

# State-Dependent Pass-through from Monetary Policy to Lending Rates

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## Abstract

The efficacy of monetary policy depends crucially on the extent to which bank lending rates respond to changes in policy rates. This paper documents that this response is state-dependent. I show empirically that the key state variable is the skewness of the cross-sectional distribution of lending rates across banks prior to the change in the policy rate. High initial skewness leads to a stronger response of (i) bank lending rates and (ii) economic activity to monetary policy. I develop a model of imperfect competition among banks that accounts for this empirical finding. A key feature of the model is that borrowers face search and switching frictions. A higher degree of dispersion among lending rates increases borrowers' expected returns to search. In these circumstances, strategic behaviour by banks leads to higher responsiveness of lending rates to policy rate changes. Through this channel, the model can also reconcile my finding that conventional monetary policy has stronger effects on economic activity the more skewness there is in bank lending rates.

**JEL classification:** E43, E44, E52, G21, I16.

**Keywords:** Monetary Policy, Lending rate responsiveness, Skewness State-Dependence, Search and Switching Frictions, Strategic Price Complementarities.

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# 1 Introduction

The efficacy of monetary policy crucially hinges on the way the financial system reacts to its interventions. In this paper, I focus on the extent to which bank lending rates respond to changes in monetary policy rates.<sup>1</sup>

In the first part of the paper, I establish two key empirical results. First, I document the state-dependence of the response of lending rates to monetary policy based on the skewness of the initial distribution of lending rates. Second, the effects of monetary policy on output are also larger the higher is the initial skewness.

In the second part of the paper, I develop a model of imperfect competition among banks that accounts for these empirical findings. In this model borrowers face search and switching frictions. In addition, banks are strategic and compete over prices (i.e., Bertrand competitors). Other things equal, borrowers prefer to stick to their current lender. However, if they observe that their lender offered particularly unfavorable rates in the recent past, they expect high gains from searching for a new lender. A higher skewness will lead to a greater mass of borrowers searching. Under these circumstances, banks respond to this larger pool of potential customers by competing more intensely on prices. As a result, a higher cross-sectional skewness in initial lending rates leads to a higher response of lending rates to policy rate changes. The stronger response in lending rates, in turn, prompts a stronger transmission of monetary policy effects to output, consistently with the second key empirical finding.

The recent literature on monetary policy state-dependence has so far focused on the role of refinancing costs on house mortgagees' refinancing decisions ([Berger et al. \(2021\)](#), [Eichenbaum et al. \(2022\)](#)). My paper focuses on the supply side of bank loan markets. The state variable that I emphasize affects commercial, consumer durables in addition to housing loan markets. My theoretical model builds on the literature studying bank competition and cost pass-through. In contrast to that literature, I emphasize the importance of customer search and switching frictions on banks' pricing strategies. Conventionally, models of state-dependent price stickiness feature adjustment costs on the side of price-setting firms.<sup>2</sup>

Two main stylized facts suggest scope for analyzing the cross-sectional skewness of lending rate as a relevant state-variable. First, the cross-sectional distribution of mortgage rates for a given period, county and loan type displays a long right fat tail, i.e. high cross-sectional skewness. This feature remains true even after controlling for borrower riskiness (FICO score, Debt to Income ratio etc.). Figure 1 Panel A provides an example. Second, the same cross-sectional skewness controlled for bank characteristics also exhibits significant variation over time, as shown in Figure 1 Panel B. The first stylized fact raises the question: why would two borrowers with the same characteristics accept

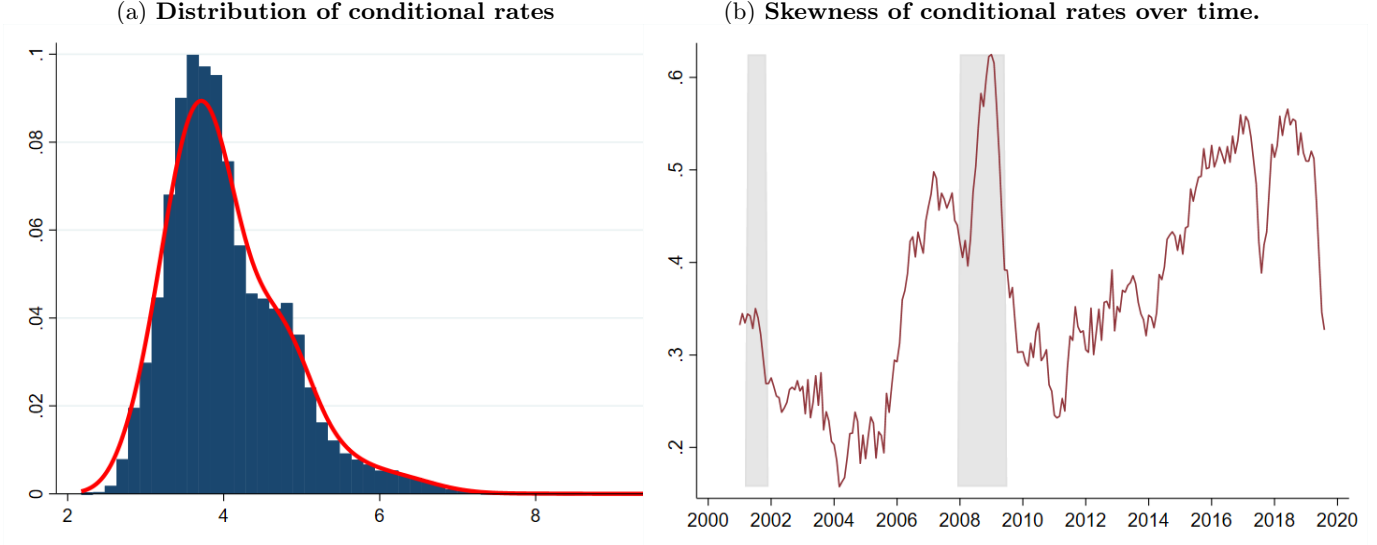
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<sup>1</sup>Policy rates are here to be intended as the set of rates that central banks can either set (e.g. Interest Rate on Excess Reserves) or influence directly through open market operations (e.g. Federal Funds Rate)

