjusts the short-term nominal interest rate.

2.1 Setup

We now introduce the problem of the representative household, the allocation of the government demand within and across sectors, and the firms' problem.

Households. The economy is populated by an infinitely-lived representative household with expected utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[(1-\chi)\log(C_t) + \chi \log(G_t) - \sum_{k=1}^{K} \nu_k \frac{N_{kt}^{1+\varphi}}{1+\varphi} \right], \tag{2.1}$$

where $\beta \in (0,1)$ is the time-discount factor, $\mathbb{E}_0$ is the expectation operator, C_t and G_t are indexes of private and public consumption, and N_{kt} denotes hours worked in sector $k = 1,...,K$. The parameter χ determines the weight of each type of consumption on per-period utility. Private and public consumption are Cobb-Douglas aggregates:

$$C_t \equiv \prod_{k}^{K} \left(\omega_{ck}^{-1} C_{kt} \right)^{\omega_{ck}} \text{ and } G_t \equiv \prod_{k}^{K} \left(\omega_{gk}^{-1} G_{kt} \right)^{\omega_{gk}}, \tag{2.2}$$

where $\varphi > 0, \nu_k > 0$ and the subscript k refers to the sector in which bundles C_{kt} and G_{kt} are assembled. Parameters ω_{ck} and ω_{gk} measure the weight of sector k in the private and public consumption index, respectively. For the sectoral bundles, we assume a CES structure:

$$C_{kt} \equiv \left[\mu_k^{-1/\theta} \int_{j \in J_k} C_{kt}(j)^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}} \text{ and } G_{kt} \equiv \left[\mu_k^{-1/\theta} \int_{j \in J_k} G_{kt}(j)^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}. \quad (2.3)$$

Infinite varieties of private and public goods exist, each indexed by j with total mass equal to 1; firm j produces variety j. A sector k is defined as the set of firms producing goods with index belonging to the set J_k with mass μ_k such that $\sum_{k=1}^{K} \mu_k = 1$. The elasticity of substitution across varieties within sectors is $\theta > 1$ for private and public goods, which is assumed to be the same across all sectors.

The household maximizes equation (2.1) subject to a period budget constraint

$$\sum_k P_{kt} C_{kt} + \sum_k P_{kt}^G G_{kt} + Q_{t-1} B_{t-1} = \sum_k W_{kt} N_{kt} + B_t + \Pi_t, \quad (2.4)$$

where P_{kt}, P_{kt}^G and W_{kt} are sector-k prices paid by households, prices paid by the government, and nominal wages paid by firms, respectively. Equation (2.4) features the government's total expenditures rather than taxes as we assume a balanced government budget throughout. In turn, Q_{t-1} is the period-t price of a one-period discount bond, B_t, and Π_t are dividends. In addition, we rule out Ponzi schemes.

$P_{kt}(j)$ denotes the price of variety j in sector k, and P_{ct} is the consumer price index. Household's demand for the sectoral consumption and varieties within sectors are given by:

$$C_{kt} = \omega_{ck} \left(\frac{P_{kt}}{P_{ct}} \right)^{-1} C_t \text{ and } C_{kt}(j) = \frac{1}{\mu_k} \left(\frac{P_{kt}(j)}{P_{kt}} \right)^{-\theta} C_{kt}, \quad (2.5)$$

where the respective price indices are:

$$P_{ct} = \prod_k (P_{kt})^{\omega_{ck}} \text{ and } P_{kt} = \left(\int_{j \in J_k} P_{kt}(j)^{1-\theta} \right)^{1/(1-\theta)}. \quad (2.6)$$

Sectoral labor supply, in turn, satisfies

$$\nu_k C_t N_{kt}^{\varphi} = (1-\chi)\frac{W_{kt}}{P_{ct}} \tag{2.7}$$

and households' consumption satisfies the Euler equation:

$$1 = \beta \mathbb{E}_t \left[I_t \left(\frac{C_{t+1}}{C_t} \right)^{-1} \frac{P_{ct}}{P_{ct+1}} \right] \tag{2.8}$$

where $I_t = 1/\mathbb{E}_t(Q_t)$ is the gross nominal interest rate.

Firms. A generic firm j in sector k specializes in the production of a unique variety, using labor $N_{kt}(j)$ as the sole input:

$$Y_{kt}(j) = A_{kt} N_{kt}(j), \tag{2.9}$$

where A_{kt} is exogenous, sector-specific productivity. The government subsidizes labor at a constant rate τ_k, such that nominal marginal costs are given by:

$$MC_{kt}^{n}(j) = (1-\tau_k)\frac{W_{kt}}{A_{kt}}. \tag{2.10}$$

Firms set prices every period *à la* Calvo and with associated probability of price adjustment $1-\alpha_k$. In doing so a generic firms solves

$$\max_{P_{kt}^*} \mathbb{E}_t \left[\sum_{\tau=0}^{\infty} (\alpha_k \beta)^{\tau} \frac{C_{kt} P_{kt}}{C_{k,t+\tau} P_{k,t+\tau}} \left(P_{kt} Y_{k,t+\tau|t}^{d}(j) - W_{k,t+\tau} N_{k,t+\tau|t}(j) \right) \right].$$

Optimality requires

$$0 = \mathbb{E}_t \left[\sum_{\tau=0}^{\infty} (\alpha_k \beta)^{\tau} \frac{C_{kt} P_{kt}}{C_{k,t+\tau} P_{k,t+\tau}} Y_{k,t+\tau|t}^{d} \left(P_{kt}^* - \frac{\theta}{\theta-1} MC_{k,t+\tau|t}^{n} \right) \right], \tag{2.11}$$

where $Y_{k,t+\tau|t}^{d}$ is the total demand at period $t+\tau$ relevant for the pricing problem of a firm j that last reset prices in period t. We assume the government buys goods in separated markets and are agnostic in that the government directly chooses its real sectoral demand without taking a stand on the degree of nominal rigidity prices that the government faces.[3]

Government. The government jointly determines fiscal and monetary policy to maximize social welfare. Its policy instruments are the nominal interest rate, $I_t = 1/\mathbb{E}_t(Q_t)$, and sectoral government spending, in real terms, $[G_{kt}]_{k=1}^{K}$.

Equilibrium conditions. Bonds are in zero net supply. Goods and labor markets all clear:

$$Y_{kt}(j) = C_{kt}(j) + G_{kt}(j) \tag{2.12}$$

$$Y_{kt} = C_{kt} + G_{kt} \tag{2.13}$$

$$N_{kt} = \int_{j \in J_k} N_{kt}(j) dj \tag{2.14}$$

such that the aggregation of firms' profits is

$$\Pi_t = \sum_{k=1}^{K} \left[P_k C_{kt} + P_k^G G_{kt} - W_{kt} N_{kt} \right].$$

2.2 Efficient allocation

To determine the efficient allocation, we take a planner perspective and maximize equation (2.1) subject to the aggregation technologies of private and public goods in equations (2.2), the production technology in equation(2.9) and sectoral resource constraints in equations (2.13). The optimality condition is

$$\nu_k \frac{N_{kt}^{\varphi}}{A_{kt}} = \frac{(1-\chi)\omega_{ck}}{C_{kt}} = \frac{\chi \omega_{gk}}{G_{kt}}. \tag{2.15}$$

This condition is consistent with the Samuelson (1954) rule: efficiency requires the marginal product of labor equals the marginal benefits of government demand.

This condition implies that working hours are invariant to sectoral productivity shocks in the first best, which is a convenient feature that facilitates the optimal policy analysis below. We obtain this result because of two assumptions:

[3] Cox et al. (2024) show that lump-sum taxes and Ricardian households imply that prices paid by the government do not affect real variables up to a log-linear approximation.

the subsidy $\tau_k = \theta^{-1}$ offsetting the effect of imperfect competition, and the optimal steady-state provision of public goods. Using this latter assumption, we normalize parameters ν_k to obtain that all firms are symmetric in steady state, so $N_k(j) = 1$, and in the aggregate $N = 1$. Thus, the measure of firms in a sector, μ_k, is the only source of cross-sectoral variation in steady-state output. The solution to the planner's problem is then given by:

$$\bar{N}_{kt} = \mu_k \tag{2.16}$$

$$\bar{Y}_{kt} = \mu_k A_{kt} \tag{2.17}$$

$$\bar{C}_{kt} = \frac{(1-\chi)\omega_{ck}}{(1-\chi)\omega_{ck} + \chi\omega_{gk}} \bar{Y}_{kt} \equiv (1-\chi_k)\bar{Y}_{kt} \tag{2.18}$$

$$\bar{G}_{kt} = \frac{\chi\omega_{gk}}{(1-\chi)\omega_{ck} + \chi\omega_{gk}} \bar{Y}_{kt} \equiv \chi_k \bar{Y}_{kt}. \tag{2.19}$$

where $\mu_k = (1-\chi)\omega_{ck} + \chi\omega_{gk}$, $\nu_k \equiv \mu_k^{-\varphi}$, $\chi_k \equiv \chi\omega_{gk}/\mu_k$ and $1 - \chi_k = (1-\chi)\omega_{ck}/\mu_k$ and upper bars denote efficient levels.

