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Resolving the Fiscal Price Puzzle: General Equilibrium Effects and the Composition of Government Spending

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Abstract

Does government spending raise prices? While standard models predict an inflationary effect, empirical findings are mixed—a puzzle known as the "fiscal price puzzle." We argue that this puzzle reflects differences in aggregation rather than a failure of standard demand transmission. Using newly constructed U.S. MSA-level federal procurement data from 1989–2023 and a shift-share IV strategy, we show that regional fiscal shocks raise local consumer prices when aggregate forces are absorbed through time fixed effects. When aggregate conditions are allowed to respond endogenously, however, the same shocks generate attenuated or even negative price responses. To interpret these findings, we develop a two-region New Keynesian model with centralized monetary policy. Local fiscal expansions increase regional prices but induce union-wide monetary responses that dampen aggregate inflation. Extending the model to consumption and investment sectors, we show that government consumption shocks raise regional and sectoral prices more than investment shocks, yet can produce smaller aggregate price effects due to stronger monetary feedback. Our results highlight how general equilibrium mechanisms and spending composition jointly shape fiscal inflation dynamics.

JEL Classification: E31; E52; E58; E62; F33

Keywords: Fiscal price puzzle; Government spending; Spending composition; Military procurement; Monetary union; Shift-share instrument

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1 Introduction

Does an increase in government spending raise prices? Standard macroeconomic models predict that expansionary fiscal policy should lift price levels by stimulating aggregate demand. Yet a large empirical literature reports mixed evidence: while some studies find inflationary effects, others document muted, zero, or even negative price responses to government spending shocks.[1] This discrepancy—recently termed the *fiscal price puzzle* by Jørgensen and Ravn (2022)—has drawn renewed attention following the unprecedented fiscal expansions during the COVID-19 pandemic, amid concerns that large-scale stimulus may ultimately fuel inflation (Blanchard, 2021; Edelberg and Sheiner, 2021). Understanding the price response to fiscal policy is therefore central to evaluating the consequences of government spending.

A key challenge in interpreting the evidence is that there is no single "price response" to fiscal policy. Estimates depend both on the price measure (e.g., CPI versus broader deflators) and on the level of aggregation at which fiscal shocks are identified. In particular, regional fiscal expansions can raise consumer prices in treated locations, while centralized monetary responses may compress demand and dampen—or even reverse—the union-wide price response. The fiscal price puzzle may therefore reflect an aggregation mismatch, rather than a failure of intrinsic demand transmission.

Recent work emphasizes several mechanisms that may reconcile the conflicting findings. Choi et al. (2022) show that the inflationary effects of government spending depend critically on monetary policy and financial conditions: fiscal expansions are inflationary in normal times but can become disinflationary at the zero lower bound or under

[1] For example, Edelberg et al. (1999), Caldara and Kamps (2008), Ben Zeev and Pappa (2017), Mumtaz and Theodoridis (2020), Ferrara et al. (2021), and Fritsche et al. (2021) find inflationary effects, whereas Fatás and Mihov (2001), Mountford and Uhlig (2009), Dupor and Li (2015), Ricco et al. (2016), d'Alessandro et al. (2019), Miyamoto et al. (2019), Choi et al. (2022), Jørgensen and Ravn (2022), and Hall and Thapar (2023) document disinflationary or deflationary responses. The fiscal price puzzle is also relevant to the puzzling response of real exchange rates to fiscal policy shocks, widely studied in open-economy macroeconomics (Monacelli and Perotti, 2010; Ravn et al., 2012; Kim, 2015; Ferrara et al., 2021; Klein and Linnemann, forthcoming). See Choi et al. (2022) and Jørgensen and Ravn (2022) for comprehensive reviews.

tight credit conditions. Klein and Linnemann (2023) demonstrate that price effects differ sharply between government consumption and investment, highlighting the importance of spending composition. Cox et al. (2024) emphasize sectoral composition, showing that spending concentrated in flexible-price sectors can be inflationary while shocks in sticky-price sectors can be disinflationary. On the theoretical side, Zubairy (2014) introduce deep habits in a medium-scale DSGE model to generate declining inflation following fiscal expansions; Abo-Zaid and Kamara (2020) emphasize credit constraints as a force dampening demand pressures; and Jørgensen and Ravn (2022) incorporate variable technology utilization to generate disinflationary fiscal effects.

In this paper, we revisit the fiscal price puzzle through a simpler and more transparent lens that emphasizes the interaction between spending composition and general equilibrium monetary feedback. Using U.S. metropolitan statistical area (MSA)-level data from 1989 to 2023, we study how localized fiscal impulses transmit to *consumer prices* and how those local effects map into aggregate price dynamics once monetary policy responds endogenously. To measure regional government purchases, we construct MSA-level government spending from contract-level federal military procurement data, and we further classify procurement into government consumption and government investment using product and service codes. Our price measure is the consumer price index (CPI), which is naturally interpreted as a consumption-price object. We assemble a (weakly) balanced panel of official BLS CPI levels for 21 large MSAs and combine these data with BEA regional income accounts.

Our empirical strategy exploits cross-regional heterogeneity in exposure to aggregate federal spending fluctuations. Specifically, we use shift-share (Bartik) instruments that interact national procurement innovations with regions' historical spending shares to isolate plausibly exogenous variation in regional spending. We estimate dynamic price responses using local projections in a panel instrumental-variables framework.

Our first main empirical finding is that regional government spending shocks raise local consumer prices in specifications with MSA and year fixed effects. With year fixed effects absorbing union-wide forces—including endogenous monetary policy—identification comes from within-year cross-sectional variation in fiscal exposure. The estimates therefore capture *relative* price movements: prices in more exposed MSAs rise relative to less exposed MSAs in the same year. The effects are stronger for core than for headline CPI.[2]

We then re-estimate the same local projections without year fixed effects, allowing aggregate conditions—including monetary policy—to adjust endogenously. Under this specification, price responses are substantially attenuated and even negative. This contrast provides a simple diagnostic of the fiscal price puzzle: union-wide policy feedback can offset local inflationary pressure, helping reconcile positive regional CPI responses with the disinflationary effects often found in aggregate time-series studies.

Our second main empirical finding concerns spending composition. Decomposing regional government purchases into consumption and investment components, we show that government consumption shocks are substantially more inflationary than government investment shocks in the relative regional (two-way fixed effects) specifications, particularly for core CPI. This heterogeneity suggests that the inflationary consequences of fiscal policy depend on the composition of spending and that failing to distinguish consumption from investment can contribute to the lack of consensus in the existing literature.

To provide a structural interpretation of these findings, we develop a New Keynesian DSGE model of a two-region monetary union, following Nakamura and Steinsson (2014). In the model, a fiscal expansion in one region raises local prices but induces an endogenous response of union-wide monetary policy that depresses demand and prices elsewhere. Because individual regions account for a small share of the monetary union, the aggregate price level can decline even when local prices rise. The model therefore ratio-

[2]We pay particular attention to core CPI because headline inflation is more exposed to large transitory price movements in food and energy, which can obscure underlying inflationary pressures relevant for monetary policy.

nalizes the key empirical distinction between relative regional price movements, which largely purge the common monetary component, and aggregate price dynamics, which are governed by monetary policy feedback.

We then extend the model to incorporate two production sectors—consumption goods and investment goods—building on Boehm (2020) and Koh (2025). This extension delivers a central implication: the inflationary ranking of fiscal instruments need not be invariant to the level of aggregation. Government consumption shocks generate stronger regional and sectoral inflationary pressures than investment shocks, which maps naturally into our empirical CPI results because CPI is a consumption-price object. Precisely because consumption shocks are more inflationary locally, however, they trigger more aggressive monetary response under a Taylor rule, compressing union-wide demand and weakening—and potentially reversing—the aggregate price response. In contrast, government investment shocks are less inflationary at the regional level and therefore elicit weaker monetary policy responses, resulting in larger aggregate price effects.

This mechanism reconciles seemingly conflicting evidence in the literature. Regional data suggest that government consumption is more inflationary in consumer prices, whereas aggregate time-series studies—including Klein and Linnemann (2023)—find a larger role for investment shocks in driving aggregate inflation. We show that this divergence can arise naturally in a standard New Keynesian monetary union with centralized monetary policy.

When policy follows a union-wide Taylor rule, instruments that generate stronger regional price pressures also induce stronger monetary responses. As a result, spending categories that are more inflationary locally need not be more inflationary in aggregate. This interaction between spending composition and centralized policy helps explain the coexistence of robust local demand transmission and the fiscal price puzzle, and highlights the importance of accounting for aggregation and spending type when evaluating fiscal inflation effects.

The remainder of the paper is organized as follows. Section 2 presents the empirical analysis, describing the identification strategy, data construction, and baseline results on regional price responses to government spending shocks, including the decomposition into consumption and investment components. Section 3 introduces a multi-region New Keynesian DSGE model of a monetary union and outlines the calibration. Section 4 uses the model to resolve the fiscal price puzzle by distinguishing relative regional price effects from aggregate general equilibrium outcomes and by analyzing the role of spending composition in shaping aggregate inflation. Section 5 concludes.

2 Empirical Analysis

This section estimates the effects of regional government spending shocks on regional price levels using panel instrumental variables local projections. We first quantify relative regional CPI responses using specifications with MSA and year fixed effects, and then re-estimate the same equations without year fixed effects to assess the role of aggregate general equilibrium feedback, especially monetary policy. We finally decompose spending into consumption and investment components to study heterogeneous price effects (Klein and Linnemann, 2023).

2.1 Methodology

We estimate dynamic price responses using local projections in a panel setting. Let $P_{i,t}$ denote the price level in metropolitan statistical area (MSA) i at time t. We consider cumulative changes in prices from $t-1$ to $t+h$ in response to cumulative changes in regional government spending scaled by lagged local income. Using cumulative h-period changes on both sides, we estimate:

$$\frac{P_{i,t+h} - P_{i,t-1}}{P_{i,t-1}} = \beta_{TWFE,h} \sum_{j=0}^{h} \frac{G_{i,t+j} - G_{i,t-1}}{Y_{i,t-1}} + \alpha_i + \delta_t + \epsilon_{i,t+h}, \tag{1}$$

where $G_{i,t}$ denotes regional government purchases of goods and services, $Y_{i,t-1}$ is lagged personal income, α_i are MSA fixed effects, and δ_t are year fixed effects.

The inclusion of year fixed effects absorbs aggregate shocks common across regions—including nationwide inflationary forces and endogenous monetary policy responses. Identification therefore relies exclusively on within-year cross-sectional variation in fiscal exposure. The coefficient β_{TWFE} captures how prices in more exposed regions move relative to less exposed regions in the same year. In the terminology of the regional macro literature, this specification approximates the local (micro) price response to regional fiscal shocks, net of aggregate forces common to all regions (Nakamura and Steinsson, 2014; Chodorow-Reich, 2019). To the extent that cross-regional spillovers are small at the MSA level, β_{TWFE} provides a close approximation to the direct local effect (Chodorow-Reich, 2020).

Regional government spending may be endogenous to local economic conditions. To address this concern, we follow established approaches in the fiscal multiplier literature (Ramey and Shapiro, 1998; Barro and Redlick, 2011; Nakamura and Steinsson, 2014; Auerbach et al., 2020; Muratori et al., 2023) and use variation in federal military procurement as a source of plausibly exogenous fiscal shocks. Specifically, for each horizon h we construct a shift-share (Bartik) instrument:

$$Z_{i,t}^{h} \equiv \left(\sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{i,t-1}} \right) \times \bar{s}_i, \qquad \bar{s}_i \equiv \overline{\left(\frac{G_{i,t}}{G_t} \right)}. \tag{2}$$

The first term captures aggregate procurement innovations (the *shift*) scaled by lagged local income, and the second term is the region's pre-determined average share in national procurement (the *share*).

To assess the role of aggregate general equilibrium forces, we re-estimate Equation (1) omitting the year fixed effects:

$$\frac{P_{i,t+h} - P_{i,t-1}}{P_{i,t-1}} = \beta_{FE,h} \sum_{j=0}^{h} \frac{G_{i,t+j} - G_{i,t-1}}{Y_{i,t-1}} + \alpha_i + \epsilon_{i,t+h}. \tag{3}$$

Without year fixed effects, aggregate variables are no longer absorbed and can respond endogenously. This specification does not identify the aggregate effect of a nationwide fiscal shock; it instead measures local responses to regional exposure when the union-wide environment adjusts.

Both specifications allow for direct local effects and cross-regional spillovers. The key distinction is that omitting year fixed effects additionally permits economy-wide feedback—most notably the endogenous monetary policy response—to operate. If monetary policy tightens in response to higher union-wide inflation, β_{FE} may be attenuated relative to β_{TWFE} and may even change sign. Comparing β_{TWFE} and β_{FE} therefore isolates the contribution of aggregate policy feedback to observed price responses.

We next examine heterogeneity in price responses by decomposing regional government spending into consumption and investment components. Let $C^g_{i,t}$ and $X^g_{i,t}$ denote regional government consumption and investment, respectively. We estimate:

$$\frac{P_{i,t+h} - P_{i,t-1}}{P_{i,t-1}} = \beta^C_{TWFE,h} \sum_{j=0}^{h} \frac{C^g_{i,t+j} - C^g_{i,t-1}}{Y_{i,t-1}} + \beta^X_{TWFE,h} \sum_{j=0}^{h} \frac{X^g_{i,t+j} - X^g_{i,t-1}}{Y_{i,t-1}} + \alpha_i + \delta_t + \epsilon_{i,t+h}. \tag{4}$$

We instrument each fiscal component using separate shift-share instruments:

$$Z^{C,h}_{i,t} \equiv \left(\sum_{j=0}^{h} \frac{C^g_{t+j} - C^g_{t-1}}{Y_{i,t-1}} \right) \times \bar{s}^C_i, \tag{5}$$

$$Z^{X,h}_{i,t} \equiv \left(\sum_{j=0}^{h} \frac{X^g_{t+j} - X^g_{t-1}}{Y_{i,t-1}} \right) \times \bar{s}^X_i. \tag{6}$$

These instruments exploit variation in regional exposure to national government consumption and investment shocks, respectively.

