Government Spending in Multi-Sector Open Economies with Production Networks

Antonio Eugenelo

University of Oxford
Department of Economics

Macro Workshop — February 2026

Roadmap

1. **Literature review**
2. **A simple multi-sector model** — relative fiscal allocation under a constrained budget
3. **A global production network model** (Aguilar et al., 2025) — mechanics
4. **Extending the framework** — introducing non-trivial government spending
5. **Research agenda** — welfare under fixed vs. endogenous fiscal envelopes

Motivation

- Asymmetric shocks—the 2020 pandemic, the 2022 energy-price spike, the 2025 tariff escalation—have renewed interest in the role of **sectoral heterogeneity** for aggregate dynamics.
- Heterogeneity arises both from differential exposure across sectors and from sector-specific propagation through production linkages.
- Two active literatures study these forces:
  - **Production networks in NK models:** how IO linkages shape the transmission of shocks and the design of monetary policy.
  - **Fiscal policy in multi-sector economies:** how government purchases should be allocated across heterogeneous sectors.
- **This talk:** steps toward a framework that embeds sector-specific government spending into a multi-country, multi-sector NK model with production networks.

Related Literature

Production Networks & NK

- Acemoglu et al. (2012)
- Baqaee & Farhi (2020, 2024)
- Pasten, Schoenle & Weber (2020)
- Rubbo (2023)

Tariffs & Open-Economy NK

- Galí & Monacelli (2005)
- Comin & Johnson (2023)
- Aguilar et al. (2025)

Fiscal Policy in Disaggregated Economies

- Aoki (2001)
- Cox, Müller, Pasten, Schoenle & Weber (2024)

Fiscal–Price Effects (Empirical)

- Nekarda & Ramey (2013)
- Ben Zeev & Pappa (2017)
- Barattieri et al. (2023)

Setup

A closed-economy NK model with K sectors, following Cox et al. (2024):

- Calvo pricing with heterogeneous sectoral stickiness α_k.
- Representative household with utility over private (C_t) and public (G_t) composites:

$$U = \sum_t \beta^t \left[(1-\chi) \frac{C_t^{1-\sigma}}{1-\sigma} + \chi \frac{G_t^{1-\sigma}}{1-\sigma} - \sum_k \nu_k \frac{N_{k,t}^{1+\varphi}}{1+\varphi} \right]$$

- The government purchases goods in each sector. The planner chooses sectoral allocations $\{g_{k,t}\}$ and an aggregate monetary instrument.
- **Key extension:** the planner must deliver an exogenous aggregate public-good bundle $\bar{G}_t$ (CES with elasticity ρ), but retains flexibility over the *sectoral composition*.

Welfare Objective

Setting $\sigma = 1$ and abstracting from government-demand pass-through to isolate the budget-constraint channel, the second-order welfare approximation is:

$$\mathcal{W} \approx -\frac{1}{2} \sum_k \mu_k \left[\underbrace{(1+\varphi)\, y_{k,t}^2}_{\text{output gaps}} + \underbrace{\frac{\theta(1-\chi_k)}{\lambda_k}\, \pi_{k,t}^2}_{\text{inflation}} + \underbrace{\chi_k^* \left(g_{k,t} - y_{k,t}\right)^2}_{\text{public-good gaps}} \right]$$

Three tensions:

1. **Output-gap stabilisation:** penalises $y_{k,t}^2$.
2. **Inflation stabilisation:** penalises $\pi_{k,t}^2$, weighted inversely by the slope λ_k.
3. **Public-good allocation:** penalises the gap $g_{k,t} - y_{k,t}$.

When $\bar{G}_t$ is unconstrained, $g_{k,t}$ can be set independently in each sector.
When only the *composition* is a choice variable, the problem changes qualitatively.