2.3 Approximate equilibrium dynamics

We now characterize the approximate log-linear equilibrium dynamics for an arbitrary level of government demand in each sector. In a steady state with optimal public good provision, $\omega_{ck} = C_k/C$ with $\sum_{k=1}^{K} \omega_{ck} = 1$, $\omega_{gk} = G_k/G$ with $\sum_{k=1}^{K} \omega_{gk} = 1$, and $\mu_k = Y_k/Y$ with $\sum_{k=1}^{K} \mu_k = 1$.[4] The first-order approximation of market-clearing conditions at sectoral and aggregate levels are

$$y_{kt} = (1-\chi_k)c_{kt} + \chi_k g_{kt} \quad \text{and} \quad y_t = (1-\chi)c_t + \chi g_t. \tag{2.20}$$

The approximation of the Euler equation (2.8) is:

$$c_t = \mathbb{E}_t(c_{t+1}) - (i_t - \mathbb{E}_t(\pi_{t+1}) - \rho),$$

where $\rho = -\log\beta$ such that the log-linear approximation of sectoral demand in

[4]Minuscules denote log-linear deviations from steady state levels. Appendix A provides a full solution of the steady state.

equation (2.5) and sectoral market clearing in equation (2.20) yield

$$\hat{y}_{kt} = \mathbb{E}_t \hat{y}_{kt+1} - (1 - \chi_k)(i_t - \mathbb{E}_t(\pi_{kt+1}) - \rho) - \chi_k \mathbb{E}_t \Delta \hat{g}_{kt+1}. \tag{2.21}$$

Next, we express variables in terms of deviations from the efficient allocation. Define sectoral output gaps as $\tilde{y}_{kt} \equiv y_{kt} - \bar{y}_{kt}$ and sectoral fiscal gaps as

$$\tilde{f}_{kt} \equiv (g_{kt} - \bar{g}_{kt}) - (y_{kt} - \bar{y}_{kt}) = g_{kt} - y_{kt}.$$

The last equality holds given that $\bar{y}_{kt} = \bar{g}_{kt} = a_{kt}$. Thus, (2.21) becomes

$$\tilde{y}_{kt} = \mathbb{E}_t \tilde{y}_{kt+1} - (i_t - \mathbb{E}_t \pi_{kt+1} - \bar{r}_{kt}) - \chi_k^* \mathbb{E}_t \Delta \tilde{f}_{kt+1}, \tag{2.22}$$

where $\chi_k^* \equiv \chi_k/(1 - \chi_k)$ and $\bar{r}_{kt}$ is the sectoral natural rate of interest:

$$\bar{r}_{kt} \equiv (1 - \chi_k)^{-1} [\mathbb{E}_t \Delta \bar{y}_{kt+1} - \chi_k \mathbb{E}_t \Delta \bar{g}_{kt+1}] = \mathbb{E}_t \Delta a_{kt+1}.$$

We turn next to the optimal price setting in equation (2.11), which implies a *sectoral* New Keynesian Phillips Curve. Using equations (2.5), (2.7), and (2.9), and the definitions of sectoral output and fiscal gaps,

$$\pi_{kt} = \beta \mathbb{E}_t \pi_{kt+1} + \lambda_k (1 + \varphi) \tilde{y}_{kt} - \lambda_k \chi_k^* \tilde{f}_{kt}. \tag{2.23}$$

where $\pi_{kt} = \Delta p_{kt}$ and $\lambda_k \equiv (1 - \alpha_k)(1 - \beta \alpha_k)/\alpha_k$. Sectoral Phillips curves do not directly depend on sectoral price distortions, but instead are reflected in the cross-sectoral dispersion of sectoral output gaps. To see this, we use the expressions in equations (2.5) and (2.20) to obtain a relationship between sectoral output and fiscal gaps:

$$\tilde{y}_{kt} - \tilde{y}_t = \chi_k^* \tilde{f}_{kt} - \chi^* \tilde{f}_t - (p_{kt} - p_{ct}) - (a_{kt} - a_t) + \chi^* \sum_k^K (\mu_k - \omega_{gk}) a_{kt} \tag{2.24}$$

where $\chi^* \equiv \chi/(1 - \chi)$ and $\tilde{f}_t$ is the aggregate fiscal gap; p_{kt} and p_{ct} are household-paid prices at sectoral and aggregate levels, respectively:

$$p_{kt} = \pi_{kt} + p_{kt-1}, \tag{2.25}$$

$$p_{ct} = \sum_{k}^{K} \omega_{ck} p_{k,t}, \tag{2.26}$$

$$\pi_t = \sum_{k}^{K} \omega_{ck} \pi_{k,t}, \tag{2.27}$$

$$\tilde{f}_t = \sum_{k}^{K} \omega_{gk} (\tilde{f}_{kt} + \tilde{y}_{kt}) - \tilde{y}_t. \tag{2.28}$$

Aggregate dynamics are characterized by equations (2.22), (2.23), (2.24) and (2.25) for all sectors $k = 1, ..., K$ and equations (2.26), (2.27), and (2.28). Note that the aggregation of sectoral equations (2.24) and equation (2.28) yield

$$\tilde{y}_t = \sum_{k}^{K} \mu_k \tilde{y}_{kt}. \tag{2.29}$$

To close this section, we want to make three remarks. First, sectoral productivity shocks and sectorally segmented labor markets imply that marginal costs are perfectly correlated for firms within sectors but independent across sectors. In this way, we rule out direct spillovers across sectors in order to focus on the degrees of freedom due to sectoral fiscal policy in a disaggregated economy. Second, the model allows for sector-specific nominal rigidity, which allows us to accommodate the empirical evidence for the U.S. documented by Pastén et al. (2020). In this way, our analysis generalizes the setup of Aoki (2001), Benigno (2004), Eusepi et al. (2011) and, although abstracting from input-output relationships, we connect with La'O and Tahbaz-Salehi (2022), Guerrieri et al. (2021), Rubbo (2023), and Afrouzi and Bhattarai (2023). Third, the model provides flexibility to accommodate the unequal sectoral composition of final private demand (here, households) and government demand documented for the U.S. in Cox et al. (2024). In what follows, we study how this sectoral bias affects the design of the optimal joint monetary and sectoral fiscal policies.

3 The Optimal Policy Mix under Sticky Prices

We now present our main theoretical result: the joint, time-consistent optimal monetary and sectoral fiscal policies, based on a second-order approximation of household's welfare and log-linearly approximated dynamics.

3.1 Trade-offs

To set the stage, we start highlighting the trade-offs involved in the optimal policy mix, first for the one-sector special case and then for the multi-sector economy.

Single-sector economy. Our model trivially collapses to a single-sector economy if $K = 1$. This setup is equivalent to a multi-sector economy with aggregate productivity shocks and perfectly symmetric sectors.

The Phillips curves in equation (2.23) imply that divine coincidence holds: monetary policy can fully stabilize aggregate inflation, $\pi_t = 0$, and closing the (aggregate) output gap, $\tilde{y}_t = 0$, with no need of fiscal policy to deviate from the first-best provision of public goods, $\tilde{f}_t = 0$. Monetary policy dominates fiscal policy as stabilization tool because the latter does not enjoy a divine coincidence: The fiscal rule $\chi^* \tilde{f}_t = (1 + \varphi)\tilde{y}_t$ that sets $\pi_t = 0$ in equation (2.23) is inconsistent with $\tilde{y}_t = 0$ in equation (2.22) if monetary policy remains passive, $i_t = 0$. Intuitively, government demand can engineer the same nominal aggregate demand expansion as monetary policy but, as it crowds out consumption, it affects labor supply, and thus it yields a different response of inflation and the output gap.

Multi-sector economy. We now consider a multi-sector economy, that is, $K > 1$. If monetary policy were the only stabilization instrument with $\tilde{f}_{kt} = 0$ for all k, then the aggregation of sectoral Phillips curves in equation (2.23) implies that divine coincidence breaks down. Instead, a modified version of divine coincidence applies, extensively shown in different contexts in the literature (Rubbo, 2023; Afrouzi et al., 2024, for example). In our setup, the aggregation of equation (2.23) implies that monetary policy alone can close the aggregate output gap, $\tilde{y}_t = 0$, if it targets an inflation index

$$\pi_t^{DC} \equiv \sum_{k=1}^{K} \frac{\lambda_k^{-1}\mu_k}{\sum_{k=1}^{K} \lambda_k^{-1}\mu_k} \pi_{kt} \tag{3.30}$$

which gives higher weight to sectors with sticker prices, i.e., those with larger expected output gaps. However, inflation π_t relevant for households is not stabilized under this monetary policy rule; sectoral inflation and sectoral output gaps are not stabilized either. This is where sectoral fiscal policy can play a complementary role: unlike aggregate monetary policy, sectoral fiscal policy can be tailored at the required disaggregated, in this case, sectoral level.

As in the single sector economy, fiscal policy does not enjoy an "aggregate divine coincidence". As such, it is a complement and not substitute of monetary policy. Fiscal policy does not enjoy a "disaggregated divine coincidence" either.[5] To see this point, note that the fiscal rule that sets $\pi_{kt} = 0$ in equation (2.23) is inconsistent with $\tilde{y}_{kt} = 0$ in equation (2.22) for all sectors k for any monetary policy rule. The intuition is the same as in the single sector economy above: to deal with productivity shocks, pure sectoral nominal demand management is required, which is unfeasible for fiscal policy as it affects labor supply. Therefore, the first best is not attainable. Yet, disaggregated fiscal policy can improve outcomes by deviating from first-best government demand when jointly working with monetary policy. This is what we turn to next.