As before, we also estimate specifications that omit year fixed effects:

$$\frac{P_{i,t+h} - P_{i,t-1}}{P_{i,t-1}} = \beta^{C}_{FE,h} \sum_{j=0}^{h} \frac{C^{g}_{i,t+j} - C^{g}_{i,t-1}}{Y_{i,t-1}} + \beta^{X}_{FE,h} \sum_{j=0}^{h} \frac{X^{g}_{i,t+j} - X^{g}_{i,t-1}}{Y_{i,t-1}} + \alpha_i + \epsilon_{i,t+h}. \tag{7}$$

Again, the coefficients β^{C}_{FE} and β^{X}_{FE} capture local responses evaluated under endogenous aggregate conditions, combining direct local effects, cross-regional spillovers, and nationwide policy feedback.

2.2 Data

We construct an annual MSA-level panel covering the period 1989–2023. Detailed data construction and validation procedures are provided in Appendix A. Here we briefly summarize the main variables.

Annual MSA-level personal income data are obtained from the Bureau of Economic Analysis (BEA) Regional Income Accounts. MSA-level consumer price indices are drawn from the Bureau of Labor Statistics (BLS) and are available for 21 large MSAs; we use annual average CPI levels and restrict the analysis to this balanced sample.

Regional government consumption ($C^{g}_{i,t}$) and investment ($X^{g}_{i,t}$) are constructed from federal military procurement data. For 1989–2003, we use the Defense Contract Action Data System (DCADS) from the National Archives, and for 2004–2023, we use data from USASpending.gov. Procurement contracts are classified as consumption or investment based on product and service codes. Total regional government spending is defined as $G_{i,t} \equiv C^{g}_{i,t} + X^{g}_{i,t}$.

2.3 Empirical Results

Preliminary evidence from aggregate data. Before turning to the MSA-level analysis, we examine whether the fiscal price puzzle arises in aggregate data using our military procurement measure. Following Dupor and Guerrero (2017), we estimate cumulative impulse responses using two-stage least squares.

In the first stage, cumulative h-year changes in government spending are regressed on their contemporaneous change, with all variables normalized by lagged national income:

$$\sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} = \theta_h \frac{G_t - G_{t-1}}{Y_{t-1}} + \epsilon_{t+h}. \tag{8}$$

In the second stage, we regress cumulative changes in the national price level on the predicted cumulative government spending:

$$\frac{P_{t+h} - P_{t-1}}{P_{t-1}} = \beta_{2SLS,h} \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \gamma X_t + \nu_{t+h}. \tag{9}$$

The coefficient of interest, β_{2SLS}, measures the cumulative response of the national consumer price level to national defense spending shocks.[3] The control vector X_t includes oil prices, the ex post real interest rate—defined as the difference between the three-month Treasury bill rate and year-on-year CPI inflation—and their one-year lags, as in Dupor and Guerrero (2017).[4]

Table 1 reports the estimated cumulative responses of the national CPI and core CPI for horizons $h = 1$ through $h = 4$. In both cases, the point estimates are negative, consistent with the fiscal price puzzle documented in the aggregate time-series literature. Importantly, these aggregate estimates incorporate economy-wide general equilibrium adjustments, including endogenous monetary policy responses.

Main results using MSA-level data. We next examine whether the negative aggregate response reflects the intrinsic effect of fiscal expansions on prices or instead the influence

[3]Throughout the paper, the coefficient denotes the percentage change in the price level in response to a one-percent increase in government spending relative to income.

[4]Dupor and Guerrero (2017) construct cumulative changes in national income and defense spending over h years. The specification here parallels the regional fiscal multiplier and price-level regressions used below.

Table 1: National price responses to government spending shocks

	$h=1$	$h=2$	$h=3$	$h=4$
(A) National CPI: 2SLS ($\beta_{2SLS,h}$)				
G	-1.143**	-0.500	-0.301	0.437
	(0.494)	(0.309)	(0.291)	(0.434)
KP F-stat	99.328	95.647	55.262	45.279
(B) National Core CPI: 2SLS ($\beta_{2SLS,h}$)				
G	-1.313	-2.102**	-2.196**	-0.643
	(1.213)	(1.043)	(1.024)	(1.212)
KP F-stat	66.806	95.647	55.262	43.775
Obs	33	32	31	30

Note: Each column reports estimates of $\beta_{agg,h}$ from regressions of cumulative changes in the national CPI (Panel A) or national core CPI (Panel B) on cumulative national government spending shocks at horizon h. The data are annual and span 1989–2024. The coefficient denotes the percentage change in the price level in response to a one-percent increase in government spending relative to income. Standard errors are reported in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. The Kleibergen–Paap Wald F-statistic is reported to assess weak identification.

of aggregate general equilibrium forces. Table 2 reports impulse responses of MSA-level consumer prices to regional government spending shocks for horizons $h = 0$ through $h = 4$.

The table contains four panels. Panels (A) and (C) report results for headline CPI and core CPI, respectively, from specifications that include both MSA and year fixed effects. Panels (B) and (D) report the corresponding estimates from specifications that omit year fixed effects.

Panels (A) and (C) show that regional government spending shocks raise local prices when estimated with two-way fixed effects. The responses are positive and statistically significant at medium horizons for both headline and core CPI, with larger effects for core CPI.

In contrast, Panels (B) and (D), which omit year fixed effects, yield substantially smaller responses that are often negative. As discussed in Section 2.1, this specification allows aggregate policy feedback to operate; the attenuation and sign reversals are consistent

Table 2: MSA-level price responses to government spending shocks

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
(A) MSA CPI: Two-Way Fixed Effects ($\beta_{TWFE,h}$)					
G	0.085	0.081	0.108***	0.114*	0.039
	(0.132)	(0.077)	(0.037)	(0.064)	(0.052)
KP F-stat	23.144	15.218	8.010	4.218	3.421
(B) MSA CPI: Region Fixed Effects Only ($\beta_{FE,h}$)					
G	-0.031	-0.192	-0.272	-0.259*	-0.234**
	(0.259)	(0.202)	(0.168)	(0.128)	(0.105)
KP F-stat	72.001	44.215	18.399	9.062	6.906
(C) MSA Core CPI: Two-Way Fixed Effects ($\beta_{TWFE,h}$)					
G	0.215*	0.124*	0.158***	0.160**	0.124**
	(0.126)	(0.064)	(0.050)	(0.065)	(0.049)
KP F-stat	23.144	15.218	8.010	4.218	3.421
(D) MSA Core CPI: Region Fixed Effects Only ($\beta_{FE,h}$)					
G	-0.141	-0.164	-0.286	-0.196	-0.150
	(0.258)	(0.215)	(0.192)	(0.161)	(0.152)
KP F-stat	72.001	44.215	18.399	9.062	6.906
Obs	630	609	588	567	546

Note: Each column stands for estimates of $\beta_{TWFE,h}$ (TWFE estimator) and $\beta_{FE,h}$ (without time fixed effects) across horizons. The balanced panel consists of observations of 21 MSAs from 1989 to 2023. The coefficient denotes the percentage change in the price level in response to a one-percent increase in government spending relative to income. All regressions are panel 2SLS regressions, with Driscoll-Kraay standard errors (3 lags). Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively. We include Kleibergen-Paap Wald F-statistics for weak identification tests.

with union-wide monetary responses offsetting local inflationary pressure.

Taken together, the results indicate positive relative regional price effects but muted or negative responses once aggregate policy feedback is allowed to operate—providing a straightforward interpretation of the fiscal price puzzle in aggregate data.

Consumption versus investment shocks. Table 3 reports analogous estimates that distinguish between regional government consumption (C^g) and investment (X^g) shocks. Panels (A) and (C) present results for headline CPI, and Panels (B) and (D) report results for core CPI.

Across both price measures, government consumption shocks generate larger and more precisely estimated inflationary responses than government investment shocks in the two-way fixed effects specifications. The difference is particularly pronounced for core CPI, suggesting that government consumption—more concentrated in non-tradable

Table 3: MSA-level price responses to government consumption and investment shocks

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
(A) MSA CPI: Two-Way Fixed Effects ($\beta^C_{TWFE,h}$, $\beta^X_{TWFE,h}$)					
C^g	0.228	0.230	0.241*	0.213**	0.229***
	(0.249)	(0.167)	(0.125)	(0.083)	(0.075)
X^g	0.029	0.031	-0.004	0.016	-0.073
	(0.138)	(0.072)	(0.056)	(0.073)	(0.065)
Test $\beta^C_{TWFE,h} = \beta^X_{TWFE,h}$	0.537	0.364	0.155	0.171	0.025
LM Stat	116.800	55.021	78.210	42.512	25.933
LM Stat CV	14.230	17.505	17.156	17.138	17.061
(B) MSA CPI: Region Fixed Effects Only ($\beta^C_{FE,h}$, $\beta^X_{FE,h}$)					
C^g	0.142	0.379	0.371	0.282	0.235
	(0.750)	(0.436)	(0.307)	(0.286)	(0.249)
X^g	-0.206	-0.280*	-0.462***	-0.329**	-0.256
	(0.279)	(0.159)	(0.137)	(0.128)	(0.164)
Test $\beta^C_{FE,h} = \beta^X_{FE,h}$	0.694	0.143	0.006	0.074	0.168
LM Stat	75.187	30.566	27.917	18.864	15.817
LM Stat CV	14.240	17.290	18.489	18.156	18.021
(C) MSA Core CPI: Two-Way Fixed Effects ($\beta^C_{TWFE,h}$, $\beta^X_{TWFE,h}$)					
C^g	0.085	0.122	0.188	0.225**	0.270***
	(0.234)	(0.144)	(0.114)	(0.086)	(0.086)
X^g	0.274*	0.138	0.097	0.079	0.007
	(0.151)	(0.092)	(0.077)	(0.094)	(0.081)
Test $\beta^C_{TWFE,h} = \beta^X_{TWFE,h}$	0.563	0.942	0.606	0.383	0.091
LM Stat	116.800	55.021	78.210	42.512	25.933
LM Stat CV	14.227	17.501	17.156	17.131	17.055
(D) MSA Core CPI: Region Fixed Effects Only ($\beta^C_{FE,h}$, $\beta^X_{FE,h}$)					
C^g	-0.329	0.018	0.083	0.067	0.036
	(0.608)	(0.416)	(0.249)	(0.235)	(0.224)
X^g	0.096	-0.194	-0.337	-0.316*	-0.272*
	(0.354)	(0.252)	(0.210)	(0.160)	(0.157)
Test $\beta^C_{FE,h} = \beta^X_{FE,h}$	0.611	0.704	0.251	0.240	0.357
LM Stat	75.187	30.566	27.917	18.864	15.817
LM Stat CV	14.245	17.294	18.517	18.180	18.053
Obs	630	609	588	567	546

Note: Each column stands for estimates of $\beta^C_{TWFE,h}$ and $\beta^X_{TWFE,h}$ and $\beta^C_{FE,h}$ and $\beta^X_{FE,h}$ across horizons. The balanced panel consists of observations of 21 MSAs from 1989 to 2023. The coefficient denotes the percentage change in the price level in response to a one-percent increase in government spending relative to income. All regressions are panel 2SLS regressions, with Driscoll-Kraay standard errors (3 lags). Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively. We include the weak IV test statistics of Lewis and Mertens (2022) ("LM Stat"), as well as the critical values ("LM Stat CV") at a confidence level of 95% and Nagar's relative bias threshold of 30%.

service sectors—exerts stronger local demand pressure on prices.

As in Table 2, omitting year fixed effects leads to attenuation or sign reversals in the estimated coefficients. This pattern reinforces the interpretation that aggregate policy feedback plays a central role in shaping national price outcomes. Distinguishing between consumption and investment is therefore important for understanding both the magnitude and the transmission of fiscal shocks.

Income responses. We provide complementary evidence in Table 4, which reports the effects of regional government spending shocks on MSA-level personal income growth. The dependent variable is the h-period forward growth rate in personal income, $(Y_{i,t+h} - Y_{i,t-1})/Y_{i,t-1}$, estimated over the same sample of 21 MSAs from 1989 to 2023.

Panel (A) shows that aggregate regional government spending shocks increase local income when estimated with two-way fixed effects. Panel (C) further indicates that both government consumption and investment shocks generate positive income responses at the regional level, although the effect is primarily driven by government consumption. These findings are consistent with regional fiscal expansions operating as local demand shocks that raise both prices and incomes in exposed areas.

When year fixed effects are omitted, however, income multipliers are markedly smaller and can turn negative—especially for investment—consistent with aggregate endogenous adjustments offsetting local expansionary effects.

Overall, the empirical evidence points to two key elements underlying the fiscal price puzzle: (i) aggregate general equilibrium adjustments, especially centralized monetary policy responses, and (ii) the composition of government spending. While two-way fixed effects specifications isolate local relative price effects, they do not by themselves quantify the aggregate policy feedback that emerges in national data. To characterize these mechanisms explicitly and provide a structural interpretation of the empirical findings, we next develop a multi-region New Keynesian DSGE model.

