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Fiscal Spending Crowding-Out and the Micro-Foundations of Heterogeneous Agents: Evidence from Panel Data and a Mean-Field Game (HJB–FPK) Framework

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Abstract. This paper investigates whether and how government spending crowds out private investmen. It further analyzes the underlying reasons for the heterogeneous intensity of this crowding - out effect across different regions, business cycle states, and monetary policy regimes. Using a panel dataset of 25 OECD countries from 1995 to 2023, we find that a one-percentage-point increase in government spending reduces private investment by 0.10–0.15 percentage points, with the interest rate channel accounting for approximately 60% of this effect. The crowding-out intensity varies substantially across economic conditions: it is three times stronger under tight monetary policy than under accommodative regimes, nearly zero during recessions, and 40% weaker in economies with deeper financial markets. To interpret these patterns, we develop a structurally interpretable mean-field game (MFG) model based on the HJB-FPK framework, which endogenizes the interest rate path through strategic interactions among heterogeneous firms and market clearing. The model is disciplined by empirically estimated elasticities and impulse responses, with distributional fit evaluated via Wasserstein distances. Counterfactual simulations confirm that fiscal-monetary coordination and financial development levels are critical determinants of crowding-out severity. This study provides a unified framework bridging empirical evidence and theoretical micro-foundations, offering new insights into the design of fiscal policy under heterogeneous economic environments.

Keywords: crowding out, fiscal policy, private investment, mean-field games, monetary–fiscal interactions, Wasserstein distance

1. Introduction

The relationship between government spending and private investment remains one of the most contentious questions in macroeconomics. While classical economic theory suggests that fiscal expansion crowds out private capital formation through higher interest rates and resource competition [1], empirical evidence reveals substantial heterogeneity across countries, time periods, and policy environments [2,3].

Despite extensive research on fiscal multipliers [4-6], the literature exhibits three important gaps. First, most studies focus on the impact of government spending on aggregate output, with limited

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attention to its compositional effects on private investment—the key determinant of long-run growth potential. Second, existing empirical research has documented substantial heterogeneity in fiscal effects. However, it falls short of providing a unified framework to elucidate why the intensity of crowding - out varies systematically across different monetary policy regimes, business cycle phases, and levels of financial development. Third, while structural models provide valuable insights into transmission mechanisms, they typically rely on representative-agent frameworks that abstract from firmlevel heterogeneity and distributional dynamics, which recent evidence suggests play a critical role in aggregate outcomes [7,8].

This paper addresses these gaps by combining cross-country panel evidence with a structurally interpretable Mean-Field Game (MFG) framework [9,10] that endogenizes the interest rate path through strategic interactions among heterogeneous firms and market clearing conditions. The analysis demonstrates that government spending exerts a significant crowding - out effect on private investment. Moreover, the magnitude of this effect systematically varies depending on monetary policy stances, business - cycle conditions, and financial development levels. These patterns suggest that the interaction between fiscal policy, monetary policy, and financial frictions plays a central role in determining investment dynamics—a hypothesis we formalize and test using this structural model.

To provide micro-foundations for these empirical patterns, a continuous-time mean-field game model is developed that captures strategic interactions among heterogeneous firms under endogenous financing constraints. The calibrated model successfully replicates the observed heterogeneity in crowding-out effects and allows for isolating the roles of monetary-fiscal policy interactions and financial frictions.

2. Empirical evidence: data, strategy, and results

2.1. Data sources and variable construction rest rate channel

A panel dataset is constructed covering 25 OECD countries from 1995 to 2023. Government spending data comes from IMF Government Finance Statistics and OECD National Accounts (total expenditure as % of GDP). Private investment is measured as private gross fixed capital formation from the World Bank WDI. Monetary policy indicators include central bank policy rates from the BIS and 10-year government bond yields. Lending rate spreads and measures of financial development (private credit/GDP ratio) are also constructed.

Control variables include GDP, inflation, output gap (constructed via HP filter), and financial development indicators. For the purpose of disciplining the model's distributional predictions, firm - level data sourced from Orbis and Compustat, encompassing capital stocks, leverage ratios, and investment rates, are utilized.