The Relative Allocation Rule

Under exogenous $\bar{G}_t$, optimal spending in sector k is expressed relative to a residual sector i:

$$g_{k,t} = \underbrace{\Phi_{ki}}_{\text{structural}} g_{i,t} - \underbrace{\frac{\varphi}{1+\lambda_k+\varphi\lambda_k}}_{\text{output response}} y_{k,t} - \underbrace{\frac{\theta\,\varphi\,(1-\chi_k)}{1+\lambda_k+\varphi\lambda_k}}_{\text{inflation response}} \pi_{k,t}$$

$$+ \quad \Phi_{ki}\left(\frac{\varphi\, y_{i,t}}{1+\lambda_i+\varphi\lambda_i(1-\chi_i)} + \frac{\theta\,\varphi\,(1-\chi_i)\,\pi_{i,t}}{1+\lambda_i+\varphi\lambda_i(1-\chi_i)}\right)$$

where Φ_{ki} collects steady-state structural ratios (consumption shares, CES weights).

Key property

The planner **reallocates** spending toward sectors with lower output gaps and lower inflation, relative to sector i. The rule is inherently *relative*: what matters is the cross-sectional dispersion of gaps.

Takeaways from the Simple Model

1. When the aggregate fiscal envelope is fixed, the planner cannot use the *level* of spending as a stabilisation tool. Policy operates through **relative reallocation**.
2. The rule preserves a countercyclical stance: spending flows toward sectors with larger negative gaps.
3. Sectoral heterogeneity in λ_k (price stickiness) and χ_k (public-good share) determines the strength of the reallocation.

Can these ideas be embedded in a richer, open-economy setting with production networks?

Overview: Aguilar et al. (2025)

A multi-country, multi-sector New Keynesian general equilibrium model:

Scale

- $K = 4$ countries (EA, US, China, ROW)
- $I = 44$ production sectors per country
- Bilateral trade flows and IO linkages

Households

- Nested CES consumption: energy vs. non-energy, domestic vs. foreign
- Incomplete international financial markets
- Calvo wage setting (country-level)

Firms

- CES production: labour $\oplus$ intermediate bundle
- Intermediates sourced domestically and abroad via nested CES aggregators
- Sector- and country-specific Calvo pricing

Policy & Government

- Country-specific Taylor rules
- Lump-sum taxes, tariff revenue
- Static production subsidies
- Balanced budget

Transmission Mechanics: Marginal Costs and the IO Network

For sector i in country k, real marginal cost depends on the full IO network:

$$\widehat{\mathrm{mc}}_{ki,t} = -a_{ki,t} + \underbrace{\mathcal{M}_{ki}\,\alpha_{ki}\;\widehat{w}_{k,t}}_{\text{domestic labour cost}} + \underbrace{\sum_{l=1}^{K}\sum_{j=1}^{I}\mathcal{M}_{ki}\,\omega_{klij}\;\widehat{p}_{klij,t}}_{\text{intermediate input costs}}$$

This feeds into the sectoral Phillips curve:

$$\pi_{ki,t} = \kappa_{ki}(\widehat{\mathrm{mc}}_{ki,t} - \widehat{p}_{ki,t}) + \beta\,\mathbb{E}_t\pi_{ki,t+1} + u^{p}_{ki,t}$$

- A cost shock in sector j of country l propagates to sector i of country k through the IO weight ω_{klij}.
- The matrix $\{\omega_{klij}\}$ encodes the *global production network*.
- Heterogeneity in κ_{ki} (Calvo probabilities) determines sectoral pass-through speed.

Tariffs as Exogenous Price Wedges

Tariffs enter as country–sector-specific price wedges on both final and intermediate goods:

$$P_{k,l,i,t} = \left(1 + \tau_{k,l,i,t}\right) \widetilde{P}_{l,k,i,t}$$

Propagation:

1. A tariff on imports from country l raises input prices $\widehat{p}_{klij,t}$ for all domestic sectors i sourcing from sector j in l.
2. Higher input costs raise $\widehat{\mathrm{mc}}_{ki,t}$, feeding into sectoral inflation.
3. Through the IO network, cost increases **cascade downstream**: sectors using the output of affected sectors face further cost pressure.
4. Tariff revenue accrues to the government; currently rebated lump-sum.

The fiscal authority plays a *passive* role in this framework. Can it be enriched?

An Original Extension

The derivations that follow are **not part of the original Aguilar et al. (2025) paper**.

They represent a low-cost extension: two supply-side fiscal instruments can be embedded without altering the core production-network structure, by modifying only the wage and price Phillips curves.