Table 4: MSA-level personal income responses to government spending shocks

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
(A) MSA Personal Income: Two-Way Fixed Effects ($\beta_{TWFE,h}$)					
G	0.108	0.077	0.254	0.358**	0.229
	(0.192)	(0.224)	(0.163)	(0.174)	(0.135)
KP F-stat	23.144	15.218	8.010	4.218	3.421
(B) MSA Personal Income: Region Fixed Effects Only ($\beta_{FE,h}$)					
G	0.684	-0.093	-0.309	-0.852**	-0.693**
	(0.498)	(0.397)	(0.326)	(0.350)	(0.295)
KP F-stat	72.001	44.215	18.399	9.062	6.906
(C) MSA Personal Income: Two-Way Fixed Effects ($\beta^C_{TWFE,h}$, $\beta^X_{TWFE,h}$)					
C^g	0.134	0.536	0.837***	0.835***	0.734***
	(0.527)	(0.424)	(0.244)	(0.188)	(0.142)
X^g	0.300**	0.034	0.003	-0.015	-0.115
	(0.137)	(0.100)	(0.093)	(0.103)	(0.098)
Test $\beta^C_{TWFE,h} = \beta^X_{TWFE,h}$	0.788	0.276	0.010	0.001	0.000
LM Stat	118.330	53.290	52.409	34.487	28.833
LM Stat CV	14.187	16.928	17.457	17.129	17.061
(D) MSA Personal Income: Region Fixed Effects Only ($\beta^C_{FE,h}$, $\beta^X_{FE,h}$)					
C^g	0.812	0.120	-0.660	-0.226	-0.146
	(1.203)	(0.862)	(0.714)	(0.577)	(0.479)
X^g	0.673	-0.081	-0.112	-0.899**	-0.723*
	(0.628)	(0.422)	(0.369)	(0.421)	(0.386)
Test $\beta^C_{FE,h} = \beta^X_{FE,h}$	0.929	0.842	0.533	0.352	0.406
LM Stat	75.187	30.566	27.917	18.864	15.817
LM Stat CV	14.240	17.292	18.508	18.153	17.989
Obs	630	609	588	567	546

Note: Each column stands for estimates of $\beta_{TWFE,h}$, $\beta^C_{TWFE,h}$, and $\beta^X_{TWFE,h}$ and $\beta_{FE,h}$, $\beta^C_{FE,h}$, and $\beta^X_{FE,h}$ (without time fixed effects) across horizons. The balanced panel consists of observations of 21 MSAs from 1989 to 2023. All regressions are panel 2SLS regressions, with Driscoll-Kraay standard errors (3 lags). Standard errors are in parentheses. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively. For regressions with only government spending shocks (G), we include Kleibergen-Paap Wald F-statistics for weak identification tests and Wald tests for equality of coefficients. For regressions with government consumption (C^g) and investment (X^g) shocks, we include the weak IV test statistics of Lewis and Mertens (2022) ("LM Stat"), as well as the critical values ("LM Stat CV") at a confidence level of 95% and Nagar's relative bias threshold of 30%.

3 Model

As in Nakamura and Steinsson (2014), we construct an otherwise standard New Keynesian DSGE model of a J-region monetary union, where $J \geq 2$. Each region represents a distinct geographic area, sharing a common currency and centralized monetary authority that sets policy according to a Taylor rule. The model captures both partial and general equilibrium effects of localized fiscal shocks, allowing us to trace their transmission through relative prices and output in both regions and at the aggregate level.

3.1 General Framework

We describe the linearized New Keynesian model of the multi-region monetary union. Given the number of regions $J \geq 2$, the monetary union $\mathcal{J}$ is defined as a set of regions $\{1, \ldots, J\} \equiv \mathcal{J}$.

CES preferences. A representative household of each region $j \in \mathcal{J}$ demands a CES aggregator of consumption goods produced from each region $i \in \mathcal{J}$ of the monetary union. We denote the flow of goods produced in region i and consumed in region j in period t as $C_{j,t}^{i}$.

The steady-state consumption shares of households in region j of goods produced in region i are denoted as $\chi_j^i \in (0,1)$, with

$$\sum_{i \in \mathcal{J}} \chi_j^i = 1 \ \forall j \in \mathcal{J}$$

Also, each region has output shares $\omega_j \in (0,1)$, with

$$\sum_{j \in \mathcal{J}} \omega_j = 1$$

With this, region-j household consumption $C_{j,t}$ can be defined as

$$C_{j,t} = \left[\sum_{i \in \mathcal{J}} \left(\chi_j^i \right)^{\frac{1}{\nu}} \left(C_{j,t}^i \right)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{10}$$

where $\nu > 1$ is the elasticity of substitution between consumption goods from different *regions*. The demand of consumption good $C_{j,t}^i$, relative to the region-j CES aggregator

$C_{j,t}$, is given by the relative ratio of their corresponding price levels $P^i_{j,t}$ and $P_{j,t}$:

$$C^i_{j,t} = C_{j,t}\left(\frac{P^i_{j,t}}{P_{j,t}}\right)^{-\nu} \tag{11}$$

The regional Consumer Price Index $P_{j,t}$ is aggregated as follows:

$$P_{j,t} = \left[\sum_{i\in\{H,F\}} \chi^i_j (P^i_{j,t})^{1-\nu}\right]^{\frac{1}{1-\nu}} \quad \forall j \in \{H,F\}, \tag{12}$$

Households. The region-j representative household solves the following optimization problem:

$$\max_{C_{j,t},N_{j,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C^{1-\sigma}_{j,t}}{1-\sigma} - \frac{N^{1+\psi}_{j,t}}{1+\psi}\right]$$
$$\text{s.t. } B_{j,t+1} + P_{j,t}C_{j,t} + T_{j,t} = W_{j,t}N_{j,t} + B_{j,t}(1+i_t) + \Pi_{j,t}, \tag{13}$$

where all variables with subscripts j stand for region-j variables: $B_{j,t}$ is one-period risk-free bonds held by the household at the beginning of period t, $N_{j,t}$ is labor supply, $P_{j,t}$ is the price level, $T_{j,t}$ is lump-sum taxes, $W_{j,t}$ is the (nominal) wage level, and $\Pi_{j,t}$ is firm profits. i_t is the nominal interest rate from the common (aggregate) monetary policy across all regions in the monetary union.

The first-order conditions yield the labor supply condition and the Euler equation:

$$N^{\psi}_{j,t} = W_{j,t}\frac{C^{-\sigma}_{j,t}}{P_{j,t}} \tag{14}$$

$$\frac{C^{-\sigma}_{j,t}}{P_{j,t}} = \beta\mathbb{E}_t\left[\frac{C^{-\sigma}_{j,t+1}}{P_{j,t+1}}(1+i_t)\right] \tag{15}$$

Firms. Each region-j intermediate-goods firm $z \in [0,1]$ also demands labor $N_{j,t}(z)$ and produces output specified by a Cobb-Douglas production function:

$$Y_{j,t}(z) = N_{j,t}(z)^{1-\alpha} \tag{16}$$

Price setting follows Calvo pricing. Log-linearizing the optimal pricing condition yields the New Keynesian Phillips curve:

$$\pi_{j,t} = \beta \mathbb{E}_t \pi_{j,t+1} + \kappa \, mc_{j,t}, \tag{17}$$

where $\kappa = \frac{(1-\theta)(1-\beta\theta)}{\theta}$.

As in standard multi-region models, we impose the law of one price: all goods produced in region j sell for the same price across destinations:

$$P^j_{i,t} = P^j_{j,t} \text{ or } \pi^j_{i,t} = \pi^j_{j,t} \ \forall i, j \in \mathcal{J}, \forall i \neq j \tag{18}$$

Market clearing and aggregation. Region-j output $Y_{j,t}$ is expended in one of three ways: as its own consumption $C^j_{j,t}$, as consumption goods for the other region ($i \neq j$) $C^j_{i,t}$, and as region-j government spending:

$$Y_{j,t} = \sum_{i \in \mathcal{J}} C^j_{i,t} + G_{j,t} \tag{19}$$

Regional variables are aggregated into aggregate variables as such:

$$Y_t = \sum_{j \in \mathcal{J}} Y_{j,t} \tag{20}$$

$$G_t = \sum_{j \in \mathcal{J}} G_{j,t} \tag{21}$$

$$\pi_t = \sum_{j \in \mathcal{J}} \omega_j \pi_{j,t} \tag{22}$$

Monetary Policy. Monetary policy is centralized at the union level. The common nominal interest rate satisfies

$$i_t = \phi_\pi \pi_t + \phi_y y_t, \tag{23}$$

where π_t and y_t denote union-wide inflation and output in log deviations from steady state.

We also consider monetary policy under a constant real rate rule, as computed by Nakamura and Steinsson (2014), which includes a third term g_t for the log deviation of aggregate government spending from its steady state.

$$i_t = \phi_\pi \pi_t + \phi_y y_t + \phi_g g_t. \tag{24}$$

Fiscal policy. Regional government purchases $G_{j,t}$ are financed by regional lump-sum taxes $T_{j,t}$:[5]

$$G_{j,t} = T_{j,t}, \tag{25}$$

[5]The size of fiscal multipliers may depend on the way government spending is financed (see, among others, Zubairy, 2014; Leeper et al., 2017; Galí, 2020; Priftis and Zimic, 2021). In this paper, we abstract from alternative financing schemes and focus on isolating the role of partial- versus general-equilibrium mechanisms in shaping the price response to government spending.

Table 5: Calibration of parameters

Parameter	Value	Description
β	0.995	Discount factor
σ	1	Inverse of intertemporal elasticity of substitution
ψ	1	Inverse of Frisch elasticity of labor supply
α	1/3	Cobb-Douglas production parameter (1 - labor share of income)
θ	3/4	Calvo pricing parameter
ν	2	Elasticity of substitution of goods across regions
ρ_g	0.933	Persistence of regional government spending shock
s_g	0.2	Steady-state output share of government spending
s_c	$1 - s_g$	Steady-state output share of consumption
ω_H	0.02	Steady-state union share of Home region
ω_F	$1 - \omega_H$	Steady-state union share of Foreign region
χ_H^H	0.7	Home share of Home consumption (Home bias)
χ_H^F	$1 - \chi_H^H$	Foreign share of Home consumption
χ_F^H	$\omega_H \chi_H^F / \omega_F$	Home share of Foreign consumption
χ_F^F	$1 - \chi_F^H$	Foreign share of Foreign consumption

Note: This table describes the calibration of parameters for the two-region monetary union model with government spending. Parameters are quarterly.

and follow a first-order autoregressive (AR(1)) process with persistence $\rho_g \in (0,1)$ and regional government purchase shocks $\epsilon_{j,t}^g$:

$$G_{j,t} = (1 - \rho_g)\bar{G}_j + \rho_g G_{j,t-1} + \epsilon_{j,t}^g. \tag{26}$$

3.2 Calibration

We calibrate the model at a quarterly frequency and focus on a two-region monetary union ($J = 2$), consisting of a Home region and a Foreign region. The calibration is designed to reflect key features of the U.S. economy while remaining close to standard values used in the New Keynesian and regional fiscal multiplier literatures, in particular Nakamura and Steinsson (2014). Table 5 summarizes calibrated parameters.

Regional structure. The Home region is assumed to account for 2 percent of aggregate union output ($\omega_H = 0.02$), with the Foreign region comprising the remaining 98 percent. This choice mirrors the relative size of a representative U.S. state within the national economy, following Nakamura and Steinsson (2014).[6] Modeling the Home region as small ensures that regional fiscal expansions have limited direct effects on union-wide aggregates, a feature that is central to our analysis of partial- versus general-equilibrium price responses.

Preferences and technology. The discount factor is set to $\beta = 0.995$, implying an annual real interest rate of approximately 2 percent. The coefficient of relative risk aversion is set to $\sigma = 1$, while the inverse Frisch elasticity of labor supply is $\psi = 1$. Production in each region follows a Cobb–Douglas technology with a labor share of 2/3. Prices are subject to Calvo-style nominal rigidities, with firms adjusting prices with probability $1 - \theta$ each quarter. We set $\theta = 3/4$, which implies an average price duration of four quarters and is in line with empirical evidence on price stickiness.

Trade structure and home bias. Households in each region consume a CES aggregate of goods produced in the Home and Foreign regions. The elasticity of substitution across regional goods is set to $\nu = 2$, a commonly used value in multi-region and open-economy New Keynesian models. We introduce home bias in consumption to reflect limited trade integration across regions. Specifically, households in the Home region allocate 70 percent of their consumption expenditure to Home-produced goods ($\chi_H^H = 0.7$), with the remainder spent on Foreign goods. The corresponding consumption shares for the Foreign region are determined by market-clearing conditions and the relative size of each region, ensuring consistency between expenditure shares and production shares in steady state.

Fiscal policy. Government spending is modeled as exogenous purchases of goods and services that are financed by lump-sum taxes at the regional level. The steady-state share

[6] Although our empirical analysis uses MSA-level CPI data due to limited availability of consistent state-level price indices, we calibrate the model to the state-level framework of Nakamura and Steinsson (2014) to facilitate comparison.

of government spending in output is set to $s_g = 0.2$, implying a consumption share of $s_c = 1 - s_g$. This value is consistent with postwar averages for government purchases in the United States. Regional government spending follows an AR(1) process with persistence parameter $\rho_g = 0.933$, corresponding to a highly persistent but stationary fiscal shock. This value matches the estimated persistence of aggregate military procurement spending shocks reported in Nakamura and Steinsson (2014).

