Mini-Review of the Literature on Amplification: Putting Ottonello and Winberry (2020) in Context

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October 7, 2022

1 Existing Literature

In this section I provide a short summary of the most relevant literature on the implications of featuring financial frictions in dynamic stochastic general equilibrium models. The literature on asymmetric information developed in the 70s paved the way for a rigorous treatment of the implications stemming from the failure of the Modigliani-Miller theorem for aggregate fluctuations. It consists of a formalization of older ideas developed by Keynes and Fisher, who, among others, attribute an important role to the financial structure of a market to explain self-reinforcing dynamics of investment and output.
The purpose of this section is to lay down a general background that helps framing the paper by Ottonello and Winberry (2020) in the context of the literature on amplification.

Bernanke and Gertler (1989) The paper proposes an overlapping generations model (entrepreneurs live one period) where borrowers with fixed side investment projects face the costly state verification problem. The optimal contract is a standard debt contract that suggests an inverse relationship between borrower's wealth and expected agency costs (monitoring/bankruptcy). High wealth implies relying less on external finance, so smaller default risk and lower premium for external finance.
In the model, productivity shocks

(i) Lower current cash flows,which raises external finance premium, causing investment to decline even more.

(ii) Change in valuation of the real and financial assets that borrowers hold. Productivity shocks lower the value of assets and hence of producers' collateral which leads to tightening of borrowing.

Carlstrom and Fuerst (1997) The paper introduces a computable general equilibrium that embeds the qualitative results in BG (agency costs as financial frictions lead to amplification of aggregate productivity shocks).
They propose a RBC general equilibrium model with agency costs in the investment good production, but no frictions in final good production. Entrepreneurs are infinitely lived, but thanks to anonymity in financial transactions history matters only for the dynamic of the state variables and does not rely on past entrepreneurial behaviour. Linearity in production and monitoring technology allow for easy aggregation focusing only on first moment. Agency costs implies internal returns are higher than external ones: to ensure that self-financing does not arise mechanically just by waiting until they have enough internal resources, entrepreneurs have higher discount factors than household.
The main results consist of

(i) An upward sloping expected capital output, a natural result of the agency problem: for a given level of net worth, increases in capital production are possible only with a greater reliance on external funds, and these external funds are subject to greater agency costs.

(ii) Hump-shaped output behavior following a productivity whock, which arises because households delay their investment decisions until agency costs are at their lowest-a point in time several periods after the initial productivity shock. Agency costs fall with time because the productivity shock increases the return to internal funds, which in turn redistributes wealth from households to entrepreneurs.

Bernanke, Gertler and Gilchrist (1998) Generalize the concept of financial accelerator as an amplification mechanism for small real and nominal shocks and first to incorporate financial frictions in a dynamic new keynesian model. Similarly to previous literature, frictions are modeled as an external finance premium arising from asymmetries of information within the borrower-lender relationship; agency costs arising from asymmetric information make the Modigliani-Miller theorem fail in the stochastic dynamic general equilibrium setting.
Contributions with respect to theoretical modeling:

(i) Incorporate price stickiness and money in a RBC model with financial frictions. A crucial aspect is the separation of entrepreneurs from retailers to avoid aggregation issues arising from complementarities in production.

(ii) Allow for decision lags in investment, which enables the model to generate both hump-shaped output dynamics and a lead-lag relationship between asset prices and investment, as is consistent with the data

(iii) Include heterogeneity among firms to capture the real-world fact that borrowers have differential access to capital markets. Exogenously model two sectors (constrained vs unconstrained) with different external premium: constrained firms react more strongly to monetary policy thanks to the endogenous dynamic of net worth, a result in constrast to previous literature.

Two main mechanisms drive the dynamics of the model:

(i) **Assumption**: risk neutrality of entrepreneurs and risk-aversion of households ensure a predetermined safe rate of return to the lenders by absorbing all the aggregate risk; negative shocks decrease entrepreneurial net worth, raise the external finance premium generating amplification.

(ii) **Implication**: in the presence of credit-market frictions present, and with the total amount of financing required held constant, standard models of lending with asymmetric information imply that the external finance premium depends inversely on borrowers' net worth. A decrease in net worth generates misalignment of interests between lenders and borrowers, increasing agency costs; given the prociclicality of net worth, the external finance premium is countercyclical and plays the role of an amplifier of aggregate shocks.In other words, the external finance premium generates an upward sloping cost of funds

Carlstrom, Fuerst and Paustian (2016) The crucial assumption of Bernanke, Gertler and Gilchrist (1999) is the lack of state contingency in the world, since they assume that the lending contract between the entrepreneur and lender is characterized by a lender return that is invariant to innovations in aggregate variables. That being said, the paper derives the private optimal contract (POC) relaxing that assumption: it emphasizes the sub-optimality of the private contract implied by BGG and shows that a the POC takes the form of a state-contingent debt contract that dampens fluctuations in leverage and the risk premium.
In the presence of a positive productivity shock, the entrepreneurs in BGG exhibit a sharp increase in net worth given the predetermined nature of the payment to the lender, which sets in motion the financial

accelerator. In contrast, the POC implies that the gains of a positive productivity shock are shared between the entrepreneur and the household, dampening the financial accelerator channel. The findings are robust also in the presence of a monetary policy shock.