3.2 Optimal Policy

Given these trade-offs, we now derive the optimal time-consistent mix of monetary and sectoral fiscal policies. Appendix B solves for the second-order approximation of the welfare function which is

$$\mathbb{W}_t = \sum_{t=0}^{\infty} \beta^t U_t = -\frac{1}{2} \sum_{t=0}^{\infty} \beta^t \sum_k \mu_k \left(\frac{\theta(1-\chi_k)}{\lambda_k} \pi_{kt}^2 + (1+\varphi)\tilde{y}_{kt}^2 + \chi_k^* \tilde{f}_{kt}^2 \right) \tag{3.31}$$

where we abstract from terms independent of monetary and fiscal policy. This welfare function has three main components. Sectoral inflation is a proxy for the inefficiency introduced by intra-sector dispersion of prices due to the nominal rigidity. Thus, this term is eliminated if a sector has fully flexible prices, in which case $\lambda_k \to \infty$. This inefficiency affects the allocation of intra-sectoral household consumption, which, in steady state is a share $1 - \chi_k^*$ of total sectoral output. Note a

[5] Appendix D shows that divine coincidence, at aggregate and disaggregated levels, does hold for sectoral fiscal policy if frictionless output is inefficient due to suboptimal fiscal policy.

given level of intra-sectoral price dispersion yields a larger distortion as the intra-sectoral elasticity of substitution of consumption θ is larger. The second term is related to sectoral output gaps capturing the inter-sectoral dispersion of consumption. Finally, sectoral fiscal gaps encapsulate the sectoral provision of public goods and, together with sectoral output gaps, the equilibrium working hours that the household provides in each sector.

We focus on time-consistent policies. To solve this problem, we follow the standard approach of directly choosing allocations $\{p_{kt}, \pi_{kt}, \tilde{y}_{kt}, \tilde{f}_{kt}, p_{ct}, \tilde{y}_t, \tilde{f}_t\}$ by optimizing equation (3.31) subject to sectoral Phillips curves in equation (2.23), sectoral demand in equation (2.24) and the relation between sectoral prices and sectoral inflation in equation (2.25) for all sectors, plus the aggregation equations (2.26), (2.28) and (2.29). Aggregate inflation π_t is defined in equation (2.27) and the monetary policy rule that solves for this allocation is implicitly defined in the aggregation of sectoral IS curves in equation (2.22).

A few observations follow from the expression for welfare in equation (3.31). First, even though we allow the sectoral composition of consumption and aggregate government demand to differ, the relative importance of sectors in welfare is given only by steady-state sectoral size, $\mu_k = Y_k/Y$. Second, no aggregate variable enters the welfare function. Thus, closing the aggregate output gap is not necessarily a target for optimal policy. Third, inter-sectoral price dispersion does not explicitly enter welfare and instead is captured by equation (2.24), which enters in the optimal policy problem as a restriction. Appendix C presents the detailed solution. The optimal sectoral fiscal rule prescribes that, in equilibrium,

$$\tilde{f}^*_{kt} = -\frac{(1+\varphi)(1+\lambda_k)}{1+(1+\varphi)\lambda_k}\tilde{y}^*_{kt} - \frac{\theta(1-\chi_k)\varphi}{1+(1+\varphi)\lambda_k}\pi^*_{kt}. \tag{3.32}$$

The intuition is that, when a positive productivity shock hits in a sector, marginal costs of firms in that sector decrease, and so do sectoral prices, to the extent that nominal price rigidity allows it, the latter introducing inefficient price dispersion. In addition, output increases but not as much as in a flex-price economy, so the sectoral output gap is negative. In this situation, as discussed in section 3.1, an expansionary sectoral fiscal policy simultaneously reduces the response of the sectoral inflation and the gap in the response of output relative to the flex-price response – although it can not set both to zero at the same time.

Equation (3.32) prescribes that sectoral fiscal policy is more aggressive in sectors with stickier prices, which is inversely captured by $\lambda_k \equiv (1-\alpha_k)(1-\beta\alpha_k)/\alpha_k$, where the government represents a smaller share of sectoral steady-state demand χ_k, the intra-sectoral elasticity of substitution θ is larger and when the inverse-Frisch elasticity φ is larger. More stickiness implies that sectoral inflation yields higher intra-sectoral price dispersion which affects only private demand. Thus, when the share χ_k of government demand is larger, price dispersion has smaller effect on welfare. In addition, larger θ implies that a given intra-sectoral price dispersion generates larger distortion and larger φ implies a stronger response of sectoral labor supply. Moreover, in stickier sectors, the output gap and inflation have stronger and weaker responses to shocks, respectively.

Turning to optimal monetary policy, the following condition holds

$$\theta \sum_{k=1}^{K} \frac{(1-\chi_k)\mu_k}{1+\lambda_k(1+\varphi)}\pi_{kt} = -\sum_{k=1}^{K} \frac{\mu_k}{1+\lambda_k(1+\varphi)}\tilde{y}_{kt}. \tag{3.33}$$

This is a variation of the usual "leaning against the wind" policy. If all sectors were symmetric in the steady state, such that $\lambda_k = \lambda$ and $\omega_{ck} = \omega_{gk} = \mu_k$ for $k = 1, ..., K$, optimal monetary policy splits the aggregate effect of sectoral shocks between aggregate inflation and the aggregate output gap. However, in general, sectoral inflation and sectoral output gaps are weighted according to steady-state output shares adjusted by their degree of nominal price rigidity and the steady-state share of private consumption on sectoral output, $(1-\chi_k)$.

To see how monetary policy, aggregate in nature, and sectoral fiscal policy interact, mixing equation (3.32) and equation (3.33) yields

$$\sum_{k=1}^{K} \mu_k(g_{kt} - \bar{g}_{kt}) = 0. \tag{3.34}$$

If sectors were symmetric in steady state, the aggregate provision of public goods would not deviate from the first best. The intuition is related to our discussion above: monetary policy is superior to fiscal policy as an aggregate stabilization tool, resulting in a separation of roles: fiscal policy stabilizes at a disaggregated level and monetary policy stabilizes at the aggregate level.

Up to log-linear approximation, aggregate government demand weights sectors by $[\omega_{gk}]_{k=1}^{K}$, whereas equation (3.34) weights them by $[\mu_k]_{k=1}^{K}$. In words, in the aggregate, fiscal policy gives higher weight to deviations from first-best public good provision in sectors in which households' steady-state demand is higher than the government's, $\omega_{ck} > \mu_k > \omega_{gk}$. A corollary of this result is that equation (3.34) does not imply that aggregate government demand g_t is unresponsive to shocks. We come back to this feature when we discuss the implications of optimal fiscal policy on a muted cyclicality of aggregate government demand.

4 Empirical Evidence

This section provides evidence that a disaggregated stabilization role for government demand is plausible empirically – suggesting that optimal policy and its implications are more than just abstract theoretical possibilities. We first motivate that government demand is flexible and rich enough to play such a role by referring to Cox et al. (2024). Second, we present empirical evidence that the sectoral allocation of government demand is indeed broadly consistent with the optimal sectoral fiscal policy in equation (3.32). The latter finding is remarkable if not surprising because, in practice, the allocation of government demand follows an involved decision-making process that may not align with our simple model.

4.1 Government demand is flexible

Based on the insights in Cox et al. (2024), government appears flexible and disaggregated enough to potentially play a stabilization role at the sectoral level.[6] Cox et al. (2024) use the universe of U.S. federal procurement contracts from USASpending.gov to establish two facts that provide validity in this regard:

1. Although federal procurement—the purchases of goods and services conducted by the U.S. federal Government—corresponds to only 16 percent of total government spending, it accounts for half of the variation of the growth

[6] More detail about the sources, features of and cleaning of these data can be found in Cox et al. (2024).

rate of total government spending. Conceptually, procurement is the component of government spending that directly speaks to the way that government spending is typically introduced in macro models. In addition, procurement is the most flexible component at the aggregate level.

2. Most of the variation in federal procurement is idiosyncratic across sectors. This fact suggests the presence of large sectoral reallocation of government spending period by period. If instead this sectoral government demand were in fixed proportions, it would suffice to model aggregate government demand.

The other three facts Cox et al. (2024) document are: (i) the government conducts its purchases in competitive auctions in segregated markets relative to private agents. This fact is the reason why the government in our model directly decides its real demand in a setup in which procurement prices play no role, as discussed above; (ii) duration of contracts that guide the persistence of fiscal shocks at the firm and sectoral levels – we abstract from such shocks in the paper at hand; (iii) distinct sectoral composition of government demand relative to private demand. We incorporate this fact in numerical exercises presented in section 5.

4.2 Government demand indeed plays a stabilization role

The sectoral allocation of government demand is indeed broadly consistent with the optimal sectoral fiscal policy in equation (3.32), which postulates a correlation of sectoral government demand with sectoral inflation and sectoral output gaps. Note that after rearranging equation (3.32), we can write the sectoral fiscal gap as:

$$\tilde{g}_{kt} = -\frac{\varphi}{1+(1+\varphi)\lambda_k}\tilde{y}_{kt} - \frac{\theta(1-\chi_k^*)}{1+(1+\varphi)\lambda_k}\pi_{kt},$$

such that government demand is expansionary relative to the first best when the sectoral output gap and/or sectoral inflation are negative. In contrast, an expansionary fiscal shock yields a positive correlation to both sectoral inflation and output gap, because it increases labor costs, pushing up inflation in the sector, whereas price stickiness generates an expansion in sectoral output relative to its frictionless counterpart. Therefore, negative estimated parameters are indicative of a stabilization role behind the allocation of sectoral government demand.