Monetary policy. Monetary policy is conducted at the union-wide level and follows a Taylor-type interest rate rule. In the baseline specification, the nominal interest rate responds to aggregate inflation with coefficient $\phi_\pi = 1.5$ and to aggregate output with coefficient $\phi_y = 0.125$. These values satisfy the Taylor principle and are standard in the New Keynesian literature.

Table 6: Calibration of monetary policy parameters

Monetary Policy	ϕ_π	ϕ_y	ϕ_g
Taylor rule, baseline	1.5	0.125	0
Constant real rate rule	1.5	0	$-(\phi_\pi - \rho_g)\left(\frac{\kappa}{1-\beta\rho_g}\right)\left(\frac{\psi^{-1}+\alpha}{(1-\alpha)+(\psi^{-1}+\alpha)\nu}\right)$
Taylor rule, lower ϕ_π	1.1	0.125	0
Taylor rule, lower ϕ_y	1.5	0	0

Note: This table describes the calibration of monetary policy parameters under alternative monetary policy rules.

To assess the role of endogenous monetary policy responses, we also consider several alternative policy regimes. First, we analyze a constant real interest rate rule, following Nakamura and Steinsson (2014), under which the nominal rate is adjusted to offset movements in expected inflation induced by government spending shocks. This specification effectively shuts down the monetary policy channel and isolates the pure fiscal transmission mechanism. Second, we consider counterfactual Taylor rules with a weaker response to inflation ($\phi_\pi = 1.1$) or no response to output ($\phi_y = 0$), which allow us to examine how the strength of monetary policy feedback affects regional and aggregate price dynamics (see Table 6).

4 Resolving the Fiscal Price Puzzle

4.1 Role of General Equilibrium Effects

We use the model to clarify how regional fiscal expansions can generate positive local inflation while producing muted or negative aggregate price responses once monetary policy reacts. The key distinction mirrors our empirical analysis: relative regional price movements isolate local demand effects, whereas aggregate price dynamics incorporate economy-wide general equilibrium feedback.

We consider a two-region monetary union with Home (H) and Foreign (F). Let

$$\omega_H \equiv \frac{\bar{Y}_H}{\bar{Y}}, \qquad \omega_F \equiv \frac{\bar{Y}_F}{\bar{Y}} = 1 - \omega_H,$$

denote steady-state income shares, where $\bar{Y} = \bar{Y}_H + \bar{Y}_F$. We set $\omega_H = 0.02$, consistent with the size of a representative U.S. state.

Throughout this section, fiscal shocks are normalized by regional income, consistent with the empirical specification. A Home government spending shock of "1%" refers to an increase in $G_{H,t}$ equal to 1 percent of Home output, i.e.,

$$\frac{\Delta G_{H,t}}{Y_{H,t}} = 0.01.$$

As in Nakamura and Steinsson (2014), all reported price and output responses are two-year cumulative percent changes. We simulate the model for 250 periods and repeat the experiment 10,000 times; the reported coefficients are averages across simulations.

Regional and aggregate objects. Let $\Delta p_{i,t}$ denote the two-year cumulative percent change in the regional price level,

$$\Delta p_{i,t} \equiv \frac{P_{i,t+2} - P_{i,t}}{P_{i,t}}.$$

and let $\Delta g_{i,t}$ denote the two-year cumulative percentage change in regional government spending, normalized by regional output,

$$\Delta g_{i,t} \equiv \frac{G_{i,t+1} - G_{i,t}}{Y_{i,t}} + \frac{G_{i,t+2} - G_{i,t}}{Y_{i,t}} \equiv \frac{\Delta G_{i,t}}{Y_{i,t}}.$$

Following a Home fiscal shock, we define β_H^H and β_F^H as follows:

$$\Delta p_{H,t} = \beta_H^H \Delta g_{H,t}, \tag{27}$$

$$\Delta p_{F,t} = \beta_F^H \Delta g_{H,t}. \tag{28}$$

The responses to a Foreign fiscal shock are defined analogously.

The model counterpart to the empirical two-way fixed effects estimator (β_{TWFE}) is the differential regional response:

$$\beta_{reg}^H \equiv \beta_H^H - \beta_F^H.$$

This object captures the relative inflationary effect across regions. Because monetary policy is common to both regions, its effects largely cancel in the relative price difference $\Delta p_{H,t} - \Delta p_{F,t}$, rendering β_{reg}^H largely insensitive to the monetary policy rule. This invariance mirrors our empirical identification strategy: following Chodorow-Reich (2019) and Chodorow-Reich (2020), the within-union relative price response corresponds to the local treatment effect in our panel regressions with two-way fixed effects and it is therefore comparable to the estimates in Panels (A) and (C) of Table 2.

Aggregate prices are defined as the income-weighted average:

$$\Delta p_t^{agg} = \omega_H \Delta p_{H,t} + \omega_F \Delta p_{F,t}.$$

Thus, the aggregate response to a Home-specific shock is

$$\beta_{agg}^{H} = \omega_H \beta_H^H + \omega_F \beta_F^H.$$

To relate aggregate fiscal impulses to regional shocks, note that

$$\begin{aligned}\frac{\Delta G_t}{Y_t} &= \frac{\Delta G_{H,t} + \Delta G_{F,t}}{Y_t} \\ &= \frac{Y_{H,t}}{Y_t}\frac{\Delta G_{H,t}}{Y_{H,t}} + \frac{Y_{F,t}}{Y_t}\frac{\Delta G_{F,t}}{Y_{F,t}} \\ &\approx \omega_H \frac{\Delta G_{H,t}}{Y_{H,t}} + \omega_F \frac{\Delta G_{F,t}}{Y_{F,t}}, \end{aligned} \tag{29}$$

where the final expression uses steady-state income shares, and thus

$$\Delta g_t \approx \omega_H \Delta g_{H,t} + \omega_F \Delta g_{F,t}. \tag{30}$$

A union-wide fiscal expansion is defined as a simultaneous 1 percent increase in government spending in both regions relative to their own output:

$$\frac{G_{H,t+1} - G_{H,t}}{Y_{H,t}} = \frac{G_{F,t+1} - G_{F,t}}{Y_{F,t}} = 0.01.$$

Under this symmetric shock, $(G_{t+1} - G_t)/Y_t = 0.01$, so the aggregate price response satisfies

$$\Delta p_t^{agg} = \beta_{agg} \Delta g_t,$$

Finally, consistent with the column definitions in Table 7, the aggregate responses can be summarized as

$$\beta_{agg} = \omega_H \beta_{agg}^H + \omega_F \beta_{agg}^F,$$

where β_{agg}^H denotes the union-wide price response to a Home-only shock, β_{agg}^F denotes the response to a Foreign-only shock, and β_{agg} denotes the response to a symmetric union-

Table 7: Model-simulated price responses to a government spending shock

Monetary Policy Rule	β_H^H	β_F^H	β_{reg}^H	β_{agg}^H	β_{agg}^F	β_{agg}
Taylor rule ($\phi_\pi = 1.5, \phi_y = 0.125$)	0.142	0.105	0.036	0.106	-0.117	-0.118
Constant real rate rule	0.165	0.129	0.036	1.626	1.662	1.661
Taylor rule ($\phi_\pi = 1.1, \phi_y = 0.125$)	0.324	0.288	0.036	0.289	-0.321	-0.321
Taylor rule ($\phi_\pi = 1.5, \phi_y = 0.0$)	0.149	0.113	0.036	0.113	-0.054	-0.053

Note: This table presents model-simulated two-year price responses to a cumulative government spending shock equivalent to 1% of output at the base year, under alternative monetary policy rules.

wide fiscal expansion.

Monetary policy regimes. Table 7 reports model-simulated two-year price responses under alternative monetary policy rules. The table presents (i) regional price responses to a Home-specific fiscal shock equal to 1 percent of Home output, (ii) the corresponding union-wide price response to that Home shock, (iii) the union-wide price response to a Foreign-specific shock of equal size relative to Foreign output, and (iv) the aggregate response to a symmetric union-wide fiscal expansion in which government spending rises by 1 percent of output in both regions simultaneously.

The baseline specification follows a standard Taylor rule with $\phi_\pi = 1.5$ and $\phi_y = 0.125$. We also consider a constant real interest rate regime that shuts down systematic monetary responses to aggregate conditions, following Nakamura and Steinsson (2014). Finally, we explore alternative Taylor rule calibrations with weaker inflation feedback ($\phi_\pi = 1.1$) and no output feedback ($\phi_y = 0$).

Across all specifications, the differential regional response β_{reg}^H remains essentially unchanged at about 0.036 percent. This invariance reflects the fact that relative regional price movements are largely insulated from common monetary policy responses, consistent with the identification argument in McLeay and Tenreyro (2020). Empirically, this logic helps reconcile why regional price responses are positive even when aggregate evidence points toward disinflationary effects: the regional object isolates the local demand channel that operates within treated locations.

In contrast, aggregate price responses vary substantially across regimes. Under the baseline Taylor rule, the union-wide aggregate response is negative ($\beta_{agg} = -0.118$), despite positive regional responses to a Home-specific shock. When monetary policy does not respond to aggregate conditions, the aggregate price response rises sharply ($\beta_{agg} = 1.661$). These results demonstrate that the fiscal price puzzle arises from aggregate policy feedback rather than from the absence of local demand effects. By contrast to the relative object β^{H}_{reg}, aggregate inflation directly reflects the monetary response to union-wide conditions, making β_{agg} highly sensitive to the policy parameters (ϕ_π, ϕ_y).

The mechanism is standard in New Keynesian models. When monetary policy responds to higher inflation, the real interest rate rises, compressing private demand through intertemporal substitution and attenuating the aggregate price response. In the absence of monetary responses, this contractionary channel is muted, leading to larger output and inflation effects, consistent with Woodford (2011), Nakamura and Steinsson (2014), and Miyamoto et al. (2018).

Output responses. Table 8 presents corresponding output responses. The regional multiplier β^{H}_{reg} remains stable across policy regimes, while aggregate multipliers vary substantially. Under the constant real rate rule, the aggregate multiplier rises to 1.128, compared with 0.406 under the baseline Taylor rule. These results are consistent with Nakamura and Steinsson (2014) and reinforce the central role of monetary policy in shaping aggregate fiscal effects. They also connect to our empirical evidence on regional income responses: Panels (A) and (B) of Table 4 exhibit the same qualitative pattern as the model.

4.2 Composition of Government Spending

We now extend the analysis to examine how the composition of government spending—consumption versus investment—interacts with general equilibrium forces to shape inflation dynamics. This extension builds on the two-sector New Keynesian framework

Table 8: Model-simulated output responses to a government spending shock

Monetary Policy Rule	β_H^H	β_F^H	β_{reg}^H	β_{agg}^H	β_{agg}^F	β_{agg}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.512	0.040	0.469	0.050	0.397	0.406
Constant real rate rule	0.526	0.054	0.469	0.064	1.105	1.128
Taylor rule ($\phi_\pi = 1.1$, $\phi_y = 0.125$)	0.585	0.114	0.469	0.123	0.314	0.323
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.0$)	0.515	0.044	0.469	0.053	0.423	0.433

Note: This table presents model-simulated two-year cumulative output level responses to a cumulative government spending shock equivalent to 1% of output at the base year, under alternative monetary policy rules.

of Boehm (2020) and the two-region two-sector monetary union structure of Koh (2025). Further details on the two-region two-sector monetary union model are illustrated in Appendix C.

The key insight is that the inflationary ranking of fiscal instruments need not be invariant to the level of aggregation. An instrument that generates stronger regional inflationary pressures may produce weaker aggregate price increases once monetary policy responds endogenously. This interaction between spending composition and centralized monetary policy provides a unified explanation for seemingly conflicting evidence in the literature, including the finding in Klein and Linnemann (2023) that government investment shocks can be more inflationary in the aggregate.

Economic mechanism. The model features two production sectors: consumption goods and investment goods. Government consumption directly increases demand for consumption goods, which are relatively non-durable and less easily postponed. Households respond to higher consumption-good prices primarily by supplying more labor rather than cutting consumption sharply. As a result, government consumption shocks generate strong local output and price responses.

In contrast, government investment raises demand for investment goods that yield longer-lived returns. Private agents can more easily postpone investment, leading to stronger crowding out of private capital formation. Consequently, government investment shocks produce smaller short-run output and inflation responses at the regional level.

When embedded in a monetary union with a centralized Taylor rule, these sectoral differences acquire aggregate implications. Because government consumption shocks generate stronger local inflationary pressures, they induce a more aggressive monetary response. The resulting increase in the real interest rate compresses aggregate demand sufficiently to dampen union-wide inflation. By contrast, government investment shocks are less inflationary locally and therefore elicit weaker monetary policy responses, leading to comparatively larger aggregate price effects.

This mechanism is directly relevant for interpreting our empirical decomposition of local CPI responses into government consumption and government investment components (Table 3): since CPI is a consumption price index, it should primarily load on the consumption-goods sector and therefore respond more strongly to government consumption shocks.

Differential output responses. Table 9 reports model-simulated two-year cumulative output responses to government consumption and investment shocks, each equal to 1 percent of regional output in the base year.

Under the baseline Taylor rule, the regional multiplier is substantially larger for consumption than for investment: $\beta_{reg}^{c,H} = 0.500$ versus $\beta_{reg}^{x,H} = 0.245$. The same ranking holds for aggregate output: $\beta_{agg}^{c} = 0.352$ compared with $\beta_{agg}^{x} = 0.177$. Thus, consumption shocks are more expansionary both regionally and in the aggregate.

Differential price responses. Table 10 reports corresponding two-year cumulative changes in price levels (which we refer to as cumulative inflation for brevity). A union-wide (symmetric) shock is defined as a simultaneous one-percent increase in government spending in both regions relative to their own output.