Dimitriev and Hoddenbagh (2017) The paper extends Bernanke, Gertler and Gilchrist (1999) by relaxing the following assumptions:

(a) Lenders returns are predetermined

(b) Entrepreneurs are myopic (they maximize only next period expected consumption)

(c) Entrepreneurs are risk-neutral,

To do so, they introduce forward-looking entrepreneurs who maximize the present discounted value of all future consumption instead of next period expected consumption, and derive the optimal contract for the CSV model. The main conclusions are that under the optimal contract the amplification is smaller than in BGG (entrepreneurs ask as they were risk averse) and that shocks to the cross-sectional variance of entrepreneurs' idiosyncratic productivity have relatively small impact on the real economy when loan contracts are optimal, in contrast with the BGG contract.

2 Ottonello and Winberry (2020)

The goal of the paper is to understand the role of financial frictions in determining the investment channel of monetary policy, given that aggregate investment is the most responsive component of GDP to monetary shocks. In particular, they contribute to characterizing the differential response of firms across the spectrum of their financial positions, given the the theoretical ambiguous answer.

2.1 Contribution

The paper's contributions span different strands of literature

(i) **Financial Frictions**: include heterogeneity in New Keynesian models featuring a financial accelerator. Show that distributional dependence is crucial to characterize the degree of amplification in models with financial frictions.

(ii) **Heterogeneous Effects of Monetary Policy**: identify default risk as an additional channel that generates heterogeneity in the investment response of firms, where other studies were focusing on aspects like size, liquidity or age.

(iii) **Heterogeneity in New Keynesian Models**: advancements in modelling firm heterogeneity and in identifying the relative strength of direct and indirect channels for the transmission of monetary policy on investment. Evidence in contrast with literature on household heterogeneous agents, given the high sensitivity of firms to interest rate fluctuations.

(iv) **State Dependence of Monetary Policy Effectiveness**: propose new mechanism that relies on the default risk distribution to explain why monetary policy is less effective in recessions.

(v) **Aggregate Investment Dynamics**: extend the literature by including capital quality shocks and time varying price of capital, which generates results in line with the financial accelerator literature.

2.2 Summary

Overall, the paper can be summarised in three main blocks

Empirical Evidence Reduced form estimates on the heterogeneous investment response of firms along their balance sheet structure following a monetary shock using Compustat data. The main elements are:

ε_t^m Monetary policy shock constructed using high-frequency identification with implied Fed Funds Rate from future contracts.

x_{jt} Measures of financial position such as leverage, distance to default and credit rating.

Z_{jt} Aggregate and firm specific controls

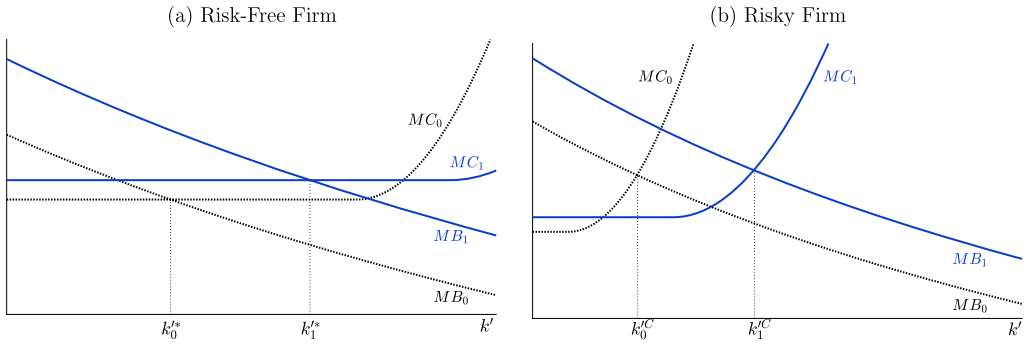
The baseline specification is

$$\Delta \log k_{jt+1} = \alpha_j + \alpha_{st} + \beta \left(x_{jt-1} - \mathbb{E}[x_{jt}] \right) \varepsilon_t^m + \mathbf{\Gamma}' Z_{jt-1} + e_{jt} \tag{1}$$

where the parameter of interest is β, which measures the semielasticity of investment to monetary policy along the spectrum of financial positions. The main takeaway is that firms with lower leverage and higher distance to default are more responsive to monetary policy shocks.