<sup>2</sup>An alternative mechanism might be that banks face adjustment costs when setting interest rates on loans. [Driscoll and Judson \(2013\)](#) show evidence that this type of frictions do not fit the data well.

different interest rates on the same loan? The answer this paper argues for is that these two borrowers differ in their search and switching costs. The second stylized fact highlights the time-varying nature of lending rates cross-sectional skewness suggesting the presence of a state-dependent and asymmetric source of stickiness in bank lending rates.

Figure 1: 30Y Mortgage Rates. Minneapolis-MSA. January 2019



*Notes:* This figure is based on interest rates on 30Y House Mortgage Loans purchased by Freddie Mac. Panel A displays the distribution of rates after partialling out the effects of Borrower and Loan characteristics (following non-parametric methodology by [Hurst et al. \(2016\)](#)). Panel B displays the time series of the skewness of the distribution displayed in Panel A. Source: Freddie Mac Single Family Loan Level Dataset and author computations.

As mentioned above, the analysis proceeds in two steps. In the empirical portion of the paper, I construct a comprehensive Macro-Banking dataset featuring different levels of dis-aggregation and granularity. The dataset contains (i) quarterly bank-level data on assets, liabilities, income and expenses, (ii) monthly branch-level data on advertised lending rates for several loan products (new auto loans 50K, motor-home loans 150K et.), and (iii) quarterly loan-level data on house mortgage loans (loan and borrower characteristics). I complement this data with information on output, unemployment, personal income, consumer and home price indexes, and wage indexes at the national, state, county, and MSA level. Using this dataset, I investigate how the response of bank lending rates to changes in monetary policy depends on the level of the initial cross-sectional skewness of lending rates. I do so using a local projection framework allowing for state-dependent responses ([Tenreyro and Thwaites \(2016\)](#); [Ramey and Zubairy \(2018\)](#)). Following the recent literature on the estimation of monetary policy effects, I address endogeneity issues by focusing on the response to monetary policy rate shock. I identify this shocks using high-frequency changes in money market interest rates in a narrow window around monetary policy announcements (see e.g. [Nakamura and Steinsson \(2018\)](#); [Bauer and Swanson \(2022\)](#), more discussed in Section V). The results provide strong evidence that

the response of lending rates and output to monetary policy shocks is increasing in the initial level of the cross-sectional skewness of lending rates. In particular, a 1-standard deviation higher initial cross-sectional skewness of lending rates is associated with a roughly 70% stronger response of lending rates and output to monetary policy over the first 10 months.

In the theoretical portion of the paper, I develop a model that can account for this empirical finding. The model analyses the behaviour of imperfectly competitive banks when there is customer segmentation due to (i) loan product differentiation, (ii) search and (iii) switching frictions. The latter features temper the degree of strategic price complementarity among banks. In what follows, I provide a sketch of the key features and implications of the model. Consider an environment in which there are two banks. For simplicity, I assume the loan duration is one period and borrowers are not risky. In reality, banks tend to cater to either a niche or a more general pool of clients. To capture this fact, I suppose that one bank has a bigger pool of customers than the other. The two banks have an advantage within their respective pool of clients: each period customers know their bank's new rate for free but they need to pay a search cost to know the rate offered by the other bank. All customers, however, know the rates charged by all banks in the previous period.<sup>3</sup> Customers use previous interest rates to estimate the returns from search and switching to a competitor bank.<sup>4</sup> I denote by "high-rate" and "low-rate" bank, the bank that has the higher and lower rate respectively at the beginning of the period.

The model timing is as follows. First, borrowers decide whether to stay with their initial bank or pay the search cost and know the rate offered by the other bank. Second, monetary policy makers set the policy rate. Third, Banks set their lending rates. Third, banks decide their lending rates. Finally, borrowers make their loan decisions. The customers of the low-rate bank never have incentives to search. Customers of the high-rate bank, instead, expect returns to search that are increasing in the gap between initial rates of the two banks. The higher is that gap the stronger are the incentives of the low-rate bank to poach customers from the high-rate bank. The high-rate bank has more of an incentive to prevent its competitor to poach its customers.

The incentives of the low-rate bank to poach customers will also increase in the mass of consumers of the high-rate bank on search. The rationale is that the low-rate bank trades off the loss (gain) in profits on its current customers (intensive margin) with the profit gain (loss) from poaching customers from the competition (extensive margin). As a result, the price complementarity between the two banks is increasing both in the initial lending rates gap and in the initial mass of the high-rate bank clients. Monetary policy shifts the marginal cost to a bank of producing a loan. When the central bank decreases the policy rate, both banks decide how much to change their lending rates. I show that banks change their lending rates more the higher is the beginning-of-period gap in lending rates and the mass of initial consumers of the high-rate bank. The more they change the lending rates, the

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<sup>3</sup>Stylized way to represent inattentive clients getting information from friends, media etc with a time lag.