With this logic in mind, we estimate the reduced form counterpart of equation (4.2), specifically:

$$\tilde{g}_{kt} = \eta_k + \gamma_t + \beta_1 \tilde{y}_{kt} + \beta_2 \pi_{kt} + \nu_{kt}.$$

Importantly, we are not attempting to identify a causal effect, but instead to put a sign on the correlations represented by β_1 and β_2. This is because equation (4.2) is an equilibrium condition. Thus, we estimate variations of equation (4.2) by OLS and by an instrumental variables approach. We construct all variables at the NAICS 4-digit industry level, at a quarterly frequency. Sectoral government demand is computed from the federal procurement data from USASpending.gov from 2001 to 2019.[7] We calculate sectoral inflation using the confidential microdata data used by the Bureau of Labor Statistics (BLS) to construct the Producer Price Index (PPI), whereas for output we use sales reported by publicly listed U.S. firms in each sector, obtained from Compustat. We deflate both the government contracts and sales series using sectoral PPI. We also add sector and time fixed effects, respectively denoted as η_k and γ_t, and weight the regressions by average annual sectoral government spending.

In the model, sectoral government demand and sectoral output in equation (4.2) are expressed as log gaps from frictionless counterparts, which are unobservable. We therefore estimate the baseline regressions with various proxy variables to show the robustness of the estimates and report the results in Table 1. Regardless, a very consistent message arises from the estimation results: Column (1) shows results when the sectoral government demand and output gaps are approximated by log-deviations from HP-filtered series with the conventional smoothing parameter of 1600. Consistent with the model, the estimated coefficients are both negative and highly significant, as prescribed in equation (4.2). In column (3), the specification exploits the result from the model that frictionless sectoral government demand is a fixed proportion of sectoral output, so the sectoral fiscal gap does not depend on its frictionless counterpart up to a constant. Thus, we use the sectoral

[7] The start of the sample is determined by data availability, and we choose the end of the sample to alleviate on concerns arising due to the COVID-19 period.

Table 1: Sectoral Relationship between Government Demand, Output and Inflation

	OLS				IV	
(lr)2-5(lr)6-7	(1)	(2)	(3)	(4)	(5)	(6)
	g_{kt}	g_{kt}	f_{kt}	f_{kt}	g_{kt}	f_{kt}
y_{kt}	-0.113***	-0.120***	-1.416***	-1.425***	-0.348***	-1.428***
	(0.032)	(0.032)	(0.043)	(0.044)	(0.093)	(0.122)
π_{kt}	-0.011***	-0.011***	-0.007*	-0.007*	0.002	-0.004
	(0.002)	(0.002)	(0.003)	(0.003)	(0.007)	(0.009)
TFP (Cyclical)		0.074*		0.087		
		(0.037)		(0.050)		
Observations	8954	8953	8954	8953	8389	8389
R^2	0.242	0.243	0.930	0.930	—	—

Note: All regressions contain time (year × quarter) and sector (NAICS 4) fixed effects and are weighted by sectoral government spending. In columns (1), (2), and (5), the dependent variable is log g_{it}. In columns (3), (4), and (6), the dependent variable is $\log \tilde{f}_{kt} = \log g_{it} - \log y_{it}$. The instruments for column (5) and (6) are constructed by estimating regressions of the type $X_{kt} = \beta_0 + \sum_k \beta_{1k} D_x \times Z_t + \epsilon_{kt}$ where $X_{kt} \in (\tilde{y}_{kt}, \pi_{kt})$, Z_t denotes one of the exogenous shocks, and instrumentation uses predicted $\hat{X}_{kt}$. This procedure is based on the baseline specification in Nakamura and Steinsson (2014). The partial R^2s for the excluded instruments are between 14 and 15 percent for each endogenous variable. Because our specification relies on such a large number of instruments (one per industry x exogenous shock), the Stock and Yogo (2005) F-Statistic is roughly 3.5 for each endogenous variable.

fiscal gap, f_{kt}, as the dependent variable in results reported in column (3): once again, parameters are negative and significant.

In columns (2) and (4), we show that the results continue to hold when we estimate the same specification, but include sectoral TFP shocks as controls. The inclusion of this variable exploits the property in our model that frictionless government demand and output are functions of productivity shocks. To calculate a proxy for productivity in period t for industry k, we aggregate firm-level estimates of TFP, which we calculate using Compustat data, to the sector level. Specifically, we estimate firm-level TFP as the protoptyical Solow residual, ε_{it}, of the following specification:

$$\log(y_{it}) = \varrho_i + \varrho_t + \alpha_s^k \log(k_{it-1}) + \alpha_s^n \log(n_{it}) + \varepsilon_{it},$$

where y_{it} denotes the real sales of firm i in sector k in quarter t, k_{it-1} denotes its real capital stock, and n_{it} denotes its employment. We include firm and time fixed effects, ϱ_i and ϱ_t. We construct firms' real capital stock from Compustat data on the change in gross property plant and equipment (PPE) and net investment. Columns (2) and (4) of Table 1 report results with the TFP control for specifications with g_{kt} and f_{kt} as dependent variables, respectively. The estimated parameters are again negative and significant, though slightly less so for inflation.

Finally, as columns (5) and (6) show, results of an instrumental variables approach align with the results from the other specifications. Here, our goal is to use instruments for both $\tilde{y}_{kt}$ and π_{kt} that are not correlated with sectoral productivity shocks. We have two endogenous variables so the analysis requires at least two instruments. We borrow three shocks from the literature that have been identified as exogenous shifters of output and inflation: a monetary policy shock—specifically, the 30-minute change in expectations of the Federal Funds rate around FOMC meetings from Acosta (2023); a credit shock—specifically, the excess bond premium measure from Gilchrist and Zakrajšek (2012); and oil supply shocks from Känzig (2021).[8] To use these aggregate shocks to instrument for sectoral variables, we follow Nakamura and Steinsson (2014) such that the independent variable is the aggregate shock interacted with an industry dummy. Hence, in a first stage we regress industry output on the aggregate shock and fixed effects, allowing industry outcomes to vary differently with the three shocks. We then use the fitted values as an instrument in the second stage. With this approach, we can no longer estimate the coefficient on inflation precisely, but the negative coefficient on output is robust also in this IV setting, again consistent with a sectoral stabilization role for fiscal policy.

A different possible concern may arise from the fact that the sectoral fiscal rule in equation (3.32) is conceptually similar to a Taylor rule. Thus, a standard issue in the estimation of Taylor rules may also apply in our context: shocks to the rule

[8] We can exactly identify or overidentify the specification and obtain similar results.

could affect parameter estimates. We belief this concern is small in our setting for two reasons. First, Carvalho et al. (2021) shows the bias obtained from OLS estimation of Taylor rules is rather small. Second, as the response of both sectoral inflation and output gap are *positive* to an expansionary sectoral fiscal shock, the potential bias is likely upwards. As our estimated parameters are negative, this potential bias therefore does not affect our conclusion that our results provide suggestive evidence that government demand does play a stabilization role at the disaggregate level broadly consistent with the optimal sectoral fiscal policy rule.

Relation with price stickiness. Pastén et al. (2020, 2024) show that sectors in U.S. data differ in their frequency of price changes. The optimal sectoral fiscal rule in (3.32) prescribes a stronger reaction to sectoral output gaps and sectoral inflation in "stickier" sectors. We explicitly take this source of heterogeneity into account by dividing sectors into sticky and flexible sectors using data on the frequency of price adjustment calculated from the confidential micro-data underlying the BLS producer price index. We define a sector to be a "sticky" sector if it is characterized by a below-median frequency of price adjustment. Doing so confirms the role of optimal fiscal policy in line with the mechanisms at work in the model: Table 2 shows that the estimated coefficients are negative, significant, and larger in magnitude for "sticky" sectors relative to more flexible sectors. This result holds for both our OLS and instrumental-variable specifications, and across alternative dependent variables, either sectoral government demand, g_{kt} or sectoral fiscal gaps, f_{kt}. In particular, it holds in the sticky price sectors – aligning with the New Keynesian intuition of effectiveness of government spending in sectors in which pricing frictions are present.

5 Implications

This section highlights the implications of the optimal mix of monetary and sectoral fiscal policies for inflation targeting and aggregate fiscal policy. To do so, we rely on a calibrated version of our model for the U.S.