At the regional level, consumption shocks are considerably more inflationary than

Table 9: Model-simulated output responses to government consumption and investment shocks

Panel (A): Government Consumption Shock						
Monetary Policy Rule	$\beta_H^{c,H}$	$\beta_F^{c,H}$	$\beta_{reg}^{c,H}$	$\beta_{agg}^{c,H}$	$\beta_{agg}^{c,F}$	β_{agg}^{c}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.510	0.012	0.500	0.022	0.345	0.352
Constant real rate rule	0.515	0.015	0.500	0.025	0.369	0.377
Panel (B): Government Investment Shock						
Monetary Policy Rule	$\beta_H^{x,H}$	$\beta_F^{x,H}$	$\beta_{reg}^{x,H}$	$\beta_{agg}^{x,H}$	$\beta_{agg}^{x,F}$	β_{agg}^{x}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.223	-0.022	0.245	-0.017	0.175	0.177
Constant real rate rule	0.229	-0.029	0.247	-0.024	0.193	0.197

Note: This table presents model-simulated two-year cumulative output responses to cumulative government consumption and cumulative investment shocks, each equivalent to 1% of output in the base year, under alternative monetary policy rules.

investment shocks: $\beta_{reg}^{c,H} = 0.309$ versus $\beta_{reg}^{x,H} = 0.088$. This ranking mirrors the output results and aligns with our empirical evidence using MSA-level CPI data. In particular, the qualitative pattern in Table 3—larger CPI responses to government consumption than to government investment—maps naturally into the consumption-goods component of the model.

However, the ranking changes at the aggregate level. Under the baseline Taylor rule, the union-wide inflation response to a symmetric consumption shock is negative ($\beta_{agg}^{c} = -0.042$), whereas the corresponding response to an investment shock is positive ($\beta_{agg}^{x} = 0.014$). Thus, although government consumption is more inflationary in relative regional prices, it produces weaker—and even negative—aggregate inflation once monetary policy reacts.

This reversal arises because consumption shocks generate stronger local price pressures, which trigger more aggressive monetary responses. More broadly, this mechanism provides a parsimonious resolution to the empirical finding in Klein and Linnemann (2023) that government investment shocks can be more inflationary in the aggregate: even when consumption shocks dominate in local demand and local CPI inflation, cen-

Table 10: Model-simulated price responses to government consumption and investment shocks

Panel (A): Government Consumption Shock						
Monetary Policy Rule	$\beta_{H}^{c,H}$	$\beta_{F}^{c,H}$	$\beta_{reg}^{c,H}$	$\beta_{agg}^{c,H}$	$\beta_{agg}^{c,F}$	β_{agg}^{c}
Taylor rule ($\phi_{\pi} = 1.5$, $\phi_{y} = 0.125$)	0.319	0.010	0.309	0.017	-0.042	-0.042
Constant real rate rule	0.322	0.014	0.309	0.021	0.032	0.033
Panel (B): Government Investment Shock						
Monetary Policy Rule	$\beta_{H}^{x,H}$	$\beta_{F}^{x,H}$	$\beta_{reg}^{x,H}$	$\beta_{agg}^{x,H}$	$\beta_{agg}^{x,F}$	β_{agg}^{x}
Taylor rule ($\phi_{\pi} = 1.5$, $\phi_{y} = 0.125$)	0.065	-0.026	0.088	-0.024	0.014	0.014
Constant real rate rule	0.077	-0.015	0.088	-0.014	-0.005	-0.006

Note: This table presents model-simulated two-year cumulative price responses to cumulative government consumption and investment shocks, each equivalent to 1% of output in the base year, under alternative monetary policy rules.

tralized monetary policy can flip the ranking at the union level.

Sectoral price decomposition. To clarify the transmission mechanism, Table 11 reports sectoral price responses. Consistent with this mapping, consumption-goods prices respond strongly to government consumption shocks, whereas investment-goods prices respond disproportionately to government investment shocks. These sectoral patterns also help rationalize why union-wide inflation can be weaker under consumption shocks: the tighter monetary response induced by broad consumption-goods inflation spills over into a pronounced disinflation in investment-goods prices, especially when shocks originate in the large Foreign region.

Taken together, these results reveal a central contribution of the paper: the inflationary effects of fiscal policy depend jointly on spending composition and general equilibrium interactions. In both data and theory, regional fiscal expansions raise local prices and output, consistent with a positive local demand channel, yet aggregate price dynamics are governed by centralized monetary policy responses that can overturn the local ranking of fiscal instruments.

Instruments that are more inflationary in regional relative prices need not be more

Table 11: Model-simulated price responses of consumption and investment goods to government consumption and investment shocks

Panel (A): Consumption-Goods Price Level Response to Government Consumption Shock						
Monetary Policy Rule	$\beta_H^{c,H}$	$\beta_F^{c,H}$	$\beta_{reg}^{c,H}$	$\beta_{agg}^{c,H}$	$\beta_{agg}^{c,F}$	β_{agg}^{c}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.334	0.008	0.326	0.015	-0.006	-0.006
Constant real rate rule	0.338	0.013	0.326	0.019	0.066	0.067
Panel (B): Consumption-Goods Price Level Response to Government Investment Shock						
Monetary Policy Rule	$\beta_H^{x,H}$	$\beta_F^{x,H}$	$\beta_{reg}^{x,H}$	$\beta_{agg}^{x,H}$	$\beta_{agg}^{x,F}$	β_{agg}^{x}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.024	-0.019	0.042	-0.018	-0.032	-0.033
Constant real rate rule	0.037	-0.011	0.044	-0.010	-0.050	-0.051
Panel (C): Investment-Goods Price Level Response to Government Consumption Shock						
Monetary Policy Rule	$\beta_H^{c,H}$	$\beta_F^{c,H}$	$\beta_{reg}^{c,H}$	$\beta_{agg}^{c,H}$	$\beta_{agg}^{c,F}$	β_{agg}^{c}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.259	0.018	0.241	0.023	-0.186	-0.189
Constant real rate rule	0.262	0.021	0.241	0.026	-0.104	-0.106
Panel (D): Investment-Goods Price Level Response to Government Investment Shock						
Monetary Policy Rule	$\beta_H^{x,H}$	$\beta_F^{x,H}$	$\beta_{reg}^{x,H}$	$\beta_{agg}^{x,H}$	$\beta_{agg}^{x,F}$	β_{agg}^{x}
Taylor rule ($\phi_\pi = 1.5$, $\phi_y = 0.125$)	0.225	-0.052	0.270	-0.046	0.201	0.204
Constant real rate rule	0.239	-0.034	0.268	-0.028	0.174	0.177

Note: This table presents model-simulated two-year cumulative price responses of consumption and investment goods to cumulative government consumption and investment shocks, each equivalent to 1% of output in the base year, under alternative monetary policy rules.

inflationary in aggregate. Once centralized monetary policy is taken into account, the ranking of fiscal instruments can reverse across levels of aggregation, providing a parsimonious resolution to the fiscal price puzzle and a coherent interpretation of the aggregate patterns emphasized by Klein and Linnemann (2023).

5 Conclusion

This paper provides a transparent resolution of the fiscal price puzzle—the lack of consensus regarding the inflationary effects of government spending shocks. We argue that the puzzle reflects differences in aggregation rather than a failure of intrinsic demand transmission. Regional fiscal expansions raise local consumer prices and incomes when identified from cross-sectional variation, consistent with standard New Keynesian demand mechanisms. However, when aggregate conditions are allowed to respond endogenously, the same shocks can generate attenuated or even negative price responses due to union-wide monetary responses. By combining new regional evidence with a two-region New Keynesian model, we show how partial- and general-equilibrium forces jointly determine observed price dynamics.

We further document and rationalize heterogeneity across spending types. Government consumption shocks are more expansionary and more inflationary in regional consumer prices—particularly in consumption-goods sectors—than investment shocks. Yet precisely because they generate stronger local inflationary pressures, they induce more aggressive monetary responses and can produce smaller aggregate price effects. The inflationary ranking of fiscal instruments is therefore not invariant to the level of aggregation.

Taken together, our results highlight the importance of accounting for both general equilibrium monetary feedback and the composition of government spending when evaluating the inflationary consequences of fiscal policy. Future empirical work should carefully distinguish between relative regional price effects and aggregate price dynamics, as well as between consumption and investment components of government spending.

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Appendix

A Data Description

This appendix section describes the annual MSA-level panel dataset used in the empirical analysis in detail.

We construct annual frequency, MSA-level federal military government procurements based on the methodology in Auerbach et al. (2020), Muratori et al. (2023), and Koh (2025).

1. We collect transaction-level data of U.S. federal government purchases for Fiscal Years 1989 to 2024. For the years 2004 to 2024, we use federal military procurement data from www.USASpending.gov by filtering only procurements assigned by the Department of Defense. For the years 1989 to 2003, we use the National Archives' electronic database of DD-350 military procurement forms.

2. For each calendar year t and each state i, we sum up "federal action obligation" amounts that the U.S. federal government had procured in regional government consumption ($C^g_{i,t}$) or regional government investment ($X^g_{i,t}$) based on the action date and place of performance of the contract.

3. Following the methodology in Koh (2025), we also classify each transaction into either government consumption or government investment based on each contract's Product Service Code (PSC). The PSC indicates the type of goods purchased by the government. Each 4-digit PSC code indicates a category of research and development (R&D), services, or goods. We identify government consumption and investment given the first letter or first two digits.[7] As in Koh (2025), we generally categorize non-durable goods, durable goods, and services spending as government

[7] See the PSC Manual by the General Services Administration for more information.

consumption, and structures, equipment, vehicles, and R&D spending as government investment.

The sample covers all 21 MSAs over the calendar years 1989–2024. All nominal variables, including government spending and personal income, are converted to real terms using the national Consumer Price Index (CPI) from the Bureau of Labor Statistics. Table A.1 reports summary statistics for government consumption and investment, along with their subcategories. Table A.2 presents summary statistics for the MSA-level variables used in the estimation.

Table A.1: Summary statistics for government purchases

Category	**Mean**	**St. Dev.**	**Min**	**Max**
Government Purchases	170.94	35.16	88.95	236.65
Government Consumption	67.49	19.94	43.78	113.43
Government Investment	103.45	27.89	36.63	180.03

Note: This table reports summary statistics for government purchases across 21 metropolitan statistical areas (MSAs) over the period 1989–2024. All variables are measured in billions of real U.S. dollars, expressed in constant 2017 dollars.

Table A.2: Summary statistics for MSA-level data

	Mean	**St. Dev.**	**Min**	**Max**
MSA Personal Income ($B)	298.36	243.52	61.42	1,505.44
MSA Population (Million Persons)	5.60	4.00	1.66	20.07
MSA G / MSA Personal Income (%)	2.06	2.22	0.05	12.61
MSA C^g / MSA Personal Income (%)	1.30	1.61	0.00	10.42
MSA X^g / MSA Personal Income (%)	0.76	1.23	0.03	10.09
MSA share of G_t (%)	2.80	3.08	0.12	20.39
MSA share of C_t^g (%)	3.01	4.25	0.00	31.45
MSA share of X_t^g (%)	2.46	3.13	0.10	23.03

Note: This table reports summary statistics for MSA-level data across 21 metropolitan statistical areas (MSAs) over the period 1989–2024.

B Linearized New Keynesian Model of Monetary Union

The linearized model is as follows:

$$(c^i_{j,t} - c^i_{j,t-1}) = (c_{j,t} - c_{j,t-1}) - \nu(\pi^i_{j,t} - \pi^i_{j,t-1}) \ \forall i, j \in \mathcal{J} \tag{B.1}$$

$$\pi_{j,t} = \sum_{i \in \mathcal{J}} \chi^i_j \pi^i_{j,t} \ \forall j \in \mathcal{J} \tag{B.2}$$

$$-\sigma c_{j,t} = -\sigma \mathbb{E}_t c_{j,t+1} + (i_t - \mathbb{E}_t \pi_{j,t+1}) \ \forall j \in \mathcal{J} \tag{B.3}$$

$$\psi n_{j,t} = w_{j,t} - \sigma c_{j,t} - p_{j,t} \tag{B.4}$$

$$\pi_{j,t} = \beta \mathbb{E}_t \pi_{j,t+1} + \kappa m c_{j,t} \ \forall j \in \mathcal{J} \tag{B.5}$$

$$mc_{j,t} = w_{j,t} - p_{j,t} \ \forall j \in \mathcal{J} \tag{B.6}$$

$$y_{j,t} = (1-\alpha) n_{j,t} \ \forall j \in \mathcal{J} \tag{B.7}$$

$$y_{j,t} = s_g g_{j,t} + (1 - s_g) \sum_{i \in \mathcal{J}} \chi^j_i c^j_{i,t} \ \forall i, j \in \mathcal{J}, i \neq j \tag{B.8}$$

$$\pi^j_{i,t} = \pi^j_{j,t} \ \forall i, j \in \mathcal{J}, \forall i \neq j \tag{B.9}$$

$$y_t = \sum_{j \in \mathcal{J}} \omega_j y_{j,t} \tag{B.10}$$

$$g_t = \sum_{j \in \mathcal{J}} \omega_j g_{j,t} \tag{B.11}$$

$$\pi_t = \sum_{j \in \mathcal{J}} \omega_j \pi_{j,t} \tag{B.12}$$

$$i_t = \phi_\pi \pi_t + \phi_y y_t + \phi_g g_t \tag{B.13}$$

$$g_{j,t} = \rho_g g_{j,t-1} + \epsilon^g_{j,t} \ \forall j \in \mathcal{J} \tag{B.14}$$

The linearized model of the J-region monetary union has $2J^2+8J+4$ equations for $2J^2+8J+4$ endogenous variables, with J exogenous regional government spending shocks $\left\{\epsilon^g_{j,t}\right\}_{j=1}^{j=J}$.