<sup>4</sup>Borrowers are assumed to have a simple random walk model in mind where lending rates evolve as a linear function of banks' cost of funds which are themselves evolving as random walks.

stronger the effect of monetary policy on output in any general equilibrium model will be. Recall that the empirical findings show evidence that the strength of the response of lending rates to monetary policy increases in the relative mass and length of the tail of the distribution of the initial lending rates captured by the skewness. My theoretical model accounts for these findings by showing that the lending rates' responses to monetary policy increase in the mass of high-rate bank clients and in the length of the initial rates gap.

An important implication of my model is the presence of an asymmetry in the way the gap between the high and low-rate bank behaves following increases and decreases in the policy rate. As the central bank decreases the policy rate, the high-rate bank responds by more than the low-rate bank. This is because it is more painful losing a customer for the low-rate bank than profitable for the high-rate bank to gain one. As a result, the gap in the end-of-period rates becomes smaller than the beginning-of-period one. Because the gap is smaller the mass of borrowers searching in the next period is smaller and a new decrease in the policy rate has weaker response than the previous. As the central bank increases the policy rate the opposite will occur. The low-rate bank has to increase its rate to maintain profitability attenuating the competitive pressure on the high-rate bank. This, in turn, allows the high-rate bank to increase its rates by more because fewer customers on search can now be poached. A final implication of the model is that a decrease in the monetary policy rate amplifies banks' strategic interaction. An increase, instead, represses it. Banks can increase their competitive pressure by decreasing their lending rates, but the extent to which they can do it while keeping a positive profit margin is bounded below by their marginal cost of funds. Whenever monetary policy shifts down banks' marginal cost of funds, banks have a larger space to set their interest rate while remaining profitable. They can compete more over customers. Monetary policy is "opening strategy space". When the opposite occurs, they can compete less. Monetary policy is "closing strategy space". The latter two implications relate to the observed phenomenon denominated "rockets and feathers pass-through" describing the observation that lending rates increase very fast following successive monetary policy tightenings but decrease very slowly when monetary policy undergoes successive easenings.

The paper is organized as follows. Section I discusses the related literature and contribution. Section II describes the dataset constructed for the empirical analysis. Section III documents the main stylized facts on various example of lending rate cross-sectional distributions. Section IV sets out the econometric model and the identification strategy used in the empirical analysis. Section V presents the empirical results. Section VI builds the theoretical framework proposed to rationalize the empirical findings. Section VII provides robustness exercises on the theoretical framework. Section VIII collects conclusions and future directions of work.

## 2 Related Literature

This paper lies at the intersection of three broad strands of literature: the Banking literature on (i) the responsiveness of bank rates to monetary policy and (ii) household refinancing decisions, the Macro-finance literature on the role of pricing frictions and heterogeneity in the financial sector in the amplification of macroeconomic shocks and finally on the Industrial Organization literature studying (i) price competition in presence of customer inertia due to search and switching frictions and (ii) cost pass-through. I bring together insights of these strands to explore a novel form of state-dependence in the strategic pricing behaviour of banks with implications for the effectiveness of monetary policy.

**Banking Literature on Lending Rates Pass-Through.** The study of lending rates pass-through has long traditions in the banking literature together with its counterpart, the deposit rates pass-through. The standard approach (Monti-Klein Model, (Monti (1972); Klein (1971))) assumes banks follow a marginal cost pricing model where monetary policy plays a role by shifting banks funding costs. Starting with the empirical contributions of Hannan and Berger (1991); Neumark and Sharpe (1992); Sharpe (1997); De Bondt (2005) evidence has been shown of a limited and heterogeneous pass-through in bank retail rates (both deposit and lending rates)<sup>5</sup> Bank interest rates are characterized by a lower time variation than money market rates and their behaviour shows various degrees of asymmetry and non-linearity (Borio and Fritz (1995); Mojon (2000); Sander and Kleimeier (2000); Hofmann and Mizen (2004); Gambacorta and Iannotti (2007); Driscoll and Judson (2013)).<sup>6</sup> One sub-strand of literature has documented the evolution of the pass-through and its causes (Hristov et al. (2014); Illes et al. (2015); von Borstel et al. (2016); Holton and Rodriguez d’Acri (2018); Zentefis (2020); Altavilla et al. (2020)), another has focused more on the sources of the heterogeneity in pass-through due to (i) balance sheet constraints (Bernanke and Blinder (1988); Kashyap and Stein (1995); Van den Heuvel (2002); Brunnermeier and Sannikov (2016)), (ii) deposit market power (Drechsler et al. (2017)) and finally (iii) loan market power (Scharfstein and Sunderam (2016)) all three recently considered jointly in Wang et al. (2022), and further adjustment costs (Hannan and Berger (1991); Elyasiani et al. (1995); Hofmann and Mizen (2004); Kopecky and Van Hoose (2012)) and asymmetric information (Berger and Udell (1995); Degryse and Van Cayseele (2000); Allen and Gale (2001); Gambacorta and Mistrulli (2014)). This paper contributes to this literature along three dimensions. First, by extending the focus to an ample variety of consumer durable loans in addition to house mortgage loans, and by considering advertised lending rates in addition to realized actual loan rates.<sup>7</sup> Advertised loan rates allow to abstract from borrower specific characteristics and focus on the competitive, as it turns out also state-dependent, forces driving bank rates responses to monetary policy. Second, most of the

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<sup>5</sup>See also Cottarelli and Kourelis (1994); Angeloni and Ehrmann (2003); Mojon (2000) for similar evidence in the Euro-Area. See De Bondt (2005); Gambacorta and Mizen (2019) for systematic surveys of empirical works on bank rates pass-through.