Two main results arise: First, divine coincidence approximately holds as zero-inflation targeting yields small welfare losses relative to the optimal monetary policy when sectoral fiscal policy is optimally conducted in both cases. At the same

Table 2: Sectoral Relationship and Price Stickiness

	OLS		IV	
(lr)2-3(lr)4-5	g_{kt}	f_{kt}	g_{kt}	f_{kt}
Flex × y_{kt}	0.232***	-0.887***	-0.232	-1.321***
	(0.058)	(0.078)	(0.135)	(0.179)
Sticky × y_{kt}	-0.255***	-1.606***	-0.585***	-1.683***
	(0.038)	(0.051)	(0.139)	(0.184)
Flex × π_{kt}	-0.011***	-0.020***	0.008	0.005
	(0.003)	(0.004)	(0.007)	(0.010)
Sticky × π_{kt}	-0.017***	0.018**	-0.121***	-0.157***
	(0.004)	(0.006)	(0.026)	(0.034)
Observations	8954	8954	8389	8389
R^2	0.247	0.931	-0.066	0.038

Notes: All regressions contain time (year × quarter) and sector (NAICS 4) fixed effects and are weighted by average sectoral government contracts. In columns (1) and (3), the dependent variable is the cyclical component of log g_{it}. In columns (2) and (4) is $\log g_{it} - \log y_{it}$. A "sticky" sector is defined as a sector in which the frequency of producer price adjustment is below the median of all 4-digit sectors. The instruments are constructed by estimating regression of the type $X_{kt} = \beta_0 + \sum_k \beta_{1k} D_x \times Z_t + \epsilon_{kt}$ where $X_{kt} \in (f_{kt}, \pi_{kt})$, Z_t denotes one of the exogenous shocks, and instrumentation uses predicted $\hat{X}_{kt}$.

time, our exercise shows that targeting a standard inflation index results in central banks having to deal with seemingly large and volatile cost-push shocks as interpreted through the lens of an aggregate Phillips curve. Second, our optimal monetary and fiscal policy mix naturally prescribes a mild cyclicality of aggregate government demand, a feature observed in U.S. data and often interpreted as fiscal policy *not* playing a stabilization role. We show that it does, just not at the aggregate but rather at the disaggregated level.

5.1 Calibration

The model is monthly, so $\beta = 0.997$. The inverse-Frisch elasticity is set at $\varphi = 4$, as in Chetty et al. (2011). Steady-state government total demand as share of GDP is $\chi = 18.5\%$ as in Cox et al. (2024). The persistence of productivity shocks is $\rho = 0.85$. For steady-state sectoral shares of private consumption, we calculate the sectoral value-added shares using the "Use Table" from the Bureau of Economic Analysis (BEA) Input-Output accounts. Specifically, we calculate the average share for 121 NAICS 4-digit sectors between 2007 and 2012—the years in which the input-output table is available at its most disaggregated level. Sectoral shares of government demand are calculated as the share of government procurement contracts allocated to each NAICS 4-digit sector, also an annual average across 2007 and 2012 to match private consumption shares. The government procurement data come from USASpending.gov. Lastly, to calculate the sectoral degree of nominal price rigidity, we utilize the frequency of producer price changes derived from the micro data that underlie the construction of the Producer Price Index (PPI) by the Bureau of Labor Statistics (BLS), as in Pastén et al. (2020, 2024).

5.2 Divine coincidence

A well-established result is that time-consistent optimal monetary policy to deal with productivity shocks in disaggregated economies deviates from targeting zero inflation. If sectors are all identical and productivity shocks are aggregate, such that the modelling a multi-sector economy is immaterial, monetary policy can achieve the first best by targeting on zero inflation as it also closes the aggregate output gap – the so-called "divine coincidence". However, this result does not hold when either sectors respond differently to aggregate shocks, for instance because of heterogeneous degrees of nominal price rigidity, and/or if productivity shocks are idiosyncratic. Optimal monetary policy does not attain the first best, and to close the aggregate output gap it needs to target a modified aggregate inflation index that gives more weight to sectors with stickier prices.

When revisiting these results in a disaggregated economy in which monetary policy is coupled to sectoral fiscal policy, our analysis recovers divine coincidence in the sense that inflation targeting is *quantitatively* approximately optimal for our model calibration to the U.S. economy. To establish this result, our analysis runs simulations for four alternative policy schemes under four alternative parametrizations, shown in Table 3 by combinations of columns (policy schemes) and rows (parametrizations). The baseline exercise is shown in column (1) and the first row in each block of Table 3. Here, we assume jointly optimal monetary and sectoral fiscal policy, as prescribed in equations (3.32) and (3.33), under a parameterization that sets the sectoral frequency of price changes and the sectoral composition of private and government demand consistent with U.S. data.

Column (2) assumes optimal monetary policy consistent with equation (3.33), whereas sectoral fiscal policy is "passive", that is, $\tilde{f}_{kt} = 0$ for any k. Column (3) assumes monetary policy targets zero-inflation, whereas sectoral fiscal policy is consistent with equation (3.32). Finally, column (4) assumes monetary policy targets zero inflation, whereas $\tilde{f}_{kt} = 0$ for any k. Each policy scheme is evaluated under the baseline parameterization—shown in the first row of each block in Table 3—and three alternative parameterizations. In the second row of each block, we assume an equal sectoral composition of public and private demands in steady state; in the third row, we assume an identical frequency of price changes for all sectors; and in the fourth row, we assume both. These alternative parameterizations allow us to study which of the sectoral features that we allow to vary across sectors are most relevant.

Table 3 and all following tables report *"variance multipliers"*, which map the variance of shocks into the variance of the respective variable. Thus, for instance, if the variance multiplier of endogenous variable X_t is one, then its variance equal that of productivity shocks, which are assumed the same for all sectors.

The main takeaway in Table 3 is that the optimal monetary and sectoral fiscal policies approximately recover divine coincidence. We start, in the first block of Table 3, reporting the variance multiplier of aggregate inflation and the aggregate output gap. Column (1) reports that, under the optimal policy mix, the variance multiplier of aggregate inflation is 0.14% and of the output gap is 0.35%. In words, as stressed in Section 3.1, the optimal mix of monetary and sectoral fiscal policies does not attain the first best.

In turn, if sectoral fiscal policy is passive ($\tilde{f}_{kt} = 0$), first row in column (2), the optimal monetary policy closes the aggregate output gap. Notice this result holds

Table 3: Variance Multipliers and Welfare Loss of Sectoral Productivity Shocks

	(1)	(2)	(3)	(4)
Policy mix:	$i_t^*, \tilde{f}_{kt}^*$	$i_t^*, \tilde{f}_{kt} = 0$	$\pi_t = 0, \tilde{f}_{kt}^*$	$\pi_t = 0, \tilde{f}_{kt} = 0$
Variance of aggregate inflation and output gap, $var(\pi_t), var(\tilde{y}_t)$				
(a) $\alpha_k, \omega_{ck}, \omega_{gk}$	0.14%, 0.35%	0.35%, 0%	0%, 1.7%	0%, 7.8%
(b) $\alpha_k, \omega_{gk} = \omega_{ck}$	0.08%, 0.21%	0.33%, 0%	0%, 0.81%	0%, 4.4%
(c) $\alpha_k = \bar{\alpha}, \omega_{ck}, \omega_{gk}$	0%, 0%	0.16%, 0%	0%, 0.07%	0%, 0.95%
(d) $\alpha_k = \bar{\alpha}, \omega_{gk} = \omega_{ck}$	0%, 0%	0%, 0%	0%, 0%	0%, 0%
Average variance of sectoral inflation and output gaps, $\overline{var(\pi_{kt})}, \overline{var(\tilde{y}_{kt})}$				
(a) $\alpha_k, \omega_{ck}, \omega_{gk}$	14.6%, 53.9%	17.9%, 117%	14.5%, 55.8%	17.7%, 127%
(b) $\alpha_k, \omega_{gk} = \omega_{ck}$	9.1%, 16.1%	17.9%, 116%	9.0%, 16.7%	17.5%, 120%
(c) $\alpha_k = \bar{\alpha}, \omega_{ck}, \omega_{gk}$	11.3%, 25.7%	13.2%, 78.6%	8.8%, 35.2%	13.1%, 77.6%
(d) $\alpha_k = \bar{\alpha}, \omega_{gk} = \omega_{ck}$	5.1%, 4.2%	12.5%, 74.5%	5.1%, 4.2%	12.5%, 74.5%
Per-period welfare loss				
(a) $\alpha_k, \omega_{ck}, \omega_{gk}$	2.8	4.7	3.1	6.3
(b) $\alpha_k, \omega_{gk} = \omega_{ck}$	2.8	4.4	2.9	4.6
(c) $\alpha_k = \bar{\alpha}, \omega_{ck}, \omega_{gk}$	2.2	4.3	2.5	4.5
(d) $\alpha_k = \bar{\alpha}, \omega_{gk} = \omega_{ck}$	2.8	3.4	2.8	3.4

Note: This table reports variance multipliers of aggregate inflation and output gap (first block), the simple average of variance multipliers of sectoral inflation and output gap (middle block) and per-period welfare (bottom block). Columns report results for four alternative policy schemes: (1) optimal monetary and sectoral fiscal policies mix, (2) optimal monetary policy and passive sectoral fiscal policy, (3) zero-inflation targeting and optimal sectoral fiscal policy and (4) zero-inflation targeting and passive sectoral fiscal policy. Rows in each block report results four alternative calibrations: (a) baseline calibration with Calvo parameters matching the sectoral average frequency of price changes in U.S. data and steady-state sectoral composition of private and public demand match U.S. data, (b) when only Calvo parameters match sectoral frequency of price changes in U.S. data and equal sectoral compositions of private and public demand are assumed, (c) when Calvo parameters match the overall average of frequency of price changes in U.S. data and steady-state sectoral composition of private and public demand match U.S. data, and (d) when when Calvo parameters match the overall average of frequency of price changes in U.S. data and equal sectoral compositions of private and public demand are assumed.

even when the aggregate output gap does not explicitly enter in sectoral marginal costs. To do so, monetary policy targets the modified aggregate inflation index in equation (3.30) such that aggregate inflation has a variance multiplier of 0.35%. The first row in column (3) reports that an optimal sectoral fiscal policy coupled with zero-inflation targeting yields a variance multiplier of the aggregate output gap of 1.7% – higher than the 0.35% reported in the first row of column (1). Finally, comparing the first row of columns (3) and (4) shows that optimal sectoral fiscal policy contributes to decreasing the variance multiplier of the aggregate output gap under zero-inflation monetary policy: if fiscal policy is passive, the variance multiplier of the aggregate output gap is 7.8%.