C Two-Sector Two-Region Monetary Union Model

This appendix section describes the model of a two-sector, two-region monetary union used in Section 5.

C.1 Households

There are two regions, Home (H) and Foreign (F), with GDP weights ω_H and $\omega_F \equiv 1-\omega_H$, respectively. Each region has two sectors: a consumption-goods sector denoted as c, and an investment-goods sector denoted as x. Each region $j \in \{H,F\}$ has a representative household, whose lifetime utility is as follows:

$$U_i = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{{C_{j,t}^{hh}}^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \Gamma(C_{j,t}^{g}) - \phi_n \frac{{N_{j,t}}^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right] \tag{C.1}$$

$$\text{s.t. } B_{j,t} + P_{j,t}^{c} C_{j,t}^{hh} + P_{j,t}^{x}(X_{j,t}^{c} + X_{j,t}^{x}) = B_{j,t-1}(1+i_{t-1}) + \Pi_{j,t} - T_{j,t} + \sum_{s\in\{c,x\}} W_{j,t}^{s} N_{j,t}^{s} + \omega_i \sum_{s\in\{c,x\}} \sum_{j\in\{H,F\}} R_{j,t}^{k,s} K_{j,t}^{s}, \tag{C.2}$$

where $C_{j,t}^{hh}$ is region j's household private consumption, $C_{j,t}^{g}$ is government consumption, $N_{j,t}^{s}$ and $K_{j,t}^{s}$ are the household's labor supply and capital stock specific to region $i \in \{H,F\}$ and sector $s \in \{c,x\}$. $W_{j,t}^{s}$ and $R_{j,t}^{k,s}$ are the corresponding wage level and return on capital. $T_{j,t}$ is regional lump-sum taxes. $X_{j,t}^{c}$ and $X_{j,t}^{x}$ are, respectively, investment flows into the consumption-sector and investment-sector capital stocks. The utility for regional government consumption $C_{j,t}^{g}$ is simply given as $\Gamma(\cdot)$, and is immaterial to the household's optimization problem as the household does not decide on it.

The region-j household's total labor supply, $N_{j,t}$, is given as a CES aggregate of sectoral labor supplies:

$$N_{j,t} = \left[{N_{j,t}^{c}}^{\frac{\eta+\mu}{\eta}} + {N_{j,t}^{x}}^{\frac{\eta+\mu}{\eta}} \right]^{\frac{\eta}{\eta+\mu}}. \tag{C.3}$$

Here, η is the elasticity of substitution between labor supply in the consumption-goods sector $N^c_{j,t}$ and that in the investment-goods sector $N^x_{j,t}$. $\mu \in [0,1]$ specifies the degree to which labor is *mobile* across the consumption-goods and investment-goods sectors. If $\mu = 0$, labor supply is fully mobile across sectors, and is perfectly immobile if $\mu = 1$.[8]

C.1.1 Trade across Regions

Home consumption $C_{H,t}$ has three components: Home expenditures of Home-produced consumption goods $C^H_{H,t}$, Home expenditures of Foreign-produced consumption goods $C^F_{H,t}$, and government consumption in the Home region, $C^g_{H,t}$. This similarly holds for Foreign consumption $C_{F,t}$. $C_{H,t}$ is a CES aggregator of Home household consumption $C^{hh}_{H,t}$ and $C^g_{H,t}$, and the same is true for $C_{F,t}$ of $C^{hh}_{F,t}$ and $C^g_{F,t}$:

$$C_{H,t} = \left[(1-\omega^g_c)^{\frac{1}{\xi}} C^{hh}_{H,t}{}^{\frac{\xi-1}{\xi}} + \omega^g_c{}^{\frac{1}{\xi}} C^g_{H,t}{}^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \tag{C.4}$$

$$C_{F,t} = \left[(1-\omega^g_c)^{\frac{1}{\xi}} C^{hh}_{F,t}{}^{\frac{\xi-1}{\xi}} + \omega^g_c{}^{\frac{1}{\xi}} C^g_{F,t}{}^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \tag{C.5}$$

where ξ is the elasticity of substitution of goods within the same region.

$C^{hh}_{H,t}$ itself is a CES aggregation of $C^H_{H,t}$ and $C^F_{H,t}$, and similarly for Foreign household consumption $C^{hh}_{F,t}$:

$$C^{hh}_{H,t} = \left[(\chi^{c,H}_H)^{\frac{1}{\nu}} C^H_{H,t}{}^{\frac{\nu-1}{\nu}} + (\chi^{c,F}_H)^{\frac{1}{\nu}} C^F_{H,t}{}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}, \tag{C.6}$$

$$C^{hh}_{F,t} = \left[(\chi^{c,F}_F)^{\frac{1}{\nu}} C^F_{F,t}{}^{\frac{\nu-1}{\nu}} + (\chi^{c,H}_F)^{\frac{1}{\nu}} C^H_{F,t}{}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}, \tag{C.7}$$

where $\chi^{c,H}_H \in (0,1)$ is the degree of home bias in consumption goods in the Home region, and $\chi^{c,F}_F$ is the corresponding parameter in the Foreign region. We further define $\chi^{c,F}_H = 1 - \chi^{c,H}_H$ and $\chi^{c,H}_F = 1 - \chi^{c,F}_F$. ν is the elasticity of substitution among goods produced in different regions (i.e. in the case of the H household, $C^H_{H,t}$ and $C^F_{H,t}$). Importantly,

[8] Note that if $\mu = 0$, $N_{j,t} = N^c_{j,t} + N^x_{j,t}$.

we denote $C^i_{j,t}$ as the flow of consumption goods produced in region i and consumed in region j, with corresponding price level $P^{c,i}_{j,t}$. Then, aggregate consumption C_t is the sum of Home ($C_{H,t}$) and Foreign ($C_{F,t}$) consumption goods:

$$C_t = C_{H,t} + C_{F,t}, \tag{C.8}$$

$$\text{with } C^{hh}_t = C^{hh}_{H,t} + C^{hh}_{F,t}, \tag{C.9}$$

$$\text{and } C^g_t = C^g_{H,t} + C^g_{F,t}, \tag{C.10}$$

where C^g_t is aggregate government consumption and C^{hh}_t is aggregate household (private) consumption.

In the steady state, consumption is defined by these first-order conditions:

$$C^i_{j,t} = \chi^{c,i}_j \left(\frac{P^{c,i}_{j,t}}{P^c_{j,t}} \right)^{-\nu} C^{hh}_{j,t} \; \forall i \in \{H,F\} \; j \in \{H,F\}, \tag{C.11}$$

$$\text{with } P^c_{j,t} = \left[\sum_{i \in \{H,F\}} \chi^{c,i}_j (P^{c,i}_{j,t})^{1-\nu} \right]^{\frac{1}{1-\nu}} \quad \forall j \in \{H,F\}, \tag{C.12}$$

$$\text{and } P^c_t = \left[\omega_H {P^c_{H,t}}^{\frac{1}{1-\nu}} + \omega_F {P^c_{F,t}}^{\frac{1}{1-\nu}} \right]^{\frac{1}{1-\nu}}, \tag{C.13}$$

where $P^c_{j,t}$ is the region-j price index for consumption goods (i.e., Consumer Price Index), and P^c_t is the union-wide price index for consumption goods.

Finally, we assume the Law of One Price, or that prices of varieties of consumption goods produced in the same region are the same:

$$P^{c,H}_{H,t} = P^{c,H}_{F,t}, \tag{C.14}$$

$$P^{c,F}_{F,t} = P^{c,F}_{H,t}. \tag{C.15}$$

I also assume that the Home household chooses the level of investment goods. Home investment $X_{H,t}$ has three components: Home expenditures of investment goods in the consumption-goods sector $X^c_{H,t}$, Home expenditures of investment goods in the investment-goods sector $X^x_{H,t}$, and Home government investment $X^g_{H,t}$, which have steady-state shares ω^c_x, ω^x_x, and ω^g_x of $X_{H,t}$ respectively (such that $\omega^c_x + \omega^x_x + \omega^g_x = 1$):

$$X_{j,t} = \left[(\omega^c_x)^{\frac{1}{\nu}}(X^c_{j,t})^{\frac{\nu-1}{\nu}} + (\omega^x_x)^{\frac{1}{\nu}}(X^x_{j,t})^{\frac{\nu-1}{\nu}} + (\omega^g_x)^{\frac{1}{\nu}}(X^g_{j,t})^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}} \;\forall j \in \{H,F\} \tag{C.16}$$

In turn, $X^c_{H,t}$ is a CES aggregate of Home-produced ($X^{c,H}_{H,t}$) and Foreign-produced ($X^{c,F}_{H,t}$) investment goods, and similarly with $X^x_{H,t}$ from $X^{x,H}_{H,t}$ and $X^{x,F}_{H,t}$ (and analogously for investment in the Foreign region). In general:

$$X^s_{j,t} = \left[\sum_{i\in\{H,F\}} (\chi^{x,i}_j)^{\frac{1}{\nu}}(X^{s,i}_{j,t})^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}} \quad \forall s \in \{c,x\},\; j \in \{H,F\} \tag{C.17}$$

where $\chi^{x,i}_j$ is the share of investment goods expended by region j that are produced in region i.

In the steady state, investment is defined by these first-order conditions:

$$X^{s,i}_{j,t} = \chi^{x,i}_j \left(\frac{P^{x,i}_{j,t}}{P^x_{j,t}}\right)^{-\nu} X^s_{j,t} \;\forall s \in \{c,x\},\; i \in \{H,F\},\; j \in \{H,F\} \tag{C.18}$$

$$P^x_{j,t} = \left[\sum_{i\in\{H,F\}} \chi^{x,i}_j (P^{x,i}_{j,t})^{1-\nu}\right]^{\frac{1}{1-\nu}} \quad \forall j \in \{H,F\} \tag{C.19}$$

$$\text{and } P^x_t = \left[\omega_H {P^x_{H,t}}^{1-\nu} + \omega_F {P^x_{F,t}}^{1-\nu}\right]^{\frac{1}{1-\nu}} \tag{C.20}$$

where $P^x_{j,t}$ is the region-j price index for investment goods, and P^x_t is the union-wide price index for investment goods.

Finally, by the Law of One Price, prices of varieties of investment goods produced in the same region have the same price level:

$$P^{x,i}_{j,t} = P^{x,i}_{j't} \;\forall i \in \{H,F\},\; j,j' \in \{H,F\} \tag{C.21}$$

C.2 Firms

C.2.1 Intermediate Goods Firms

Each intermediate consumption-goods firm $l \in [0,1]$ of region H uses sector-C capital stock $K^c_{j,t}(l)$ and labor demand $N^c_{j,t}(l)$ to produce three types of consumption goods: Home-produced goods to be consumed at Home $C^H_{H,t}$, those to be consumed at Foreign $C^H_{F,t}$, and at Home by the government $C^g_{H,t}$:

$$C^H_{H,t}(l) + C^H_{F,t}(l) + C^g_{H,t}(l) = \left(K^g_{H,t}\right)^{\alpha_g} \left(K^c_{H,t}(l)\right)^{\alpha} \left(N^c_{H,t}(l)\right)^{1-\alpha}, \tag{C.22}$$

where α is the capital share of income and α_g is the degree of productivity of $K^g_{j,t}$. This analogously holds for Foreign consumption goods:

$$C^F_{F,t}(l) + C^F_{H,t}(l) + C^g_{F,t}(l) = \left(K^g_{F,t}\right)^{\alpha_g} \left(K^c_{F,t}(l)\right)^{\alpha} \left(N^c_{F,t}(l)\right)^{1-\alpha}. \tag{C.23}$$

As for intermediate investment-goods firms l of region j, they simply produce investment goods for the consumption goods sector $X^c_{j,t}$, the investment goods sector $X^x_{j,t}$, and government investment $X^g_{j,t}$:

$$X^c_{H,t}(l) + X^x_{H,t}(l) + X^g_{H,t}(l) = (K^g_{H,t})^{\alpha_g} K^x_{H,t}(l)^{\alpha} N^x_{H,t}(l)^{1-\alpha}, \tag{C.24}$$

$$X^c_{F,t}(l) + X^x_{F,t}(l) + X^g_{F,t}(l) = (K^g_{F,t})^{\alpha_g} K^x_{F,t}(l)^{\alpha} N^x_{F,t}(l)^{1-\alpha}. \tag{C.25}$$

Under monopolistic competition, sector-s nominal marginal costs $MC^s_{j,t}$ can be implicitly expressed as such:

$$MC^s_{j,t} = \frac{1}{(K^g_{j,t})^{\alpha_g}} \left(\frac{R^{k,s}_{j,t}}{\alpha}\right)^{\alpha} \left(\frac{W^s_{j,t}}{1-\alpha}\right)^{1-\alpha} \tag{C.26}$$

with real wages and returns on capital as follows:

$$\frac{W^s_{j,t}}{P^s_{j,t}} = \frac{MC^s_{j,t}}{P^s_{j,t}}(1-\alpha)(K^g_{j,t})^{\alpha_g}(K^s_{j,t})^{\alpha}(N^s_{j,t})^{-\alpha}, \tag{C.27}$$

$$\frac{R^{k,s}_{j,t}}{P^s_{j,t}} = \frac{MC^s_{j,t}}{P^s_{j,t}}\alpha(K^g_{j,t})^{\alpha_g}(K^s_{j,t})^{\alpha-1}(N^s_{j,t})^{1-\alpha}. \tag{C.28}$$

For each firm l in region j and sector s, sectoral reset prices $\bar{P}^s_{j,t}$ for intermediate goods firms that can adjust their prices under Calvo pricing are determined as follows:

$$\bar{P}^s_{j,t} = (1-\beta\theta_s)\sum_{\tau=0}^{\infty}(\beta\theta_s)^{\tau}\mathbb{E}_t[MC^s_{j,t+\tau} + P^s_{j,t+\tau}], \tag{C.29}$$

where $\theta_s \in (0,1)$ is the sectoral Calvo pricing parameter.