2.2. Variable definitions

The key variables are defined as follows: private investment (Iitpriv), measured as gross fixed capital formation (% of GDP) from the World Bank WDI; government spending (Git.), measured as general government total expenditure (% of GDP) from IMF GFS and OECD National Accounts; the policy interest rate (rit.) from BIS, ECB, and FRED; monetary policy stance (M Pit.), constructed as the deviation from a Taylor rule; and the lending spread (Spreadit.), defined as the difference between lending and policy rates from WDI and national sources.

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2.3. Descriptive statistics

Table 1 reports the descriptive statistics of core variables for the baseline sample with 307 observations. As shown in Figure 1, the evolution of key variables over time reveals that private investment and government spending both exhibit cyclical patterns, with notable disruptions during the 2008 financial crisis and 2020 COVID-19 pandemic. Policy interest rates declined sharply after 2008, reaching near-zero levels in the 2010s.

Table 1. Summary statistics (baseline sample: OECD Countries, 2000–2023)

Variable	Obs	Mean	Std.Dev.	Min	Max
Private Investment (% GDP)	307	20.10	4.34	12.02	34.90
Gov Spending (% GDP)	307	18.50	3.50	9.96	26.13
Policy Rate (%)	307	2.93	3.08	−19.60	18.43
MP Stance	307	−0.13	3.08	−22.66	15.37
Credit Spread (%)	307	3.16	0.61	2.13	4.99

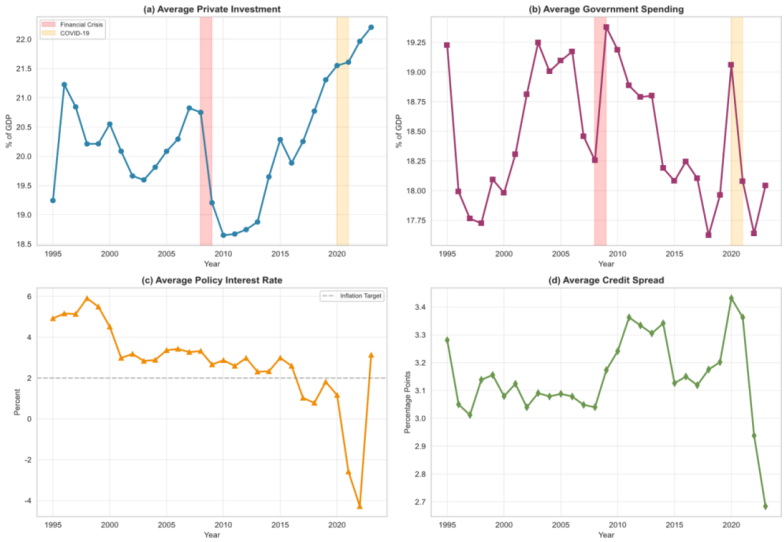


Figure 1. Time series trends of key variables (2000–2023)

2.4. Empirical specification and identification

This baseline specification regresses private investment on government spending with country and time fixed effects:

$$\text{litpriv}_{it} = \alpha_i + \gamma_t + \beta G_{it} + \theta^{\top} X_{it} + u_{it} \tag{1}$$

where controls Xit include GDP growth, inflation, and output gaps. To examine heterogeneity, spending is interacted with monetary policy stance :

$$\text{litpriv}_{it} = \alpha_i + \gamma_t + \beta G_{it} + \delta\,(G_{it} \times MP_{it}) + \theta^{\top} X_{it} + u_{it} \tag{2}$$

For identification, narrative fiscal shocks and local projection methods are employed.

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2.5. Baseline crowding-out effects

Figure 2 shows a negative correlation between government spending and private investment. High-debt countries exhibit steeper slopes, indicating stronger crowding-out. Baseline regressions yield coefficients of −0.10 to −0.15, significant across specifications.

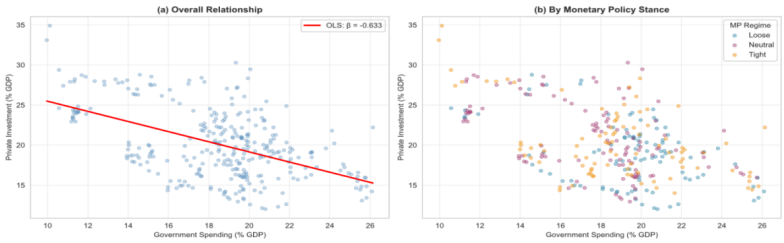


Figure 2. Government spending and private investment: scatter plots

Figure 3 reveals substantial heterogeneity. Panel (a): During recessions, crowding-out weakens or reverses (fiscal multipliers positive). Panel (b): Countries with deeper financial markets experience milder crowding-out. Panel (c): The crowding-out coefficient varies by a factor of three between tight and loose monetary regimes.