The first row of the second block of Table 3 reports the simple mean of the variance multipliers of sectoral inflation and output gaps under our baseline calibration. Unsurprisingly, the joint optimal monetary and fiscal policy setup, in column (1), is the one that delivers the lowest mean of the sectoral variance multipliers, 14.6% and 53.9% for sectoral inflation and output gaps, respectively. What is perhaps more surprising is that, under the optimal sectoral fiscal policy, zero-inflation targeting in column (3) gets very close, respectively to 14.5% and 55.8%. We confirm this result when computing per-period welfare losses, shown in the third block of the Table. Welfare losses are 2.8% for the optimal mix of monetary and fiscal policy—column (1)–and 3.1% for zero-inflation monetary policy and optimal fiscal policy—column (3). Still focusing on the baseline calibration (first row), columns (2) and (4) of the second and third blocks, show that a passive sectoral fiscal policy has a strong effect on the volatility of sectoral inflation and sectoral output gaps regardless of whether monetary policy is acting optimally in column (2) or targeting zero inflation in column (4).

Looking at alternative parameterizations reported in rows 2-4 in all blocks of Table 3, results indicate that sectoral bias in the steady-state composition of private and government demand has a stronger impact on the welfare loss than heterogeneous frequency of price changes across sector.

5.3 Cost-push shocks

As stressed by Rubbo (2023) in the context of production networks with no fiscal policy, the aggregation of sectoral Phillips curves yields an additional term akin to an aggregate cost-push shock even when with only productivity shocks at the sectoral level. Although our economy does not have input-output linkages, qualitatively, the same result arises when any source of sectoral heterogeneity makes aggregation not trivial – input-output linkages is one of them, but a similar result arises from nominal price rigidities and the unequal composition of private and government demand. We now explore the implications of optimal sectoral fiscal policy over this "aggregate cost-push shock" when monetary policy is optimally set versus when it follows zero-inflation targeting.

Aggregating the sectoral Phillips curves in equation (2.23) using equations (2.27), (2.28) and (2.29), and defining $\bar{\lambda} = \sum_{k=1}^{K} \omega_{ck} \lambda_k$ yields:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \bar{\lambda} \left[(1-\varphi) \tilde{y}_t - \chi^* \tilde{f}_t \right] + u_t,$$

where $u_t \equiv \sum_{k'=1}^{K} \omega_{ck'} \lambda_{k'} \left[(1-\varphi) \tilde{y}_{k't} - \chi^*_{k'} \tilde{f}_{k't} \right] - \bar{\lambda} \left[(1-\varphi) \tilde{y}_t - \chi^* \tilde{f}_t \right]$. Table 4 reports the variance multiplier of u_t for all four monetary and sectoral fiscal policies mixes we report in Table 3, as well as all four alternatives for the setup of sectoral nominal price rigidity and the sectoral composition of private and public demand.

When all sectors are symmetric, the aggregate cost push shock is trivially zero, as reported in the last row of Table 4 and can be verified in the definition of u_t above. When the only source of sectoral heterogeneity is the sectoral composition of private and public demand, reported in the third row of Table 4, the aggregate cost push shock is almost zero for all policy mixes we analyze. Thus, although it theoretically can generate a so called "aggregate cost push shock" u_t, the sectoral composition of private and public demand, alone, has little quantitative force. In turn, when sectors only differ in their degree of nominal rigidity, reported in the second row of Table 4, the aggregate cost-push shock becomes somewhat stronger.

We report the main result in this subsection in the first row of Table 4. When both sources of sectoral heterogeneity are present, the variance multiplier of u_t is the largest. This reflects a reinforcing effect between the two sources of sectoral heterogeneity we consider, nominal price rigidity and the composition of public and private demands. The first row of Table 4 shows that optimal monetary policy has a strong effect on reducing the variance multiplier of u_t relative to a zero-inflation policy – compare columns (1) and (2) with columns (3) and (4). In turn, the optimal

Table 4: Variance Multiplier of Aggregate Cost-Push Shock

	(1)	(2)	(3)	(4)
Policy mix:	$i_t^*, \tilde{f}_{kt}^*$	$i_t^*, \tilde{f}_{kt} = 0$	$\pi_t = 0, \tilde{f}_{kt}^*$	$\pi_t = 0, \tilde{f}_{kt} = 0$
(a) $\alpha_k, \omega_{ck}, \omega_{gk}$	0.35%	0.14%	0.89%	7.1%
(b) $\alpha_k, \omega_{gk} = \omega_{ck}$	0.08%	0.07%	0.12%	3.3%
(c) $\alpha_k = \bar{\alpha}, \omega_{ck}, \omega_{gk}$	0%	0.03%	0%	0.03%
(d) $\alpha_k = \bar{\alpha}, \omega_{gk} = \omega_{ck}$	0%	0%	0%	0%

Note: This table reports the variance multiplier of an aggregate cost-push shock u_t. Columns report results for four alternative policy schemes: (1) optimal monetary and sectoral fiscal policies mix, (2) optimal monetary policy and passive sectoral fiscal policy, (3) zero-inflation targeting and optimal sectoral fiscal policy and (4) zero-inflation targeting and passive sectoral fiscal policy. Rows report results four alternative calibrations: (a) baseline calibration with Calvo parameters matching the sectoral average frequency of price changes in U.S. data and steady-state sectoral composition of private and public demand match U.S. data, (b) when only Calvo parameters match sectoral frequency of price changes in U.S. data and equal sectoral compositions of private and public demand are assumed, (c) when Calvo parameters match the overall average of frequency of price changes in U.S. data and steady-state sectoral composition of private and public demand match U.S. data, and (d) when when Calvo parameters match the overall average of frequency of price changes in U.S. data and equal sectoral compositions of private and public demand are assumed.

sectoral fiscal policy increases the variance multiplier of u_t when monetary policy is optimal – compare first row, columns (1) and (2) – but reduces the variance multiplier of u_t for a zero-inflation monetary policy – compare first row, columns (3) and (4).

5.4 Cyclicality of aggregate government spending

Finally, our analysis offers a new perspective on the cyclicality of aggregate government demand. In doing so, we also compare the implications of the optimal monetary and sectoral fiscal policy mix to the implications of a zero-inflation monetary policy and optimal sectoral fiscal policy.

A well-documented fact is that government spending is largely acyclical in advanced economies (see, for instance, Talvi and Vegh (2005)). In contrast, the basic theory of the optimal provision of public goods, as pioneered by Samuelson (1954), implies pro-cyclicality by equalizing the marginal willingness to pay for the public good and its marginal rate of transformation. In our setup, with additive separability in preferences between consumption, leisure and public goods as well as lump-sum taxation, the optimal provision of sectoral public goods in the first best is a fixed proportion of sectoral output, and thus, indeed, perfect pro-cyclicality at the sectoral level arises. Yet, in our fully calibrated baseline model, the correlation between aggregate output and government demand is lower, 0.62, when both monetary and sectoral fiscal policies are optimal and 0.43 when monetary policy targets zero inflation and sectoral fiscal policy is optimal. The following discussion highlights the key features that generate such mild aggregate cyclicality despite the perfect pro-cyclicality at the sectoral level in the first best.

Two ingredients are key for this pattern: the unequal composition of aggregate output and government demand, and the stabilizing role of disaggregated fiscal policy. Under the optimal monetary and fiscal policy mix, government demand must satisfy the condition in equation (3.34) which, for convenience, we reproduce here after some algebra to facilitate the discussion:

$$\sum_{k=1}^{K} \mu_k g_{kt} = \sum_{k=1}^{K} \mu_k \bar{g}_{kt},$$

where g_{kt} and $\bar{g}_{kt}$ denote actual and first-best sectoral government demand, and $[\mu_k]_{k=1}^K$ are steady-state sectoral shares of aggregate output. This result stems from the optimal separation between monetary policy and fiscal policy as aggregate and disaggregated stabilizers, respectively. Note that, in general, the log-linear approximation of aggregate government demand weights sectors by its steady-state sectoral composition denoted by $[\omega_{gk}]_{k=1}^K$. If the sectoral composition of private and public demand are the same, then $\mu_k = \omega_{gk}$ for all k. As the Samuelson (1954) rule implies in our setup that $\bar{g}_{kt} = \bar{y}_{kt}$, that is, perfect sectoral pro-cyclicality in the first best, and output aggregates sectors by $[\mu_k]_{k=1}^K$. Aggregate government demand in this case is perfectly correlated with first-best aggregate output.