<sup>6</sup>see Fuertes and Heffernan (2009) for a pre-GFC survey of the early works on the topic

<sup>7</sup>The results are then compared to more standard data sources present in my dataset such as Bank Call Reports and House Mortgage level data.

papers in the literature focus on either bank-specific or demand-specific heterogeneity in lending rates pass-through, this paper contributes to the debate by offering a source of variation at the intersection of the two. Intuitively, a bank with branches in two different counties with the same demand schedule, will differentiate its response in lending rates across the two branches depending on its potential to poach customers from other banks in each of the two counties.

**Macro-Finance Literature.** This paper mostly relates to three strands of this vast literature.

**Heterogeneity in Financial Intermediaries.** This recent strand of literature studying the role played by *ex-ante* or *ex-post* heterogeneity in financial intermediaries as in (see e.g. [Coimbra and Rey \(2021\)](#); [JRios Rull et al. \(2020\)](#); [Jamilov and Monacelli \(2021\)](#); [Rojas \(2020\)](#); [Begenau and Landvoigt \(2021\)](#); [Bianchi and Bigio \(2022\)](#); [Bellifemine et al. \(2022\)](#)) on the amplification of macroeconomic shocks is part of the broader literature on heterogeneous agents (see e.g. [Buera and Moll \(2015\)](#); [Kaplan et al. \(2018\)](#); [Auclert \(2019\)](#); [Ottonello and Winberry \(2020\)](#); [Auclert et al. \(2020a;b\)](#); [Kekre and Lenel \(2020\)](#); [Kaplan et al. \(2020\)](#); [Ravn and Sterk \(2021\)](#); [Baqae et al. \(2021\)](#); [Bigio and Sannikov \(2021\)](#); [Bilbiie \(2021\)](#)). This paper shares the view that different types of heterogeneity produce different, yet quantitatively important aggregate amplification effects of macroeconomic shocks. It contributes by documenting a new channel of state-dependence of lending rates reaction to monetary policy shocks based on the heterogeneity banks face in terms of own- and cross-price demand elasticity.

**Modelling Banking Competition.** While most of literature on the topic has been focusing on monopolistically Competitive environments á la Dixit-Stiglitz (see e.g. [Gerali et al. \(2010\)](#)) and its generalizations, this paper mostly relates to the handful of studies introducing competitive environments where banks are non-atomistic and strategic (see e.g. [Corbae et al. \(2013\)](#); [Aliaga-Díaz and Olivero \(2010\)](#); [Cuciniello and Signoretti \(2015\)](#); [Corbae and D’Erasmus \(2021\)](#); [Villa \(2022\)](#)). When the competitive market structure is characterized by a finite number of large entities, these entities internalize their effect on aggregate demand and competitors’ pricing rules. This, in turn, produces significant additional variation in mark-ups and amplification in lending rates responses to macro-shocks. This paper revives and shares the emphasis on the importance of focusing on imperfect competition and strategic price complementarities and contributes along two dimensions. It is the first paper to study an environment featuring state-dependent and heterogeneous local demand elasticities in a Bertrand competition game two banks. Also, it stresses the important conditioning effect of monetary policy on bank strategic interactions (easing shocks increase the room to decrease rates and compete and viceversa).

**Customer Capital and Deep Habits** Tangentially, this paper also reinforces the aggregate effects of *customer capital*. [Gourio and Rudanko \(2014\)](#) first make this point for non-financial firms by showing its important effects on the level and volatility of their investments, profits, value, sales and markups, most importantly on the timing of their responses to shocks. The present study also relates to the models featuring "Deep Habits" [Ravn et al. \(2006\)](#); [Gilchrist et al. \(2017\)](#) in borrowers [Vives \(2001\)](#); [Aliaga-Díaz and Olivero \(2010\)](#) and depositors demand functions [Kravik and Mimir \(2019\)](#);



Polo (2021). These latter studies stress the importance of deep habits' static and dynamic effects on banks' interest rate setting decisions. This paper complements this view by showing that such effects might give rise to state-dependent responses. It also adds to the literature by showing how search frictions are a complementary yet different source of demand stickiness with respect to switching costs, normally considered to be the main source of deep habits.<sup>8</sup>

**Price Stickiness.** Time-dependent or state-dependent stickiness in firms pricing decisions is at the root of monetary policy non-neutrality (Taylor (1980), Calvo (1983), Rotemberg and Saloner (1987), Reis (2006), Golosov and Lucas Jr (2007), Nakamura and Steinsson (2010), Midrigan (2011), Alvarez and Lippi (2014)).<sup>9</sup> In both types, every period only a subset of firms change their prices following a macroeconomic shock due to exogenous or endogenous price-adjustment frictions. In recent works, pricing frictions are further combined with information frictions (on the firms side, (see e.g. Alvarez et al. (2011; 2017a)) or with strategically engaged firms (see e.g. Mongey (2021)). The theoretical framework proposed in this paper similarly features a state-dependent form of price stickiness. Yet, while those works normally retrieve the sources of state-dependence on the *price-setters* side, here they arise from search and switching frictions on the *price-taker* (borrowers) side. In the model developed in this paper, price stickiness emerges as price-setters (banks) anticipate the effects of such frictions in terms of borrower inertia and compete more or less intensely depending on the mass of consumers searching for lenders. Last, this paper shares the view of Alvarez et al. (2016) that higher order moments of the cross-sectional distribution of prices carry important information for predicting the strength of an economy's response to nominal shocks. In particular Alvarez et al. (2016) prove that the ratio of the kurtosis of the size distribution of *current* price changes and their frequency is a sufficient statistic for the output response to a monetary shock. Differently this paper provides empirical evidence that the skewness of the *past* distribution of interest rates acts as a relevant state-variable for the lending rate pass-through of monetary policy shocks.