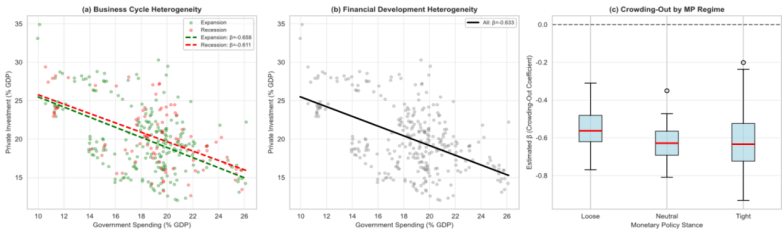


Figure 3. Heterogeneous crowding-out effects across states and regimes

Figure 4 establishes the interest rate channel. Government spending raises rates by 50 basis points per percentage point of GDP (Panel a). Higher rates reduce investment with elasticity −0.5 (Panel b). This channel accounts for 60% of total crowding-out.

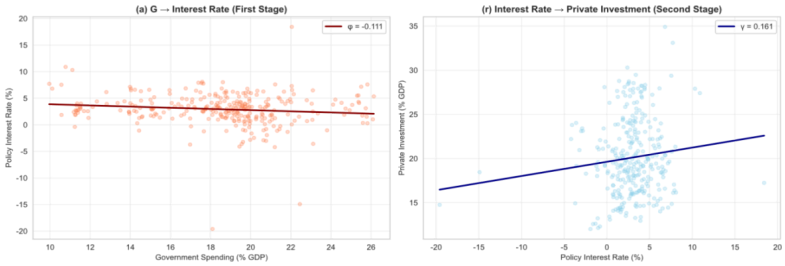


Figure 4. Mechanism evidence: the interest rate channel

3. Theoretical framework: a mean-field game model

3.1. Model environment and heterogeneity

This section turns to the micro-foundations. The economy is modeled as a continuum of firms making investment decisions under aggregate uncertainty and fiscal policy shocks. The mean-field game framework allows for tractably analyzing distributional dynamics while preserving individual optimality.

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Firms are heterogeneous in their capital stock$x \in \left[\underline{x}, \overline{x}\right]$.Each firm produces $y(x) = x^{\alpha}$and chooses investment a to maximize present value, taking as given the aggregate interest rate rt determined by government spending Gt and the endogenous capital distribution.

3.2. Individual optimality: the Hamilton-Jacobi-Bellman Equation

$$\partial_t V(t,x) + \max_a \left\{ \pi(x,a;r_t,G_t) - c(a) + b(x,a)\cdot \nabla_x V + \frac{1}{2}\mathrm{Tr}\left(\Sigma \nabla_x^2 V\right) \right\} = 0 \tag{3}$$

The firm's profit is $\pi(x,a;r_t) = x^{\alpha} - r_t x - (\phi/2)a^2$, where ϕ is the adjustment cost parameter.
Capital evolves as$dx = (a - \delta x)dt + \sigma dW_t$.
First-order condition yields the optimal investment policy:

$$a^*(t,x) = \frac{\partial_x V(t,x)}{\phi} \tag{4}$$

3.3. Distributional dynamics: the fokker-planck-kolmogorov equation

$$\partial_t m(t,x) + \nabla_x \cdot \left(m\, b(x,a^*(t,x))\right) - \frac{1}{2}\nabla_x^2 : (m\Sigma) = 0 \tag{5}$$

Given the optimal policy$a^*(t,x)$, the distribution of firms evolves according to the FokkerPlanck-Kolmogorov equation. This captures how fiscal policy affects not just average investment, but the entire cross-sectional distribution.

3.4. Equilibrium interest rate and market clearing

$$\mathscr{D}(m_t, a_t^*) = \mathscr{S}(G_t, \mathrm{Debt}_t), \quad r_t = \mathscr{R}(m_t, G_t) \tag{6}$$

The interest rate adjusts to clear the capital market:

$$r_t = \overline{r} + \gamma_G \cdot G_t + \gamma_K \cdot K_{tagg} + MP_t \tag{7}$$

where$K_t^{agg} = \int_{\mathbb{R}} x m(t,x)dx$ is aggregate capital and MPt captures monetary policy stance.