However, if $\mu_k \neq \omega_{gk}$, this correlation between aggregate government demand and first-best output can be lower, amounting to 0.73 in our baseline calibration – which accounts for the long-run sectoral composition of private and public demand in the U.S.. Then, the correlation with actual output can be even lower depending on the optimal sectoral fiscal policy rule in equation (3.32), also reproduced here after some algebra as follows:

$$g_{kt} = \bar{g}_{kt} - \frac{\varphi}{1+(1+\varphi)\lambda_k}\tilde{y}_{kt} - \frac{\theta(1-\chi_k^*)}{1+(1+\varphi)\lambda_k}\pi_{kt},$$

where $\tilde{y}_{kt}$ denotes the sectoral output gap, π_{kt} denotes sectoral inflation and $\lambda_k \equiv (1-\alpha_k)(1-\beta\alpha_k)/\alpha_k$ is decreasing in Calvo parameters α_k. In the U.S., aggregate government demand is tilted to stickier sectors relative to private demand (Cox et al., 2024). Hence, aggregate government demand puts higher weight than aggregate output to sectors in which fiscal policy has on average larger deviations from the first best. In turn, those are also the sectors in which idiosyncratic productivity shocks yield larger output gaps. As a result, the correlation of aggregate output and government demand is 0.62 in our baseline calibration.

If instead monetary policy targets zero inflation, this correlation is 0.43 in the baseline calibration, because in this case the optimal sectoral fiscal rule implies even larger deviations of government demand at the sectoral level as well as larger volatility of the aggregate output gap. This effect further lowers the correlation between output and government demand. A perhaps interesting observation is that, in contrast to results under the optimal policy mix, here, the unequal composition of private and government demand and the sectoral heterogeneity in nominal price rigidity do not reinforce each other in lowering aggregate pro-cyclicality. In our numerical exercises, if we assume $\mu_k = \omega_{gk}$ and calibrate sectoral Calvo parameters to match the average sectoral frequency of price changes in the U.S., the correlation of aggregate government demand with aggregate output only is 0.20.

These mechanisms do not fully explain the acyclicality observed in U.S. data: The correlation between GDP and aggregate real purchases of the federal U.S. government, based on our procurement data, both at quarterly frequency, in logs, detrended and seasonally adjusted, is -0.05; likewise, the correlation of GDP with Government Consumption Expenditures and Gross Investment, both obtained from National Income and Product Accounts (NIPA) is 0.19 for the longest sample available, for 1947 to 2023. Still, the pro-cyclicality we obtain is quite mild considering the perfect pro-cyclicality at the sectoral level in the first best. This perfect pro-cyclicality also holds at the aggregate level when prices are sticky and monetary policy is optimal if all sectors are identical, a corollary of divine coincidence. Hence, disaggregated stabilization is key for aggregate fiscal policy to align theory and data.

6 Conclusion

A common recommendation for monetary policy when shocks are disaggregated and/or sectors are heterogeneous is to target an inflation index that gives higher weight to sectors with larger deviations from efficient output. We revisit this conclusion when sectoral government demand is used as a stabilization tool in a conventional multi-sector New Keynesian model, deriving several new insights.

The optimal mix of monetary and fiscal policy takes a simple form: monetary policy takes care of aggregate stabilization, whereas sectoral fiscal policy focuses on sectors. Specifically, we derive an optimal fiscal rule which characterizes optimal sectoral government spending. Optimal monetary policy deviates from a zero-inflation target, and both monetary and sectoral fiscal policy give higher weight to sectors in which a given shock yields larger deviations of output from efficient levels. However, numerical exercises show that the deviation of optimal monetary policy from a zero-inflation target is quantitatively small relative to a case when monetary policy is the only stabilization tool. In line with our optimal fiscal rule, we find that the relationship of sectoral government demand, sectoral inflation and sectoral output implied by the model is broadly confirmed in the U.S. data.

Finally, we show that aggregation of sectoral Phillips curves yields an extra term akin to an aggregate cost-push shock that is much more volatile under monetary policy targeting zero inflation than under its an optimal rule. We also show that a mild cyclicality of aggregate government demand is not inconsistent with the optimality of fiscal policy playing a stabilization role; it just does so at a disaggregated level. Future work may be able to fine-tune the alignment of the model predictions with the data, for example by incorporating the role of the zero-lower bound for monetary policy or by incorporating alternative taxation schemes relative to the lump-sum taxes in our analysis.

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Online Appendix: Optimal Monetary and Fiscal Policies in Disaggregated Economies

Lydia Cox, Jiacheng
Feng, Gernot J. Müller, Ernesto Pastén, Raphael Schoenle, and Michael Weber

July 2024

A Steady-State Solution

We focus on a symmetric steady state at the firm level with all firms setting the same prices $P_k(j) = P$. Then, from equations in (2.6), $P_k = P_c = P$. Further, using the convention that $A_k = 1$, the optimal pricing rule is such that

$$P = \frac{\theta}{\theta - 1} MC_k^n = W_k$$

once we impose the proper subsidy τ_k to offset markups in the steady state. This result implies that sectoral wages should be all equal in the steady state, which is confirmed by the household's first order condition on leisure in (2.7) after imposing $\nu_k = \mu_k^{-\varphi}$ since W_k only relates to aggregate variables. These two latter results together with (2.16) yield

$$C = 1 - \chi$$

such that (2.5) solves $C_k = \omega_{ck}(1 - \chi)$. As (2.16) implies $Y = 1$, the aggregation of (2.13) implies $G = \chi$. Further, the efficient allocation in (2.15) implies $G_k = \omega_{gk}\chi)$. Finally, constant consumption and prices imply from (2.3) that $I = \beta^{-1}$.

B Welfare function

Per-period household utility is given by

$$U_t \equiv (1 - \chi) \log C_t + \chi \log G_t - \sum_k \frac{N_{kt}^{1+\varphi}}{1 + \varphi}.$$

In the following we obtain second-order expansions for all its components. First, putting together the flow utility function of consumption with the Cobb-Douglas aggregator of sectoral consumption yields

$$\log C_t = \sum \omega_{ck} \log C_{kt}$$

Since χ_k may be interpreted as the optimal share of sectoral real public consumption on sectoral production, the second-order Taylor expansion of the flow utility of consumption is[9]

$$\log C_{kt} = \log(Y_{kt} - G_{kt}) \simeq \log\left[(1-\chi_k)Y_k\right] + \frac{1}{1-\chi_k}(\hat{y}_{kt} - \chi_k \hat{g}_{kt}) - \frac{1}{2}\frac{\chi_k}{(1-\chi_k)^2}(\hat{g}_{kt} - \hat{y}_{kt})^2.$$

Using definitions $\tilde{y}_{kt} = y_{kt} - \bar{y}_{kt}$ and $\tilde{g}_{kt} = g_{kt} - \bar{g}_{kt}$, yields that $\hat{g}_{kt} - \hat{y}_{kt} = (\tilde{g}_{kt} - \tilde{y}_{kt}) + (\bar{g}_{kt} - \bar{y}_{kt}) - (g_k - y_k) = \tilde{g}_{kt} - \tilde{y}_{kt}$ yields

$$\log C_{kt} \simeq \frac{1}{1-\chi_k}(\hat{y}_{kt} - \chi_k \hat{g}_{kt}) - \frac{1}{2}\frac{\chi_k}{(1-\chi_k)^2}(\tilde{g}_{kt} - \tilde{y}_{kt})^2 + t.i.p.$$

where the $t.i.p.$ are constants and third order and above terms that are ignored in the Taylor expansion. Aggregating across C_{kt},

$$\log C_t \simeq \sum_k \omega_{ck}\left(\frac{1}{1-\chi}(\hat{y}_{kt} - \chi_k \hat{g}_{kt}) - \frac{1}{2}\frac{\chi_k}{(1-\chi_k)^2}(\tilde{g}_{kt} - \tilde{y}_{kt})^2\right) + t.i.p. \tag{B.35}$$

Second, for public consumption, the second order Taylor expansion is

$$\log G_{kt} \simeq \log G_k + (\hat{g}_{kt} + \frac{1}{2}\hat{g}_{kt}^2) - \frac{1}{2}\hat{g}_{kt}^2 = \hat{g}_{kt} + t.i.p.$$

$$\log G_t \simeq \sum_k \omega_{gk}\hat{g}_{kt} + t.i.p. \tag{B.36}$$

Third, to obtain the second-order expansion of disutility of labor, we start from disutility in each sector

$$\frac{\nu_k N_{kt}^{1+\varphi}}{1+\varphi} \simeq \mu_k\left[\hat{n}_{kt} + \frac{1}{2}(1+\varphi)\hat{n}_{kt}^2\right] + t.i.p.$$

where working hours in sector k is the aggregation across all firms in set J_k

$$N_{kt} = \int_{j\in J_k} N_{kt}(j)dj = \frac{1}{A_{kt}}\int_{j\in J_k}\left[C_{kt}(j) + G_{kt}(j)\right]dj = \frac{C_{kt}}{A_{kt}}\int_{j\in J_k}\left(\frac{P_{kt}(j)}{P_{kt}}\right)^{-\theta} dj + \frac{G_{kt}}{A_{kt}}$$

which log-linearization is

$$\hat{n}_{kt} \simeq \hat{y}_{kt} - a_{kt} + (1-\chi_k)z_{kt} = \tilde{y}_{kt} + (1-\chi_k)z_{kt}$$