Notation. Define the *effective tax-wedge deviations*:

$$\hat{\tau}^{w}_{k,t} \equiv \frac{\tau^{w}_{k,t} - \bar{\tau}^{w}_{k}}{1 - \bar{\tau}^{w}_{k}} \qquad \hat{\tau}^{s}_{ki,t} \equiv \frac{\tau^{s}_{ki,t} - \bar{\tau}^{s}_{ki}}{1 - \bar{\tau}^{s}_{ki}}$$

where $\tau^{w}_{k,t}$ is a proportional tax on labour income and $\tau^{s}_{ki,t}$ is a production subsidy. Both are measured as percentage-point changes scaled by the steady-state net rate.

Extension 1: Labour Income Tax in the Wage Phillips Curve

Original (Aguilar et al., 2025):

$$\pi_{wk,t} \;=\; \kappa_{wk}\Big(\sigma\,\hat{c}_{k,t} + \varphi\,\hat{n}_{k,t} - \hat{w}_{k,t}\Big) + \beta\,\mathbb{E}_t\pi_{wk,t+1} + u^{w}_{k,t}$$

Extended — with a proportional labour income tax $\tau^{w}_{k,t}$:

$$\pi_{wk,t} \;=\; \kappa_{wk}\Big(\sigma\,\hat{c}_{k,t} + \varphi\,\hat{n}_{k,t} - \hat{w}_{k,t} \;+\; \hat{\tau}^{w}_{k,t}\Big) + \beta\,\mathbb{E}_t\pi_{wk,t+1} + u^{w}_{k,t}$$

- The tax wedge enters the household's wage-setting FOC: after-tax pay $(1-\tau^{w}_{k,t})\,W^{*}_{k,t}/P_t$ must cover the desired markup over the MRS.
- A tax increase ($\hat{\tau}^{w}_{k,t} > 0$) raises the pre-tax wage demanded, acting as an **inflationary** wage cost-push shock.

Extension 2: Time-Varying Production Subsidy in the Price Phillips Curve

Original (Aguilar et al., 2025) — the subsidy τ^s_{ki} is a *static* parameter:

$$\pi_{ki,t} \;=\; \kappa_{ki}\left(\widehat{\mathrm{mc}}_{ki,t} - \hat{p}_{ki,t}\right) + \beta\,\mathbb{E}_t \pi_{ki,t+1} + u^p_{ki,t}$$

Extended — making the subsidy time-varying:

$$\pi_{ki,t} \;=\; \kappa_{ki}\left(\widehat{\mathrm{mc}}_{ki,t} - \hat{p}_{ki,t} - \hat{\tau}^s_{ki,t}\right) + \beta\,\mathbb{E}_t \pi_{ki,t+1} + u^p_{ki,t}$$

- The subsidy enters the firm's pricing FOC through effective marginal cost $(1-\tau^s_{ki,t})\,\mathrm{MC}_{ki,t}$.
- A subsidy increase ($\hat{\tau}^s_{ki,t} > 0$) lowers the effective cost, acting as a **disinflationary** cost-push term.
- Both extensions preserve the additive Phillips curve structure and do not alter the IO transmission mechanics.

Government Budget Dynamics

The linearised law of motion for the government debt-to-GDP ratio:

$$\hat{b}_{t+1} = \underbrace{\frac{1+\bar{\imath}}{1+\bar{g}_Y}}_{\rho_b}\,\hat{b}_t + \frac{\bar{\imath}}{1+\bar{g}_Y}\,\hat{\imath}_t - \frac{\bar{g}_Y}{1+\bar{g}_Y}\,\hat{g}_{Y,t+1} + \frac{\bar{s}}{\bar{b}}\,\hat{s}_{t+1} - \frac{\bar{\mathcal{T}}}{\bar{b}}\,\hat{\mathcal{T}}_{t+1}$$

where $\hat{s}_t$ is the spending-to-GDP deviation and $\hat{\mathcal{T}}_t$ is the total-revenue-to-GDP deviation.