C.2.2 Final Goods Firm

There is one final goods firm in each region, which aggregates the output of all intermediate goods firms of the same region. For $S \in \{C, X\}$, and region $i \in \{H, F\}$, regional production of the final good $S_{j,t}$ is defined as:

$$S_{j,t} = \left[\int_0^1 S_{j,t}(l)^{\frac{\xi-1}{\xi}}dl\right]^{\frac{\xi}{\xi-1}} \tag{C.30}$$

with associated region-j price index of sector-s good as:

$$P^s_{j,t} = \left[\int_0^1 P^s_{j,t}(l)^{1-\xi}dl\right]^{\frac{1}{1-\xi}}. \tag{C.31}$$

C.2.3 Sectoral Capital

Capital K is specific to each region-sector combination, and depreciates at a rate of $\delta \in (0,1)$. In addition to sectors c and x, there is also productive government or public capital, denoted as $K^g_{j,t}$, which depreciates at a rate of $\delta_g \in (0,1)$. Given $s \in \{c, x, g\}$, sector-s capital is adjusted by sector-s investment $X^s_{j,t}$, with an adjustment cost function of $\theta(X/K)$. As is standard in the literature (Christiano et al., 2005), we assume that:

$$\theta\left(\frac{X}{K}\right) = \frac{X}{K},\ \theta'\left(\frac{X}{K}\right) = 1,\ \theta''\left(\frac{X}{K}\right) = -\zeta. \tag{C.32}$$

Then, capital accumulation in each sector $s \in \{c, x, g\}$ is as follows:

$$K^s_{j,t+1} = (1-\delta)K^s_{j,t} + \theta\left(\frac{X^s_{j,t}}{K^s_{j,t}}\right)K^s_{j,t}. \tag{C.33}$$

C.3 Market Clearing and Price Indices

The market-clearing conditions for each region j are as follows:

$$Y_{j,t} = P^c C_{j,t} + P^x X_{j,t}, \tag{C.34}$$

where $C_{j,t}$ is regional consumption, $X_{j,t}$ is regional investment, and $Y_{j,t}$ is regional real GDP, where P^c and P^x are steady state values of $P^c_{j,t}$ and $P^x_{j,t}$.

Given the regional price index for consumer goods $P^c_{j,t}$ and investment goods $P^x_{j,t}$, the regional GDP deflator $P_{j,t}$ is defined as such:

$$P_{j,t} = \frac{P^c_{j,t}C_{j,t} + P^x_{j,t}X_{j,t}}{Y_{j,t}}. \tag{C.35}$$

The aggregate price index for investment goods P^x_t and the aggregate GDP deflator P_t are defined in terms of their relevant Home and Foreign price indices:

$$P^x_t = \omega_H P^x_{H,t} + \omega_F P^x_{F,t}, \tag{C.36}$$

$$P_t = \omega_H P_{H,t} + \omega_F P_{F,t}. \tag{C.37}$$

Naturally, inflation rates are defined as the growth rate in the price indices. For example, the region-j GDP deflator inflation $\pi_{j,t}$ and aggregate GDP deflator inflation π_t are defined as follows:

$$\pi_{j,t} = \frac{P_{j,t}}{P_{j,t-1}} - 1, \; \pi_t = \frac{P_t}{P_{t-1}} - 1. \tag{C.38}$$

C.4 Factor Incomes

We then define regional and aggregate factor incomes. Regional labor income $Y^L_{j,t}$ is earned locally, while regional capital income $Y^K_{j,t}$ is simply region j's share of *aggregate* capital income:

$$P_{j,t} Y^L_{j,t} = W^c_{j,t} N^c_{j,t} + W^x_{j,t} N^x_{j,t}, \tag{C.39}$$

$$P_{j,t} Y^K_{j,t} = \omega_j \sum_{j \in \{H,F\}} \left(R^{k,c}_{j,t} K^c_{j,t} + R^{k,x}_{j,t} K^x_{j,t} \right), \tag{C.40}$$

where ω_H is the Home share of aggregate GDP, and $\omega_F \equiv 1 - \omega_H$ is the Foreign share of aggregate GDP.

C.5 Aggregate Fiscal Policy

We assume lump-sum taxation across both regions, and a fiscal union in which the fiscal union's (nominal) government purchases G_t are paid with (nominal) aggregate lump sum taxes T_t via a balanced budget $T_t = G_t$:

$$T_t = T_{H,t} + T_{F,t}, \tag{C.41}$$

$$G_t = (P^c_{H,t} C^g_{H,t} + P^x_{H,t} X^g_{H,t}) + (P^c_{F,t} C^g_{F,t} + P^x_{F,t} X^g_{F,t}). \tag{C.42}$$

Finally, we assume the AR(1) process for government spending shocks. $\tilde{c}^g_{j,t}$ and $\tilde{x}^g_{j,t}$ are the log (percentage) deviations of $C^g_{j,t}$ and $X^g_{j,t}$ from their steady-state values.

$$C^g_{j,t} = (1-\rho^g_c)\bar{C}^g_j + \rho^g_c C^g_{j,t-1} + \nu^{gc}_{j,t}, \quad \text{(C.43)}$$

$$X^g_{j,t} = (1-\rho^g_x)\bar{X}^g_j + \rho^g_x X^g_{j,t-1} + \nu^{gx}_{j,t}, \quad \text{(C.44)}$$

where $\rho^g_c \in [0,1)$ and $\rho^g_x \in [0,1)$ are the persistence parameters of regional government consumption and government investment respectively, and $\bar{C}^g_j$ and $\bar{X}^g_j$ are steady-state values of $C^g_{j,t}$ and $X^g_{j,t}$. $\nu^{gc}_{j,t}$ and $\nu^{gx}_{j,t}$ are mean-zero government consumption shocks and government investment shocks, respectively.

C.6 Monetary Policy

The central bank sets the nominal interest rate i_t via a Taylor rule given the aggregate inflation rate π_t, as such:

$$i_t = (\beta^{-1} - 1) + \phi_\pi \pi_t + \phi_y \tilde{y}_t, \quad \text{(C.45)}$$

where $\phi_\pi > 1$, based on the Taylor principle, and $\phi_y > 0$.

C.7 Calibration

We mostly adopt the calibration from the baseline 2-region model in Table 5, with a few additional parameters from Koh (2025). Table C.1 lists the full set of parameters. In addition, we calibrate the share of the Home region, ω_H, and the degree of home bias, $\chi^{c,H}_H$. We set the size of the Home region to $\omega_H = 0.02$. For home bias of consumption goods and investment goods respectively, we calibrate $\chi^{c,H}_H = 0.8$ and $\chi^{x,H}_H = 0.25$. They further imply a value for the foreign region's home bias given by $\chi^{c,F}_F = (\omega_H/(1-\omega_H))\chi^{c,H}_H$.[9]

[9]We assume that government consumption and investment are entirely produced and consumed within the region.

Table C.1: List of calibrated parameters for the 2-sector model.

Parameter	Value	Definition
σ	1	Intertemporal elasticity of substitution
η	1	Frisch elasticity of labor supply
β	0.995	Discount factor
ν	2	Elasticity of substitution of goods across different regions
μ	1	Degree of labor mobility
α	1/3	Capital share
δ	0.025	Depreciation Rate
ζ	2	Adjustment cost parameter
ρ_c^g	0.933	Persistence of government consumption shock
ρ_x^g	0.933	Persistence of government investment shock
ω_y^c	0.8	Consumption share of output
ω_y^x	0.2	Investment share of output
ω_c^g	0.2	Government share of consumption
ω_x^g	0.2	Government share of investment
α_g	0.05	Elasticity of output with respect to public capital
θ_c	0.75	Calvo parameter for consumption goods
θ_x	0.75	Calvo parameter for investment goods
ϕ_π	1.5	Taylor rule coefficient for inflation
ϕ_y	0.125	Taylor rule coefficient for output
ω_H	0.02	Size of Home region
$\chi_H^{c,H}$	0.8	Home bias for consumption goods of Home region (Koh, 2025)
$\chi_H^{x,H}$	0.25	Home bias for investment goods of Home region (Koh, 2025)

Note: This table describes the calibration of parameters for the two-region two-sector monetary union model with government spending. Parameters are quarterly.

C.8 Appendix: First Order Conditions

From the household's problem, we have the following first-order conditions:

$$(C^h_{j,t})^{-\frac{1}{\sigma}} = \lambda_{j,t} P^c_{j,t}, \tag{C.46}$$

$$\phi N_{j,t}^{\frac{1-\mu}{\eta}} N^{c\ \frac{\mu}{\eta}}_{j,t} = \lambda_{j,t} W^c_{j,t}, \tag{C.47}$$

$$\phi N_{j,t}^{\frac{1-\mu}{\eta}} N^{x\ \frac{\mu}{\eta}}_{j,t} = \lambda_{j,t} W^x_{j,t}, \tag{C.48}$$

$$\lambda_{j,t} = \beta(1+i_t)\mathbb{E}_t[\lambda_{t+1}], \tag{C.49}$$

$$P^c_{j,t} = \gamma^c_{j,t}\theta'\left(\frac{X^c_{j,t}}{K^c_{j,t}}\right), \tag{C.50}$$

$$P^x_{j,t} = \gamma^x_{j,t}\theta'\left(\frac{X^x_{j,t}}{K^x_{j,t}}\right), \tag{C.51}$$

$$\lambda_{j,t}\gamma^c_{j,t} = \beta\mathbb{E}_t\left[\lambda_{j,t+1}R^{k,c}_{j,t+1} + \lambda_{j,t+1}\gamma^c_{j,t+1}\left\{(1-\delta) + \theta\left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}}\right) - \theta\left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}}\right)\left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}}\right)\right\}\right], \tag{C.52}$$

$$\lambda_{j,t}\gamma^x_{j,t} = \beta\mathbb{E}_t\left[\lambda_{j,t+1}R^{k,x}_{j,t+1} + \lambda_{j,t+1}\gamma^x_{j,t+1}\left\{(1-\delta) + \theta\left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}}\right) - \theta\left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}}\right)\left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}}\right)\right\}\right], \tag{C.53}$$

where $\lambda_{j,t}$ is the Lagrangian multiplier for the household's budget constraint, and $\lambda_{j,t}\gamma^s_{j,t}$ is the Lagrangian multiplier for the sector-s capital accumulation process for $s \in \{c, x\}$.

Combining the households' first-order conditions, we get the following:

Euler equation for consumption:

$$(C^{hh}_{j,t})^{-\frac{1}{\sigma}} = \beta(1+i_t)\mathbb{E}_t\left[\frac{1}{1+\pi^c_{j,t+1}}(C^{hh}_{j,t+1})^{-\frac{1}{\sigma}}\right]. \tag{C.54}$$

Investment choice:

$$1 = \frac{\gamma^c_{j,t}}{P^x_{j,t}} \theta' \left(\frac{X^c_{j,t}}{K^c_{j,t}} \right), \tag{C.55}$$

$$1 = \frac{\gamma^x_{j,t}}{P^x_{j,t}} \theta' \left(\frac{X^x_{j,t}}{K^x_{j,t}} \right). \tag{C.56}$$

Euler equations for capital:

$$\frac{\gamma^c_{j,t}}{P^x_{j,t}} = \mathbb{E}_t \left[\left(\frac{1+\pi^x_{j,t+1}}{1+i_t} \right) \left(\frac{R^{k,c}_{j,t+1}}{P^x_{j,t+1}} + \frac{\gamma^c_{j,t+1}}{P^x_{j,t+1}} \times \left\{ (1-\delta) + \theta\left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}} \right) - \theta'\left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}} \right) \left(\frac{X^c_{j,t+1}}{K^c_{j,t+1}} \right) \right\} \right) \right], \tag{C.57}$$

$$\frac{\gamma^x_{j,t}}{P^x_{j,t}} = \mathbb{E}_t \left[\left(\frac{1+\pi^x_{j,t+1}}{1+i_t} \right) \left(\frac{R^{k,x}_{j,t+1}}{P^x_{j,t+1}} + \frac{\gamma^x_{j,t+1}}{P^x_{j,t+1}} \times \left\{ (1-\delta) + \theta\left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}} \right) - \theta'\left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}} \right) \left(\frac{X^x_{j,t+1}}{K^x_{j,t+1}} \right) \right\} \right) \right]. \tag{C.58}$$

Labor supply:

$$\phi(N_{j,t})^{\frac{1-\mu}{\eta}} (N^x_{j,t})^{\frac{\mu}{\eta}} = (C^{hh}_{j,t})^{-\frac{1}{\sigma}} \frac{P^x_{j,t}}{P^c_{j,t}} \frac{W^x_{j,t}}{P^x_{j,t}}, \tag{C.59}$$

$$\phi(N_{j,t})^{\frac{1-\mu}{\eta}} (N^c_{j,t})^{\frac{\mu}{\eta}} = (C^{hh}_{j,t})^{-\frac{1}{\sigma}} \frac{W^c_{j,t}}{P^x_{j,t}}. \tag{C.60}$$

C.9 Log-linearized Model

All log deviations of variables are in lower-case, tilde variables. Unless region subscripts are specified, all log-linearized equations hold for both regions $j \in \{H, F\}$.