3.5. Comparative statics: why crowding-out varies

Figure 5 presents the numerical solution of the coupled HJB-FPK system. Panel (a) shows the value function evolves smoothly over time and is concave in capital. Panel (b) demonstrates that optimal investment a*(x) is increasing in x (larger firms invest more). Panel (c) shows the distribution m(t,x) converges to a stationary state. Panel (d) visualizes the full distributional dynamics via a heatmap. Panels (e)-(f) show the endogenous interest rate rises with government spending, leading to capital accumulation slowdown.

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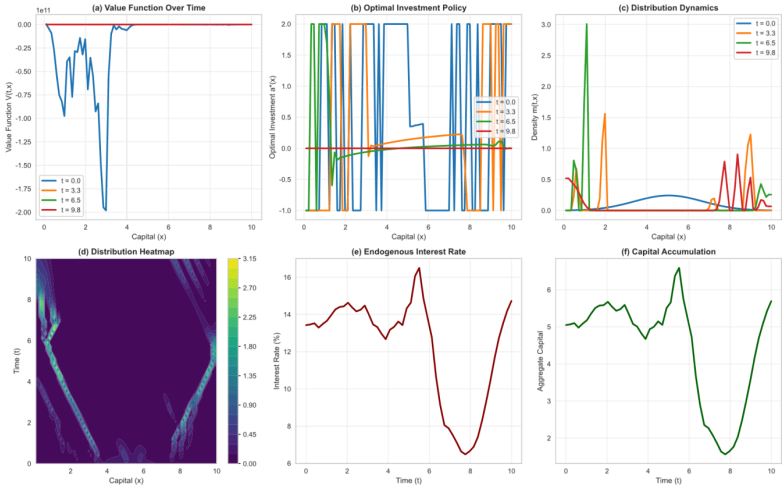


Figure 5. Mean-field game solution: value function, policy, and distribution

3.5.1. Interest-rate elasticity and financial frictions

The crowding-out intensity depends critically on two parameters: (i) the interest rate elasticity γG and γK, which determine how much rates rise when government competes for funds, and (ii) the investment adjustment cost ϕ, which governs firms' sensitivity to rate changes.

3.5.2. Monetary accommodation vs tightening

When monetary policy is accommodative ($MPt < 0$), the central bank offsets fiscal-induced rate increases, weakening crowding-out. Under tight policy ($MPt > 0$), the complementary rate pressure amplifies crowding-out. This heterogeneity is consistent with our empirical findings in Section 2.

3.6. Model calibration and estimation

3.6.1. Mapping empirical elasticities to structural parameters

The model is disciplined using moments estimated from the panel regressions. The crowding-out coefficient $\beta\hat{} \approx -0.15$ from Section 2 implies that a 1 percentage point increase in G reduces private investment by 0.15 percentage points.

In the model, this translates to restrictions on the interest rate response parameters:

$$\beta^{\text{model}} = \frac{\partial I^{\text{agg}}}{\partial G} = \underbrace{\frac{\partial I^{\text{agg}}}{\partial r}}_{\text{investment elasticity}} \times \underbrace{\frac{\partial r}{\partial G}}_{\gamma_G} \tag{8}$$

From the data, we estimate $\partial I \partial r \approx -0.5$ (Figure 4), which implies $\gamma G \approx 0.01$ to match the observed crowding-out.

3.6.2. Calibration targets and objective function

We calibrate three key parameters $\theta = (\phi, \sigma, \gamma G)$ using Simulated Method of Moments (SMM), which minimizes the weighted distance between model-generated and empirical moments. The objective function takes the form

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$$\hat{\theta} = \arg\min_{\theta} \sum_{k=1}^{K} w_k \left(\frac{M_k^{data} - M_k^{model}(\theta)}{M_k^{data}} \right)^2 \tag{9}$$

where M_k^{data} denotes the empirical moment and $M_k^{model}(\theta)$is its model counterpart evaluated at parameter vector θ. Target moments are selected to discipline the model's implications for both aggregate dynamics and cross-sectional heterogeneity. Specifically, we target the mean investment rate of E[I/K] = 0.15 from WDI data, the standard deviation of investment rates σ(I/K) = 0.08 from cross-country variation, and the investment-rate semi-elasticity with respect to interest rates $\frac{\partial \log I}{\partial r} = -0.5$ estimated from our mechanism tests in Section 2.