The Model The setup is a heterogeneous firms NK model with default risk, where the investment block plays the most important role.
Main theoretical result: unconstrained firms and constrained ones follow different capital accumulation policies. Conditional on being a constrained firm[1], the authors propose a candidate mechanism that explains how financial heterogeneity is crucial for investment response. For a given level of productivity, figure 1 shows marginal cost (MC) and marginal benefit (MB) schedules as function of capital accumulation for two firms with different net worth, a proxy for default risk.

Figure 1: Response to monetary policy for risk-free and risky firms.



The mechanics of the model can be summarised as it follows:

(a) **Risk-Free Firm**: thanks to high net worth, the MC is mostly flat and increasing only for high k' due to credit spread cost for financing, which signals higher default risk. MB is downward sloping due

[1]The reason to focus on the set of constrained firm is justified by the fact that they account for more than 99% of the sample in Compustat.

to diminishing returns to capital. Being risk-free implies that MC and MB meet on the flat portion.
Reaction to ε_t^m: there are different channels that contribute to the overall effect. MB shifts due to: (i) inflated discounted return on capital; (ii) general equilibrium effects on the real wage, the price of output and the price of capital; (iii) covariance term in MB; (iv) change in default threshold. MC shifts because of increase in q due to increased aggregate demand for investment. In equilibrium, the schedules still intersect along the flat region.

(b) **Risky Firm**: due to its lower net worth, for the same level of investment it must pay more so MC is steep in regions where the risk-free one is flat.
Reaction to ε_t^m: while MB shifts in a similar fashion, there are two additional channels that shape MC other than the shift due to pure demand effect:

(i) Extended flat region thanks to an increase in n through the cash flow channel

(ii) Flattened curve (i.e. lower creadit spread) thanks to an increase of the recovery rate $\alpha q_{t+1}\omega_{t+1}k_{jt+1}$ through higher q_{t+1}

Analysis The main objective is to assess through the lens of the model the relative strength of the before mentioned identified mechanism. To do so, the paper calibrates the model with a mix of fixed and fitted parameters to match a set of empirical regularities. Three validation exercises are performed:

1. Characterize how the model replicates the distribution of growth rates in comparison with the data, which they claim to be a key source of financial heterogeneity, finding a positive performance.

2. Compare empirical estimates with the model implied regression coefficients and test implications of model mechanisms for the data. The main results are the following:

   (i) High-leverage firms are less responsive to monetary policy shocks in the model, as in the data

   (ii) The model implied R^2 is almost 5 times the one observed in the data, which suggests that the data contain more unexplained variation.

   (iii) The dynamics of differential responses of investment are persistent, consistent with the data

3. Decompose the relative contribution of different channels to better understand the source of the observed heterogeneous responses across firms. The paper looks at which are the most relevant prices that work as shifters of the schedules by feeding the model with the path of each price $p \in P$ keeping $\mid P_{-p} \mid$ fixed for different levels of productivity.
   The paper finds out that the heterogeneous responses in the model are indeed driven by the fact that firms with high default risk face a steeper marginal cost curve for financing investment, and that the direct effect through the real interest rate is the main driver of the response, in contrast with the heterogeneous households literature which emphasizes the importance of indirect effects; the reason hinges on the fact that firms are more sensitive than households to interest rates.

Comments The main criticism of Ottonello and Winberry (2020) appears in Jeenas (2019), which stresses the importance of liquidity as a source of heterogeneity in investment responses following a monetary shock. In the paper, the ability of leverage to explain this heterogeneity disappears when simultaneously controlling for liquid asset holdings. In contrast, the estimates for the relevance of liquid asset holdings barely change when conditioning on leverage. These results suggest that the negative correlation between leverage and liquid asset holdings in the cross-section of firms leads to an omitted

variable bias in the leverage regression.
While the criticism in Jeenas (2019) takes a stand on what actually matters within the firms' balance sheet composition (the x term of the interaction), it could be possible to better understand what the ε is accounting for. Monetary policy shocks are identified in a narrow window around the FOMC meetings, ignoring potential exogenous variations within those events. We know that nowadays central bankers use communication as a tool more frequently than in the past, and markets price the central banks decision far before the actual meetings. It could be possible that the identified shocks account for something that has already happened in the past, something that the markets have partially already internalized, leading to a dampening of the size of the shock. Using new data sources that track all the monetary policy communication tools could help to understand whether this hypothesis holds in practice or not.

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