### **Industrial Organization Literature: Customer Inertia, Competition and Cost Pass-Through.**

**Competition with Customer Inertia.** The theoretical framework proposed in this paper builds on the IO literature on Cournot/Bertrand/Stackelberg Competition in presence *customer inertia* arising from *switching costs* (pioneered by Klemperer (1987), Beggs and Klemperer (1992) or Nilssen (1992) and more recently extended to account for network externalities (Irina and Christian (2011), Weiergraeber (2022)), firm heterogeneity (Biglaiser et al. (2013; 2016)), interaction with market structure (see e.g. Fabra and García (2015) for High vs Low Concentration Markets and Lam (2015) for the case of two-sided markets) or product innovation (Salies (2012)).<sup>10</sup> and search costs (first considered as separate form switching costs in Moshkin and Shachar (2000); Waterson (2003). Wilson (2012) is

<sup>8</sup>Notice search frictions are different from frictions arising from processing information as in the "rational inattention" Sims (2003); Moscarini (2004); Sims (2006); Moscarini (2004); Woodford (2009); Matějka and McKay (2015)

<sup>9</sup>As shown by Auclert et al. (2022) or Alvarez et al. (2017b) the two models exhibit similar patterns to macroeconomic shock as long as the shock is small

<sup>10</sup>Klemperer (1995) and Farrell and Klemperer (2007) provide extensive surveys on the effects of switching costs in various theoretical and empirical settings.



the first to model them jointly in order to distinguish their respective effects on consumer behaviour, competition and welfare). This literature stresses how search and switching costs fundamentally create a dichotomy between existing locked-in and new customers. Thanks to switching costs firms can extract *rents* from their locked-in consumers. As the present value of acquiring a new *locked-in customer* is high, firms will compete strongly on new consumers entering the market. This dichotomy explains the empirical observation of teasing prices for new customer acquisition followed by increasing prices once those customers are locked-in. This paper contributes by adding a *signaling channel* into the consumer problem. If the previous period distribution of interest rates is considerably skewed a greater proportion of consumer will *have a signal* that it is profitable to search and switch to a new lender. This consumers will be considered as potential new customers by competitor suppliers and in equilibrium all banks will compete more to poach them. This channel combined with Search and Switching costs delivers a novel form of state-dependence in customer inertia which, in turn, determines a form of state-dependence in cost pass-through of banks. In addition the model also illustrates that if firms face pools of customers that are different in size and price elasticity, then equilibria featuring both cross-sectional asymmetric prices and cost-pass-through may arise.<sup>11</sup>

**Cost Pass-Through.** Finally, this paper also broadly relates to the strand of literature studying specifically the pass-through of shocks to firms’ marginal costs to prices. Building on the foundational framework of [Shubik and Levitan \(1980\)](#) recent empirical works have shown how a higher degree of product differentiation may lead to lower cost pass-through (see e.g. [Kim and Cotterill \(2008\)](#); [Loy and Weiss \(2019\)](#); [Pless and van Benthem \(2019\)](#); [Bittmann et al. \(2020\)](#)).<sup>12</sup> This paper marginally contributes to the literature by showing evidence of skewness based state-dependence of the cost pass-through in the banking sector, a feature that was still unexplored both theoretically and empirically.<sup>13</sup>

**Other Literature.** The empirical estimation builds on the literature on the identification ([Kuttner \(2001a\)](#); [Gürkaynak et al. \(2005\)](#); [Swanson \(2021\)](#)) and estimation ([Christiano et al. \(1999\)](#); [Jorda \(2005\)](#); [Gertler and Karadi \(2015\)](#); [Ramey \(2016\)](#); [Nakamura and Steinsson \(2018\)](#); [Miranda-Agrippino and Ricco \(2021\)](#); [Jarociński and Karadi \(2020\)](#); [Plagborg-Møller and Wolf \(2021\)](#)) of Monetary Policy shocks. A more detailed discussion is left to Section IV.

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<sup>11</sup>On the empirical side, search and switching costs have been receiving a lot of attention in recent years (see e.g. [Dube et al. \(2006\)](#); [Gamble et al. \(2009\)](#); [Cabral \(2016\)](#); [González and Miles-Touya \(2018\)](#); [Illanes \(2017\)](#); [Luco \(2019\)](#); [Buso and Hey \(2021\)](#); [Anell et al. \(2021\)](#); [Heiss et al. \(2021\)](#) and more specifically for the financial industry, see e.g. [Yankov \(2018\)](#); [Li and Netessine \(2020\)](#); [Wang and Yang \(2020\)](#)). First, in both physical and online markets search and switching costs are highly predictive of brand loyalty or consumer inaction. Second, when considered jointly, search costs have a more prominent role than switching costs in consumer decisions. Lowering search rather than switching costs delivers the highest proportion of customers switching to the best alternative in a given market. See the appendix for more details.

<sup>12</sup>See [Arkolakis and Morlacco \(2017\)](#) for a theoretical note on variable demand elasticities, cost pass-through and markups.

<sup>13</sup>Examples of the cost pass-through empirical literature focusing on the effects of search and switching costs in the banking sector (see e.g. [Sharpe \(1990\)](#); [Ausubel \(1991\)](#); [Degryse and Van Cayseele \(2000\)](#); [Brown and Hoffmann \(2016\)](#); [Brunetti et al. \(2020\)](#); [Allen and Li \(2020\)](#)) will be discussed in the next sections and in the appendix.