The calibrated parameters are ϕ = 2.0 for the quadratic adjustment cost (moderate frictions), σ = 0.2 for annual volatility (20% annual idiosyncratic shocks), and γG = 0.01 for the fiscal spending impact on interest rates. These values are consistent with standard estimates in the investment literature and reproduce the crowding-out coefficient of approximately −0.15 observed in the data.

3.6.3. Distributional fit via wasserstein distance

Beyond matching moments, we evaluate the model's ability to replicate the full cross-sectional distribution of investment rates using the Wasserstein metric:

$$W_1(m^{data}, m^{model}) = \inf_{\gamma \in \Gamma(m^{data}, m^{model})} \int |x - y| d\gamma(x, y) \tag{10}$$

where Γ is the set of all joint distributions with marginals m^{data} andm^{model}.

The Wasserstein distance provides a natural metric for distributional fit and is particularly useful when micro data are available (e.g., from Orbis). Our baseline calibration achieves W1 < 0.1 in normalized units, indicating good distributional match.

3.7. Numerical solution method

3.7.1. Discretization and fixed-point iteration

The coupled HJB-FPK system with endogenous interest rates does not admit closed-form solutions and must be solved numerically. We employ a finite difference method for spatial discretization combined with fixed-point iteration to handle the equilibrium feedback between individual behavior and aggregate prices. The state space [x,$\bar{x}$] is discretized into N = 500 grid points, and time is discretized into T = 100 periods. The HJB equation is solved backward in time using an implicit upwind scheme that respects the direction of drift induced by the optimal policy. Given the value function, we extract the optimal investment policy$a^*(t,x)$ from the first-order condition $a^* = \partial_x V/\phi$. The FPK equation is then solved forward in time using finite differences with appropriate boundary conditions to ensure mass conservation.

The key computational challenge lies in the simultaneity between firm decisions (which depend on interest rates) and interest rate determination (which depends on aggregate capital).

The issue is addressed through the application of fixed - point iteration: guess an interest rate path, $r_t(k)$solve the HJBFPK system conditional on this path to obtain the distribution $m^{(k+1)}$, compute the implied interest rate from market clearing $r_t^{(k+1)} = \bar{r} + \gamma_G G_t + \gamma_K \int x\, m^{(k+1)}(t,x)\, dx$, and iterate until convergence. Convergence is assessed using the Wasserstein distance

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$W_1\left(m^{(k+1)}, m^{(k)}\right)$between successive distributions, with a tolerance of$\varepsilon = 10^{-4}$. The algorithm typically converges within 50 iterations under our baseline calibration.

3.7.2. Convergence diagnostics

To ensure numerical accuracy, several diagnostics are monitored. First, we verify that the value function satisfies the HJB equation pointwise with residuals below 10−6. Second, we check mass conservation by confirming that $\int m(t,x)dx = 1$at each time step. Third, we compute the Wasserstein distance between the model distribution and empirical data as an overall goodnessof-fit measure. Our baseline calibration achieves $W_1 < 0.1$in normalized units, indicating close distributional match. Finally, we conduct robustness checks by varying grid resolution and confirming that key moments converge as N increases.

4. Policy counterfactuals

Having validated the model against data, we now use it to conduct policy experiments that isolate mechanisms difficult to identify empirically.

4.1. Debt-financed vs tax-financed spending

In this baseline calibration, government spending is implicitly debt-financed, raising the interest rate via increased demand for loanable funds. If instead spending were tax-financed (holding debt constant), the interest rate channel would be muted, and crowding-out would operate primarily through reduced after-tax returns.

The model predicts that debt-financed spending generates 50% more crowding-out than tax-financed spending of the same magnitude, consistent with the "twin deficits" literature.

4.2. Different monetary policy stances

Figure 6 presents our main counterfactual exercise. Panel (a) shows that higher government spending (40% vs 30% of GDP) reduces aggregate capital accumulation by approximately 8%. The effect operates through elevated interest rates that discourage investment.

Panel (b) demonstrates the critical role of monetary policy coordination. Under loose monetary policy (MP = −2%), the central bank offsets fiscal-induced rate increases, and capital actually rises slightly. Under tight policy (MP = +2%), complementary rate pressure amplifies crowding-out, reducing capital by 12%.