In the Aguilar et al. framework, total revenue includes tariff receipts:

$$\mathrm{Rev}_{k,t} = T_{k,t} + \sum_{l \neq k} \sum_{i=1}^{I} \tau_{kli,t}\, P^{I}_{kli,t}\Big(C_{kli,t} + \textstyle\sum_j X_{klji,t}\Big)$$

- Currently, tariff revenue is rebated lump-sum—no feedback to spending.
- **Extension:** allow revenue to finance sector-specific purchases $G_{ki,t}$, linking trade policy to the real allocation of public goods.

Next Steps

Goal: introduce endogenous, sector-specific government purchases $G_{ki,t}$ into the goods market clearing condition of the global production network model:

$$Y_{ki,t} = \sum_{l} C_{lki,t} + \sum_{l}\sum_{j} X_{lkji,t} + G_{ki,t}$$

Proposed approach:

1. **Exogenous aggregate budget.** $\bar{G}_{k,t}$ is set outside the model. The planner chooses only the sectoral allocation.
2. **Second-order welfare approximation.** Derive the loss function with IO linkages; characterise additional terms from government demand.
3. **Relative allocation rules.** Study how the optimal composition depends on the cross-sectional distribution of gaps, weighted by network position.

Fixed vs. Endogenous Fiscal Envelopes

A central question is the **welfare cost of fixing the aggregate budget**.

Fully endogenous spending

- Planner chooses both the level $\bar{G}_{k,t}$ and the composition $\{G_{ki,t}\}$.
- Both the level and the cross-sectional allocation respond to shocks.
- Benchmark: first-best fiscal stabilisation within the model.

Fixed aggregate budget

- The aggregate envelope is exogenous; only the composition adjusts.
- The simple model suggests the loss is concentrated in *aggregate* stabilisation, not in the cross-sectional allocation.
- Relevant for settings where total spending is politically constrained.

If the welfare gap is small, relative reallocation may be a sufficient instrument even without aggregate fiscal flexibility—a result with direct policy implications for budget-constrained governments.

Open Questions

- **Network centrality and fiscal allocation.** How does a sector's position in the IO network affect its optimal public-good allocation? The IO weights ω_{klij} introduce spillovers absent in the simple model.
- **Fiscal–trade policy interaction.** With tariff revenue financing government purchases, trade policy changes alter the fiscal envelope. The welfare implications of this feedback are to be characterised.
- **Dimensionality.** The Ramsey problem involves $K \times I$ spending instruments. Practical approaches may require restricting the class of admissible rules.

Summary

1. A **simple multi-sector model** shows that under a fixed fiscal envelope, optimal policy takes the form of a *relative allocation rule*: spending is directed toward sectors with larger gaps.
2. The **global production network model** of Aguilar et al. (2025) provides a quantitative environment with rich IO linkages, heterogeneous nominal rigidities, and sectoral tariffs—but currently lacks non-trivial government spending dynamics.
3. **Original, low-cost extensions**—a labour income tax in the wage Phillips curve, a time-varying production subsidy in the price Phillips curve, and a government budget identity—introduce richer fiscal dynamics without altering the core model.
4. The **research agenda** is to derive sectoral spending rules within this environment, and to assess whether the welfare cost of a fixed aggregate budget is large relative to fully endogenous spending.

Thank you

antonio.eugenelo@economics.ox.ac.uk

Appendix: Derivation — Wage Phillips Curve with Tax

The household (union) FOC with labour income tax $\tau^{w}_{k,t}$:

$$\sum_{l=0}^{\infty} (\beta\theta^{W}_{k})^{l}\, \mathbb{E}_t \left[N_{k,t+l|t}\, C^{-\sigma}_{t+l|t} \left(\frac{(1-\tau^{w}_{k,t+l})\, W^{*}_{k,t}}{P_{t+l}} - \mathcal{M}_{wk,t}\, \mathrm{MRS}_{k,t+l|t} \right) \right] = 0$$

Log-linearising the optimal reset wage:

$$w^{*}_{k,t} = (1-\beta\theta^{W}_{k}) \sum_{l=0}^{\infty} (\beta\theta^{W}_{k})^{l}\, \mathbb{E}_t \left[\mathrm{mrs}_{t+l|t} + \mu^{n}_{wk,t+l} + p_{kC,t+l} + \hat{\tau}^{w}_{k,t+l} \right]$$

After Calvo aggregation ($\pi_{wk,t} = w_{k,t} - w_{k,t-1}$):

$$\pi_{wk,t} = \kappa_{wk} \left(\sigma \hat{c}_{k,t} + \varphi \hat{n}_{k,t} - \hat{w}_{k,t} + \hat{\tau}^{w}_{k,t} \right) + \beta\, \mathbb{E}_t \pi_{wk,t+1} + u^{w}_{k,t}$$

The tax deviation enters additively: wage-setters pass the tax wedge through to the pre-tax wage.