### 3 Data

The empirical analysis of this paper is carried at three different levels of dis-aggregation: State-Bank level, County-Branch level and MSA-Loan level. The exposition proceeds in three steps. First it introduces the various types of data dividing them by category, Macroeconomic or Banking data. Second it describes how the three datasets are compiled. Third it explores some of the main properties of the main variable of interest of the analysis. This third step will be carried out using the second dataset as this is the dataset exploited for the exposition of the flagship results of the empirical portion of the paper.

#### 3.1 Macroeconomic Data

. The macroeconomic data is here introduced according to their level of dis-aggregation. Four levels are present: national, state, county and MSA level.

##### 3.1.1 National-Level

At the National level I collect information on (i) economic activity, namely Real GDP, Industrial Production and Unemployment, (ii) prices, namely GDP Deflator, Consumer Price Index, Commodity Price Index, House Price Index, and (iii) financial variables, namely S&P 500, Excess Bond Premium ([Gilchrist and Zakrajšek \(2012\)](#)), Treasury Rates at 1,2, 10 years maturity and the Federal Fund Rate. All data is publicly available from FRED. These variables are conventionally employed in the Monetary literature for the empirical identification of exogenous monetary policy shocks at the aggregate US level (see e.g. [Christiano et al. \(1999\)](#); [Gertler and Karadi \(2015\)](#); [Ramey \(2016\)](#); [Caldara and Herbst \(2019\)](#); [Swanson \(2021\)](#)).

##### 3.1.2 State-Level

I collect information Personal Income and GDP at quarterly frequency from the Bureau of Economic Analysis (BEA)<sup>14</sup>. Real Personal income is obtain by deflating Nominal Personal Income through the aggregate US CPI. I obtain state-level indexes of CPI inflation from [Hazell et al. \(2020\)](#). In their paper the authors reconstructs state-level price indices at monthly frequency for the United States based on the micro-price data the BLS collects for the purpose of constructing the US aggregate CPI. Our sample period is 1978 to 2018. I this data with information on GDP by industry as a measure of the industry mix by state. Finally I collect state-level price and rent indexes at quarterly frequency from FRED.

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<sup>14</sup>GDP is only available from 2005. In absence of GDP, Personal Income is normally considered a good proxy.

### 3.1.3 County-Level and MSA-Level

At the county and MSA level I collect data from the Bureau of Labour Statistics (BLS) on employment, labour force and unemployment rates from Local Area Unemployment Statistics (LAU), together with wage data from Current Employment Statistics (CES), and the Quarterly Census of Employment and Wages (QCEW). I further collect house price data publicly available from Zillow ([Link](#))<sup>15</sup>

## 3.2 Banking Data

Banking data is now introduced also according to the increasing level of dis-aggregation. Three levels are present: bank, branch and loan level. Throughout the paper the terms bank, depository and financial institution will be used interchangeably for all entities that are entitled to issue loans in the united states (servicing institutions or brokers are hence excluded from this definition)

### 3.2.1 Bank-Level Data

I collect bank-level information on Balance Sheet and Income Statement quantities from the Call Reports filed by depository institutions at the quarterly level. Data is publicly available and retrieved from [Wharton Data Service](#).<sup>16</sup> I further collect information on Bank Holding Companies from [Federal Financial Institutions Examination Council \(FFIEC\)](#). Finally I collect information on the number of branches and total deposit volume by depository institution at the county level from the Federal Deposit Insurance Corporation (FDIC) Summary of Deposit Statistics (SOD). This data is used in order to compute a proxy of market concentration by county. In both the Call Reports and SOD datasets each institution is assigned with either an RSSDID and/or a FDIC certificate (CERT) number which are respectively the unique identifiers of the Federal Reserve Census of financial institutions or of the FDIC census of financial institutions. The SOD data also have a specific unique identification number for each branch (UNINBR).

### 3.2.2 Branch-Level Data

The core of the empirical analysis crucially relies on this data. I collect branch-level information for more than 7500 financial institutions (including banks, credit unions, savings and loan associations, and others) in the U.S.. The data is obtained from the private vendor [S&P 500 Global Market Insights](#). The data provider surveys more than 96000 branches at a monthly frequency and gathers information on a variety of deposit and loan products such as CD, checking account, saving account, money markets or loans for new and used auto purchases, personal loans, LOCs, HELOCs and mortgages. For each category of loan or deposit the dataset contains a number of characteristics like term length, dollar

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<sup>15</sup>As suggested by [Chodorow-Reich et al. \(2021\)](#) Zillow house price data is represents a good substitute for other confidential or private sources of housing data at disaggregated geographical level in the US.

<sup>16</sup>These data is then pre-processed following [Drechsler et al. \(2017\)](#)

tier, and, importantly the offered interest rate at survey date. For each branch, information on their holding financial institution (connected with either the RSSDID or the CERT number), location and level of autonomy is also available (i.e. whether they have the right to set their own interest rates offered to the public). For each branch the FDIC UNINUMBR is also included in the data.