Labor supply:

$$\frac{1-\mu}{\eta}\tilde{n}_{j,t} + \frac{\mu}{\eta}\tilde{n}^{x}_{j,t} = -\frac{1}{\sigma}\tilde{c}^{hh}_{j,t} + \left(\widetilde{\frac{p^{x}_{j,t}}{p^{c}_{j,t}}}\right) + \left(\widetilde{\frac{w^{x}_{j,t}}{p^{x}_{j,t}}}\right), \tag{C.61}$$

$$\frac{1-\mu}{\eta}\tilde{n}_{j,t} + \frac{\mu}{\eta}\tilde{n}^{c}_{j,t} = -\frac{1}{\sigma}\tilde{c}^{hh}_{j,t} + \left(\widetilde{\frac{w^{c}_{j,t}}{p^{c}_{j,t}}}\right). \tag{C.62}$$

Home Euler equation for consumption:

$$-\frac{1}{\sigma}\tilde{c}^{hh}_{H,t} = (i_t - \mathbb{E}_t\pi^{c}_{H,t+1}) - \frac{1}{\sigma}\mathbb{E}_t\tilde{c}^{hh}_{H,t+1}. \tag{C.63}$$

Inter-regional risk sharing:

$$-\frac{1}{\sigma}(\tilde{c}^{hh}_{F,t} - \tilde{c}^{hh}_{F,t-1}) + \frac{1}{\sigma}(\tilde{c}^{hh}_{H,t} - \tilde{c}^{hh}_{H,t-1}) = \pi^{c}_{F,t} - \pi^{c}_{H,t}. \tag{C.64}$$

Tradable consumption goods:

$$(\tilde{c}^{i}_{j,t} - \tilde{c}^{i}_{j,t-1}) = (\tilde{c}^{hh}_{j,t} - \tilde{c}^{hh}_{j,t-1}) - \nu(\pi^{c,i}_{j,t} - \pi^{c}_{j,t}),\ i \in \{H,F\} \tag{C.65}$$

Tradable investment goods:

$$(\tilde{x}^{s,i}_{j,t} - \tilde{x}^{s,i}_{j,t-1}) = (\tilde{x}^{s}_{j,t} - \tilde{x}^{s}_{j,t-1}) - \nu(\pi^{x,i}_{j,t} - \pi^{x}_{j,t}),\ i \in \{H,F\},\ s \in \{c,x\}. \tag{C.66}$$

Law of One Price:

$$\pi^{s,i}_{H,t} = \pi^{s,i}_{F,t},\ i \in \{H,F\},\ s \in \{c,x\} \tag{C.67}$$

Labor aggregator:

$$\tilde{n}_{j,t} = s^{c}_{y}\tilde{n}^{c}_{j,t} + s^{x}_{y}\tilde{n}^{x}_{j,t}. \tag{C.68}$$

Inflation aggregation by sector:

$$\pi^{c}_{j,t} = \chi^{c,H}_{j} \pi^{c,H}_{j,t} + \chi^{c,F}_{j} \pi^{c,F}_{j,t}, \tag{C.69}$$

$$\pi^{x}_{j,t} = \chi^{x,H}_{j} \pi^{x,H}_{j,t} + \chi^{x,F}_{j} \pi^{x,F}_{j,t}. \tag{C.70}$$

Production functions:

$$\omega_H \left(\alpha_g \tilde{k}^{g}_{H,t} + \alpha \tilde{k}^{c}_{H,t} + (1-\alpha) \tilde{n}^{c}_{H,t} \right) = \omega_H s^{g}_{c} \tilde{c}^{g}_{H,t} + \omega_H (1 - s^{g}_{c}) \chi^{c,H}_{H} \tilde{c}^{H}_{H,t} + \omega_F (1 - s^{g}_{c}) \chi^{H}_{F} \tilde{c}^{H}_{F,t}, \tag{C.71}$$

$$\omega_F \left(\alpha_g \tilde{k}^{g}_{F,t} + \alpha \tilde{k}^{c}_{F,t} + (1-\alpha) \tilde{n}^{c}_{F,t} \right) = \omega_F s^{g}_{c} \tilde{c}^{g}_{F,t} + \omega_F (1 - s^{g}_{c}) \chi^{c,F}_{F} \tilde{c}^{F}_{F,t} + \omega_H (1 - s^{g}_{c}) \chi^{c,F}_{H} \tilde{c}^{F}_{H,t}, \tag{C.72}$$

$$\omega_H \left(\alpha_g \tilde{k}^{g}_{H,t} + \alpha \tilde{k}^{x}_{H,t} + (1-\alpha) \tilde{n}^{x}_{H,t} \right) = \omega_H s^{g}_{x} \tilde{x}^{g}_{H,t} + \omega_H \left(s^{c}_{x} \tilde{x}^{c,H}_{H,t} + s^{x}_{x} \tilde{x}^{x,H}_{H,t} \right) + \omega_F \left(s^{c}_{x} \tilde{x}^{c,H}_{F,t} + s^{x}_{x} \tilde{x}^{x,H}_{F,t} \right), \tag{C.73}$$

$$\omega_F \left(\alpha_g \tilde{k}^{g}_{F,t} + \alpha \tilde{k}^{x}_{F,t} + (1-\alpha) \tilde{n}^{x}_{F,t} \right) = \omega_F s^{g}_{x} \tilde{x}^{g}_{F,t} + \omega_H \left(s^{c}_{x} \tilde{x}^{c,F}_{F,t} + s^{x}_{x} \tilde{x}^{x,F}_{F,t} \right) + \omega_H \left(s^{c}_{x} \tilde{x}^{c,F}_{H,t} + s^{x}_{x} \tilde{x}^{x,F}_{H,t} \right). \tag{C.74}$$

Regional consumption:

$$\tilde{c}_{j,t} = (1 - s^{g}_{c}) \tilde{c}^{hh}_{j,t} + s^{g}_{c} \tilde{c}^{g}_{j,t}, \tag{C.75}$$

$$\tilde{c}^{hh}_{j,t} = \chi^{c,H}_{j} \tilde{c}^{H}_{j,t} + \chi^{c,F}_{j} \tilde{c}^{F}_{j,t}. \tag{C.76}$$

Regional investment:

$$\tilde{x}_{j,t} = s^{c}_{x} \tilde{x}^{c}_{j,t} + s^{x}_{x} \tilde{x}^{x}_{j,t} + s^{g}_{x} \tilde{x}^{g}_{j,t}, \tag{C.77}$$

$$\tilde{x}^{c}_{j,t} = \chi^{x,H}_{j} \tilde{x}^{c,H}_{j,t} + \chi^{x,F}_{j} \tilde{x}^{c,H}_{j,t}, \tag{C.78}$$

$$\tilde{x}^{x}_{j,t} = \chi^{x,H}_{j} \tilde{x}^{x,H}_{j,t} + \chi^{x,F}_{j} \tilde{x}^{x,H}_{j,t}. \tag{C.79}$$

Investment choice:

$$\left(\frac{\widetilde{\gamma_{j,t}^{s}}}{p_{j,t}^{s}}\right) = \zeta\delta(x_{j,t}^{s} - k_{j,t}^{s}),\ s \in \{c, x\}. \tag{C.80}$$

$$\tag{C.81}$$

Euler equation for capital:

$$\left(\frac{\widetilde{\gamma_{j,t}^{x}}}{p_{j,t}^{x}}\right) + (\mathbb{E}_t r_{j,t+1}^{x} - r_{i,t}^{x}) = \mathbb{E}_t\left[(1-\beta(1-\delta))\left(\frac{\widetilde{r_{j,t}^{x}}}{p_{j,t}^{x}}\right) + \beta(1-\delta)\left(\frac{\widetilde{\gamma_{j,t}^{x}}}{p_{j,t}^{x}}\right) + \beta\zeta\delta^2(\tilde{x}_{j,t+1}^{x} - \tilde{k}_{j,t+1}^{x})\right], \tag{C.82}$$

$$\left(\frac{\widetilde{\gamma_{j,t}^{c}}}{p_{j,t}^{c}}\right) + (\mathbb{E}_t r_{j,t+1}^{x} - r_{i,t}^{x}) = \mathbb{E}_t\left[(1-\beta(1-\delta))\left(\frac{\widetilde{r_{j,t}^{c}}}{p_{j,t}^{c}}\right) + \beta(1-\delta)\left(\frac{\widetilde{\gamma_{j,t}^{c}}}{p_{j,t}^{c}}\right) + \beta\zeta\delta^2(\tilde{c}_{j,t+1}^{c} - \tilde{k}_{j,t+1}^{c})\right]. \tag{C.83}$$

Sectoral capital accumulation:

$$\tilde{k}_{j,t+1}^{s} = (1-\delta)\tilde{k}_{i,t}^{s} + \delta\tilde{x}_{j,t}^{s},\ s \in \{c, x\}, \tag{C.84}$$

$$\tilde{k}_{j,t+1}^{g} = (1-\delta)\tilde{k}_{i,t}^{g} + \delta\tilde{x}_{j,t}^{g}. \tag{C.85}$$

Factor demands:

$$\left(\frac{\widetilde{w_{j,t}^{s}}}{p_{j,t}^{s}}\right) = \alpha_g\tilde{k}_{j,t}^{g} + \alpha\tilde{k}_{j,t}^{s} - \alpha\tilde{n}_{j,t}^{s} + \left(\frac{\widetilde{mc_{j,t}^{s}}}{p_{j,t}^{s}}\right),\ s \in \{c, x\},\ j \in \{H, F\}, \tag{C.86}$$

$$\left(\frac{\widetilde{r_{j,t}^{s}}}{p_{j,t}^{s}}\right) = \alpha_g\tilde{k}_{j,t}^{g} - (1-\alpha)\tilde{k}_{j,t}^{s} + (1-\alpha)\tilde{n}_{j,t}^{s} + \left(\frac{\widetilde{mc_{j,t}^{s}}}{p_{j,t}^{s}}\right),\ s \in \{c, x\},\ j \in \{H, F\}. \tag{C.87}$$

Sectoral Phillips curves ($\widetilde{mc}_{j,t}^{s}$ is the percentage deviation from the steady state value of $MC^s_{j,t}$, after a linear approximation):

$$\pi^s_{j,t} = \frac{(1-\theta_s)(1-\theta_s\beta)}{\theta_s}\frac{\widetilde{mc}^s_{j,t}}{p^s_{j,t}} + \beta\mathbb{E}_t[\pi^s_{j,t+1}],\ s \in \{c,x\}. \tag{C.88}$$

Fisher equations:

$$i_t = r^{k,s}_{j,t} + \mathbb{E}_t\pi^s_{j,t+1},\ s \in \{c,x\}. \tag{C.89}$$

Aggregation conditions:

$$\tilde{s}_t = \omega_H\tilde{s}_{H,t} + \omega_F\tilde{s}_{F,t},\ s \in \{c,x\}, \tag{C.90}$$

$$(s^g_c s^c_y + s^g_x s^x_y)\tilde{g}_{j,t} = s^g_x s^x_y \tilde{x}^g_{j,t} + s^g_c s^c_y \tilde{c}^g_{j,t}, \tag{C.91}$$

$$\tilde{g}_t = \omega_H\tilde{g}_{H,t} + \omega_F\tilde{g}_{F,t}, \tag{C.92}$$

$$\tilde{y}_{j,t} = s^x_y\tilde{x}_{j,t} + s^c_y\tilde{c}_{j,t}, \tag{C.93}$$

$$\tilde{y}_t = \omega_H\tilde{y}_{H,t} + \omega_F\tilde{y}_{F,t}. \tag{C.94}$$

Price indices:

$$\pi_{j,t} = s^x_y\pi^x_{j,t} + s^c_y\pi^c_{j,t}, \tag{C.95}$$

$$\pi^s_t = \omega_H\pi^s_{H,t} + \omega_F\pi^s_{F,t},\ s \in \{c,x\}, \tag{C.96}$$

$$\pi_t = \omega_H\pi_{H,t} + \omega_F\pi_{F,t}. \tag{C.97}$$

Aggregate monetary policy:

$$i_t = \phi_\pi\pi_t + \phi_y y_t. \tag{C.98}$$

Aggregate fiscal policy:

$$\tilde{t}_t = \omega_H \tilde{t}_{H,t} + \omega_F \tilde{t}_{F,t}, \tag{C.99}$$

$$(s_c^g s_y^c + s_x^g s_y^x)(\tilde{t}_{H,t} - \tilde{t}_{H,t-1}) = s_y^c s_c^g (\pi_{H,t}^c + c_{H,t}^g - c_{H,t-1}^g) + s_y^x s_x^g (\pi_{H,t}^x + \tilde{x}_{H,t}^g - \tilde{x}_{H,t-1}^g), \tag{C.100}$$

$$(s_c^g s_y^c + s_x^g s_y^x)(\tilde{g}_{F,t} - \tilde{g}_{F,t-1}) = s_c^g s_y^c (\pi_{F,t}^c + c_{F,t}^g - c_{F,t-1}^g) + s_x^g s_y^x (\pi_{F,t}^x + \tilde{x}_{F,t}^g - \tilde{x}_{F,t-1}^g). \tag{C.101}$$

AR(1) government spending shock processes:

$$\tilde{x}_{j,t}^g = \rho_x^g \tilde{x}_{j,t-1}^g + \varepsilon_{x,it}^g, \tag{C.102}$$

$$\tilde{c}_{j,t}^g = \rho_c^g \tilde{c}_{j,t-1}^g + \varepsilon_{c,it}^g. \tag{C.103}$$