Appendix: Derivation — Price Phillips Curve with Subsidy

The firm FOC with time-varying production subsidy $\tau^s_{ki,t}$:

$$\sum_{l=0}^{\infty} (\beta\theta^p_{ki})^l \, \mathbb{E}_t \left[\Lambda_{t,t+l} \, Y_{ki,t+l|t} \left(P^*_{ki,t} - \mathcal{M}_{pk,t+l} \, (1 - \tau^s_{ki,t+l}) \, \mathrm{MC}^n_{ki,t+l|t} \right) \right] = 0$$

Log-linearising the optimal reset price:

$$p^*_{ki,t} = (1 - \beta\theta^p_{ki}) \sum_{l=0}^{\infty} (\beta\theta^p_{ki})^l \, \mathbb{E}_t \left[\mathrm{mc}^n_{ki,t+l|t} + \mu^n_{pki,t+l} - \hat{\tau}^s_{ki,t+l} \right]$$

After Calvo aggregation ($\pi_{ki,t} = p_{ki,t} - p_{ki,t-1}$):

$$\pi_{ki,t} = \kappa_{ki} \left(\widehat{\mathrm{mc}}_{ki,t} - \hat{p}_{ki,t} - \hat{\tau}^s_{ki,t} \right) + \beta \, \mathbb{E}_t \pi_{ki,t+1} + u^p_{ki,t}$$

A subsidy increase lowers effective marginal cost, acting as a disinflationary cost-push term.

Appendix: Optimal Fiscal Rule (Unconstrained Budget)

When both the aggregate level and the composition are choice variables, and $\sigma > 1$, the optimal fiscal rule is:

$$g_{k,t} = \frac{H_k}{X_k}\, y_{k,t} + \frac{J_k}{X_k}\, a_{k,t} - \frac{\theta}{\lambda_k X_k}\, \pi_{k,t} + \frac{\sigma - 1}{(1-\chi)^{1/\sigma} X_k} \sum_k \mu_k \lambda_k\, \phi^{\pi}_{k,t}$$

$$H_k = \chi_k^* + 1 + \varphi + (\sigma - 1)\frac{\omega_{c,k}}{1-\chi_k} - \varphi\lambda_k\, \frac{1+\chi_k^*+\varphi+\frac{1}{\lambda_k(1-\chi_k)}}{\lambda_k\varphi+\frac{\kappa}{\theta-1}\,\frac{\lambda_k}{1-\chi_k}}$$

$$X_k = \chi_k^* + (\sigma-1)\chi_k^*\omega_{c,k}\chi_k + \Big(1 + (\sigma-1)\omega_{g,k}\Big)\left(\lambda_k + \frac{1+\chi_k^*+\varphi}{\lambda_k\varphi+\frac{\kappa}{\theta-1}\,\frac{\lambda_k}{1-\chi_k}}\right)$$

Comparing the welfare loss under this rule vs. the constrained rule (Section 2) quantifies the cost of fiscal inflexibility.

Appendix: Optimal Monetary Rule

Optimal monetary policy sets a weighted inflation target:

$$\sum_k \frac{\theta(1-\chi_k)}{\lambda_k}\,\pi_{k,t} = -\sum_k \mu_k\,\frac{\varphi\, y_{k,t} + g_{k,t}\Big(1+(\sigma-1)\omega_{g,k}\Big) + (1+\varphi)\,a_{k,t}}{\lambda_k\varphi + \frac{\kappa}{\theta-1}\frac{\lambda_k}{1-\chi_k}}$$

- Inflation weights increase with private-consumption share, decrease with λ_k.
- Government spending enters the target when it affects marginal costs ($\kappa > 0$).