### 3.2.3 Loan-Level Data

We finally use the public dataset available under the House Mortgage Disclosure Act from [Freddie Mac’s Single Family Loan-Level Dataset](#). The collection contains loan-level origination and monthly loan performance data on all fully amortizing fixed-rate Single-Family mortgages that Freddie Mac acquired from private lenders with origination dates from 1999. Loans are 15-, 20-, 30-, and 40-year fixed-rate mortgages with either verified or waived documentation (i.e. “full documentation”),<sup>17</sup> “Relief refinance” mortgages, and “Home Possible” Mortgages originated on or after March 1, 2015. The loan origination information in the dataset includes data about (i) borrowers observables such as FICO score, Debt-to-Income ratio or number of borrowers, (ii) loan characteristics such as maturity, age, Loan-to-value ratio, prepayment penalties, purpose (new loan, cash-out and no-cash-out refinancing), location of issuance and of the property insuring the loan, among others; (iii) type of originator of the loan. The loan performance information in the dataset includes the monthly loan balance, delinquency status, actual Loss data components of Net Sale Proceeds, Expenses (such as Legal Costs or Maintenance and Preservation Costs), MI Recoveries, Non-MI Recoveries, Zero Balance Removal UPB, and certain information up to and including termination event.<sup>18, 19</sup>

## 3.3 Macro to Banking Data match

The empirical analysis makes use of three newly constructed datasets from the items described above. The first dataset is at the state-bank level and quarterly frequency. The second dataset is at the branch-county level and monthly frequency and the third dataset is at the Loan-MSA level at quarterly frequency.

### 3.3.1 State/Bank Level dataset

This dataset is compiled by matching State Level Macro data with Bank level data from the Call Reports. National-level macro data will be matched using the simple time index. For each bank several variables of interest are created building on information from the Call Reports. First and most importantly I create average realized interest rates on various loan categories by taking the ratio of

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<sup>17</sup>Generally, Freddie Mac requires that Sellers of mortgage loans document or verify loan application information about the Borrower’s income, assets and employment.

<sup>18</sup>Possible termination events are: Prepaid or Matured (Voluntary Payoff), Third Party Sale, Short Sale or Charge Off, Repurchase prior to Property Disposition, REO Disposition, Note Sale, Reperforming Loan Sale

<sup>19</sup>Appendix A contains a more detailed description of all data items and sources.

Interest Income on the specific loan category and the corresponding total balance-sheet volume (e.g. the average realized interest on Commercial and Industrial Loans, C& I is computed as the ratio of Interest Income from C& I Loans and Total Volume of C&I Loans). This is an imperfect measure of interest rates although widely used in the literature in absence of more precise sources of information. Second, I create measures of bank financing costs by taking the ratio of total interest expense and the total volume of interest carrying liabilities (e.g. demand deposits, time deposits or debt securities). Third I compute the ratio of total loan loss provisions and total loans as a proxy of banks expectations of future losses and default on the loan portfolio. Finally I compute measures of profitability such as the return on asset, return on loans or return on equity according to their standard definition. The match with State Level macro-variables is performed using the information contained in the FDIC summary of deposit data. Bank Call Reports and Summary of deposits are merged based on the RSSDID and/or CERT identifier. Each bank is assigned to the states in the U.S. in which it has at least a branch. For each state and quarter the first four moments of the cross-sectional distribution of lending rates of the same loan category are hence computed using the total branch deposit volume as weights. For instance the mean of the cross-sectional distribution of C&I lending rates in state  $s$  is computed as the average lending rate weighted by the total bank deposit volume in state  $s$  divided by the total volume of deposits across all branches in the state.

### 3.3.2 Branch/County-level data

This dataset is compiled by first matching county level macro data with state and national level data using the QCEW County-MSA-CSA Crosswalk file from the BLS.<sup>20</sup> Using information on branches location, the branch-level data is hence matched with the county/state/national macro data. Using information on the Financial Institutions holding each branch the branch level data is hence matched with Call Reports data. For each of the loan categories contained in the branch level data, the first four moments of the cross-sectional distribution of lending rates are computed at the county, state and national level. These moments are computed either using equal weights  $\frac{1}{N}$  or deposit volume weights. Recall that in the branch-level data only a subset of branches have the right to set interest rates, the other branches either follow the near rate setting branch of the same bank or the rate setting directives centrally planned by the bank headquarters. Using an equally weighting scheme hence amounts to weight each rate setting branch by the number of branches that follow its set rates over the total amount of branches. For instance, for county  $c$  and month  $t$  the variance of the cross-sectional distribution of offered lending rates for the new auto loans category is computed as the average squared deviations from the county mean of the lending rate observations in county  $c$  and month  $t$  with either weights  $\frac{1}{N}$  or weighted by the share of average branch deposit volumes over total deposit volume in

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<sup>20</sup>The procedure is slightly more involved as in the history some counties have been merged or changed name, a preliminary step to the merging based on the the cross-walk file is hence the reconstruction of the history of counties mergers and changes of denomination.

the county. Similarly the state and national versions of the first four moments of the cross-sectional distribution are computed.<sup>21</sup> This dataset will be hence available in two forms. In the first form the minimal unit of observation is the county/level. All variables available at higher levels of disaggregation will be hence averaged to obtain a unique observation for the county. In its second form the minimal unit of information will be the branch-level. In this case for each branch and month, all the branch level variables will be kept at the branch level and will share the same bank level information with the other branches belonging to the same bank and will share the same county and state level information with all branches located in the same county.