[9] Here, we use $\hat{x}_{kt} = \log\frac{X_{kt}}{X_k} \simeq \frac{X_{kt}-X_k}{X_k} - \frac{1}{2}\left(\frac{X_{kt}-X_k}{X_k}\right)^2 \simeq \frac{X_{kt}-X_k}{X_k} - \frac{1}{2}\hat{x}_{kt}^2$

for $Z_{kt} = \int_{j \in J_k} \left(\frac{P_{kt}(j)}{P_{kt}}\right)^{-\theta} dj$ such that $z_{kt} = \log Z_{kt} \simeq \frac{\theta}{2} var\{p_{kt}(j)\}$ is a second order term around a steady state with zero inflation. Then, since $z_{kt}^2 \simeq 0$ and $\mu_k = N_k/N = Y_k/Y = (1-\chi)\omega_{ck} + \chi\omega_{gk}$,

$$\sum_k \frac{\nu_k N_{kt}^{1+\varphi}}{1+\varphi} \simeq \sum_k [(1-\chi)\omega_{ck} + \chi\omega_{gk}] \left(\tilde{y}_{kt} + (1-\chi_k) z_{kt} + \frac{1}{2}(1+\varphi)\tilde{y}_{kt}^2\right) + t.i.p. \tag{B.37}$$

Using (B.35), (B.36) and (B.37), the per-period utility can be written as

$$\begin{aligned} U_t = &(1-\chi)\log C_t + \chi \log G_t - \sum_k \frac{\nu_k N_{kt}^{1+\varphi}}{1+\varphi} \\ \simeq &(1-\chi)\sum_k \omega_{ck}\left(\frac{1}{1-\chi_k}(\hat{y}_{kt} - \chi_k \hat{g}_{kt}) - \frac{1}{2}\frac{\chi_k}{(1-\chi_k)^2}(\tilde{g}_{kt} - \tilde{y}_{kt})^2\right) \\ &+ \chi \sum_k \omega_{gk}\hat{g}_{kt} - \sum_k \left[(1-\chi)\omega_{ck} + \chi\omega_{gk}\right] \left(\tilde{y}_{kt} + (1-\chi_k)z_{kt} + \frac{1}{2}(1+\varphi)\tilde{y}_{kt}^2\right) + t.i.p. \end{aligned}$$

Since $(1-\chi)\omega_{ck}\frac{\chi_k}{1-\chi_k} = \chi\omega_{gk}$, the terms $\hat{g}_{kt}$ cancels out in the utility. Furthermore, since $(1-\chi)\omega_{ck}\frac{1}{1-\chi_k} = \chi\omega_{gk} + (1-\chi)\omega_{ck}$, $\hat{y}_{kt}$ cancels with $\tilde{y}_{kt}$, as their difference is the exogenous productivity shock a_{kt}, so it goes in t.i.p. Simplifying the equation, writing $\tilde{g}_{kt} - \tilde{y}_{kt}$ as the fiscal gap, using $\mu_k = (1-\chi)\omega_{ck} + \chi\omega_{gk}$ and plugging in $\sum_t \beta^t z_{kt} = \sum_t \beta^t \frac{\theta}{\lambda_k}(\pi_{kt})^2$ from Woodford (2001),

$$\mathbb{W}_t = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U_t \simeq -\frac{1}{2}\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \sum_k \mu_k \left(\frac{\theta(1-\chi_k)}{\lambda_k}\pi_{kt}^2 + (1+\varphi)\tilde{y}_{kt}^2 + \chi_k^* \tilde{f}_{kt}^2\right) + t.i.p.$$

C Solution for Time-Consistent Optimal Policy

The system of first order conditions is characterized by

$$\frac{\theta(1-\chi_k)}{\lambda_k}\pi_{kt} + \phi_{kt}^{\pi} + \phi_{kt}^{p} = 0 \tag{C.38}$$

$$(1+\varphi)\tilde{y}_{kt} - (1+\varphi)\lambda_k\phi_{kt}^{\pi} + \phi_{kt}^{y} - \nu_{yt} - \frac{\omega_{gk}}{\mu_k}\nu_{ft} = 0 \tag{C.39}$$

$$\tilde{f}_{kt} + \lambda_k\phi_{kt}^{\pi} - \phi_{kt}^{y} - (\chi^*)^{-1}\frac{\omega_{gk}}{\mu_k}\nu_{ft} = 0 \tag{C.40}$$

$$\phi^p_{kt} = \phi^y_{kt} + \frac{\omega_{ck}}{\mu_k}\nu_{\pi t} \tag{C.41}$$

$$\nu_{pt} = \sum_{k=1}^{K} \mu_k \phi^y_{kt} \tag{C.42}$$

$$\nu_{yt} + \nu_{ft} = \sum_{k=1}^{K} \mu_k \phi^y_{kt} \tag{C.43}$$

$$(\chi^*)^{-1}\nu_{ft} = -\sum_{k=1}^{K} \mu_k \phi^y_{kt} \tag{C.44}$$

Combining (C.42), (C.43) and (C.44) yields

$$\nu_{\pi t} = (1-\chi)\nu_{yt} = -\chi^{*-1}\nu_{ft} = -(1-\chi)\nu_{pt}.$$

Using these expressions in (C.38), (C.39), (C.40) and plugging (C.41) in, we obtain a simplified system of first-order conditions:

$$\frac{\theta(1-\chi_k)}{\lambda_k}\pi_{kt} + \phi^\pi_{kt} + \phi^y_{kt} - (1-\chi_k)\nu_{yt} = 0 \tag{C.45}$$

$$(1+\varphi)\tilde{y}_{kt} - (1+\varphi)\lambda_k\phi^\pi_{kt} + \phi^y_{kt} - (1-\chi_k)\nu_{yt} = 0 \tag{C.46}$$

$$\tilde{f}_{kt} + \lambda_k\phi^\pi_{kt} - \phi^y_{kt} + (1-\chi_k)\nu_{yt} = 0 \tag{C.47}$$

$$(1-\chi_k)\nu_{yt} = \sum_{k=1}^{K} \mu_k \phi^y_{kt} \tag{C.48}$$

Optimal fiscal policy. Start by mixing (C.45) and (C.46) to obtain

$$\phi^\pi_{kt} = \frac{1+\varphi}{1+(1+\varphi)\lambda_k}\tilde{y}_{kt} - \frac{\theta/\lambda_k}{1+(1+\varphi)\lambda_k}\pi_{kt}$$

Now sum equation (C.46) and (C.47) up to obtain

$$\varphi\lambda_k\phi^\pi_{kt} = (1+\varphi)\tilde{y}_{kt} + \tilde{f}_{kt}$$

and combining these two expressions yield (3.32) which describes the equilibrum relationship between sectoral fiscal gap, sectoral output gap and inflation under the optimal policy labelled as "optimal sectoral fiscal policy".

Optimal monetary policy. Take the solution for ϕ^π_{kt} obtained above and plug it in (C.46) and use (C.48) to obtain equation (3.33) which describes an aggregate relationship under optimal policy between sectoral output gaps and sectoral inflation labelled as "optimal monetary policy".

Optimal aggregate fiscal policy. Equation (3.34) can be obtained by replacing sectoral inflation in (3.33) by using (3.32).

D Feasibility of a Fiscal Divine Coincidence

The key in this analysis is to relax the assumption that the fiscal rule in the frictionless economy is optimal. Deflated marginal costs are given by

$$\begin{aligned} mc_{kt} - p_{kt} &= c_t + p_t + \varphi(y_{kt} - a_{kt}) - a_{kt} - p_{kt} \\ mc_{kt} - p_{kt} &= c_{kt} + \varphi y_{kt} - (1+\varphi)a_{kt} - p_{kt} \\ mc_{kt} - p_{kt} &= \frac{1+\varphi(1-\chi_k)}{1-\chi_k} y_{kt} - \frac{\chi_k}{1-\chi_k} g_{kt} - (1+\varphi)a_{kt} \end{aligned}$$

after using that $c_{kt} = (y_{kt} - \chi_k g_{kt})/(1-\chi_k)$. Define y^n_{kt} as the log-deviations of output in a frictionless economy from steady state for an arbitrary sectoral fiscal rule g_{kt}. Setting $mc_{kt} = p_{kt}$ yields

$$y^n_{kt} = \frac{\chi_k g_{kt} + (1+\varphi)(1-\chi_k)a_{kt}}{1+\varphi(1-\chi_k)} \tag{D.49}$$

such that $y^n_{kt} = \bar{y}_{kt} = a_{kt}$ if $g_{kt} = \bar{g}_{kt} = a_{kt}$. Plugging (D.49) in deflated marginal costs yields

$$mc_{kt} - p_{kt} = \frac{1+\varphi(1-\chi_k)}{1-\chi_k}(y_{kt} - y^n_{kt})$$

such that $\pi_{kt} = 0$ if $y_{kt} = y^n_{kt}$. The last piece is the solution of y_{kt} in (2.22) after assuming that $i_t = 0$ and $\pi_{kt} = 0$ for all k, t. After some algebra, equation (2.22) becomes

$$y_{kt} - \chi_k g_{kt} = \mathbb{E}_t(y_{kt} - \chi_k g_{kt})$$

which solves $y_{kt} = y^n_{kt}$ if $\chi_k g_{kt} = y^n_{kt}$. Using (D.49), this is equivalent to: $g_{kt} = \frac{1+\varphi}{\varphi\chi_k} a_{kt}$. This sectoral fiscal rule closes the output gap, that is, output is equal to its flex price level, and at the same time inflation is stabilized. Yet the flex price level of sectoral output is not efficient because government demand deviates from the Samuelson rule which calls for government spending to be adjusted one-for-one with productivity, see Section 2.2.The same results hold for an aggregate economy if $K = 1$. See also the discussion in Woodford (2011).