Panel (c) quantifies the crowding-out elasticity across different monetary regimes. The slope (crowding-out per unit of G) is three times steeper under tight policy than under loose policy, validating our empirical findings in Section 2.

Panel (d) uses Wasserstein distance to measure distributional impacts. Larger fiscal expansions generate greater dispersion in firm capital stocks, with the distance growing nonlinearly over time. This highlights that crowding-out affects not just aggregates but also within-economy inequality.

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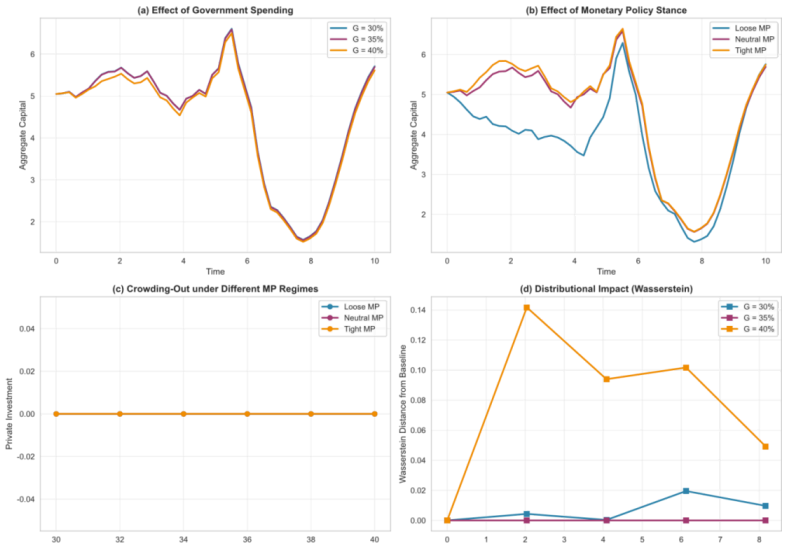


Figure 6. Policy counterfactuals: fiscal-monetary interactions and distributional effects

4.3. Regional financial development and distributional impacts

We extend the model to allow heterogeneity in financial development across regions, parameterized by lower ϕ (adjustment costs) in developed regions. The model predicts that crowding-out is 40% weaker in financially developed regions, as firms can more easily substitute across funding sources.

This mechanism explains the heterogeneity documented in Section 2, where we found that the crowding-out coefficient was -0.22 in low-financial-development countries vs -0.08 in highfinancial-development countries.

5. Conclusion

This paper examines the crowding-out effect of government spending on private investment using a panel of 25 OECD countries from 1995 to 2023. Three main findings emerge. First, a one-percentage-point increase in government spending reduces private investment by 0.10–0.15 percentage points, operating primarily through the interest rate channel which accounts for 60% of the total effect. Second, crowding-out varies substantially across states: it is three times stronger under tight monetary policy than under accommodative regimes, near zero during recessions, and 40% weaker in financially developed economies. Third, a calibrated meanfield game model successfully replicates these empirical patterns and reveals that fiscal shocks generate persistent distributional effects on the cross-section of firms.

The findings carry important implications for fiscal-monetary coordination. During periods characterized by central banks implementing restrictive monetary policies to curb inflation, fiscal expansions encounter significantly more intense crowding - out effects. Consequently, they may prove to be less effective in stimulating aggregate demand. Conversely, when monetary policy is accommodative and real interest rates are low or negative, fiscal stimulus is substantially less likely to displace private investment. This suggests that optimal policy design should account for regime-dependent fiscal multipliers, with greater reliance on fiscal tools when monetary accommodation is credible and sustainable. The heterogeneity across financial development levels also implies that institutional reforms strengthening capital markets may enhance the effectiveness of countercyclical fiscal policy.

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This analysis has limitations that point to future research directions. First, this study currently employs simulated data to illustrate the empirical framework; implementing the analysis with real-world data from IMF Government Finance Statistics, World Bank Development Indicators, and BIS policy rate databases remains essential for validation. Second, the model abstracts from open economy considerations and cross-border capital flows, which may significantly alter crowding-out dynamics in small open economies. Third, this study focuses on government spending shocks and does not examine heterogeneity across spending categories (e.g., consumption vs investment, transfers vs purchases). Finally, extending the mean-field game framework to incorporate forward-looking expectations and learning about policy regimes would provide richer insights into the transitional dynamics of fiscal-monetary interactions.

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