### 3.3.3 MSA/Loan-level data

Similarly to the County-Level macro data, MSA Macro data are matched with county and state level macro data using the QCEW County-MSA-CSA Crosswalk file from the BLS. Loan level data is aggregated at the quarterly level.<sup>22</sup> State/County/MSA data is also aggregated at the quarterly level. National data is matched to the so form dataset by quarter of observation. Loan-level data is matched with MSA/County/State macro data using information on the location of the issuance available for each loan in the dataset. Loan-level data is also matched with bank-level information from the Call Reports information using RSSDID and/or CERT and/or name of the private lender issuing the loan when available. These are realized lending rates, and as such, the interest rates includes the bank’s consideration of borrowers and loan type characteristics. Following [Hurst et al. \(2016\)](#), I parse out the effects of the latter two factors using a time-varying regression model including most of the borrowers and loan observable characteristics obtained in the dataset. As it will become clear in the following sections the focus of the paper is on competition over interest rates among banks. Intuitively absent any borrower or loan type heterogeneity the lending rates offered by different banks should be all the same when there is high competition, and should be increasingly differing as competition decreases. The focus of the paper is exactly on the forces that drive interest rates other than borrower and loan type characteristics. For this reason the lending rates in this dataset are residualized and the main lending rates utilized in the empirical analysis come from the Branch-Level Data described in the previous subsection. The Branch Level Rates are indeed advertised rates, in other words they are the rates that a specific branch provides as base quotes before sitting at the bargaining table with a specific borrower. As for the branch-level data, using the residualized lending rates the first four moments of the MSA

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<sup>21</sup>As argued in [Drechsler et al. \(2017\)](#), banks may have high deposit market share in one county but not equally high loan market share in the same county, a more precise weighting scheme would ideally use the loan volumes by branch for the specific category of loans, unfortunately however this information is not available at the branch level. Loan level data at the annual frequency would be available from the House Mortgage Disclosure Act data but this would be only house mortgage loans which need not be correlated for instance with New auto loans or other consumer durable loans across counties.

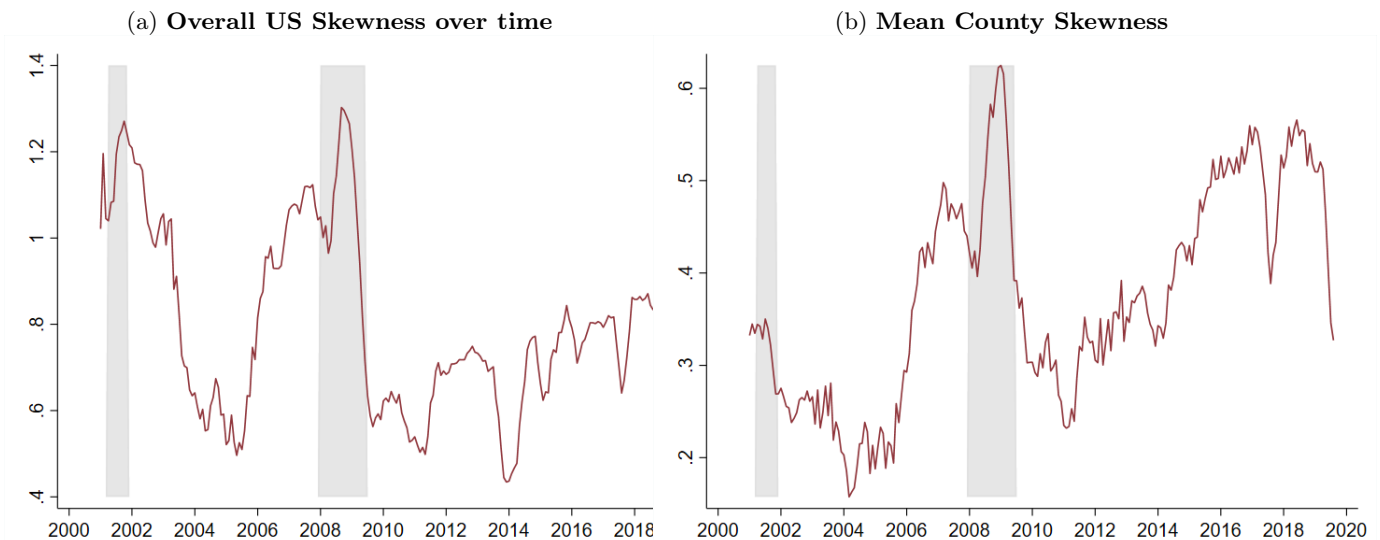
<sup>22</sup>Although the data would be available at monthly level in its row form, quarterly aggregation is a common choice in the papers carrying empirical analysis on the Freddie Mac data such as [Eichenbaum et al. \(2022\)](#) or [Scharfstein and Sunderam \(2016\)](#) and is here kept for comparability reasons

cross-sectional distribution of mortgage rates is created. In this case again two weighting schemes are used, either assigning an equal weight of  $\frac{1}{N}$  or weighting by the ratio of loan volume to total MSA loan volume. The main empirical analysis will be carried based on the Branch Level data aggregated to county level using the equal weighted scheme (with the caveat above). In the next subsection the some of the cross-county and time series properties of the cross-sectional skewness of lending rates will be introduced and studied.

### 3.4 Stylized Facts

In a perfectly competitive market where there is a unique type of borrower and type of loan, all branches should charge the same interest rate on the same loan. As shown in the introduction however, after controlling for borrower and loan characteristics, still a great deal of variation remains across different lending rates within the same quarter and county. This subsection will focus on the *advertised* lending rates data available from the compiled County-Branch level dataset. Again within each county and in the same month any conventional banking model with homogeneous banks would predict that all banks should advertise the same lending rate for the same loan<sup>23</sup> This is not the case. The within county variation in advertised lending rates is always particularly high over the years covered in the dataset. One conventional explanation to lending rates dispersion is market concentration. Market concentration however is a slow moving variable over time within county, the lending rates dispersion instead is highly volatile over months.

Figure 2: Personal Recreational Vehicle Advertised Loan Rates.



Notes: .

<sup>23</sup>Note that the S&P Global market Insights Ratewatch Data purposely surveys branch over *standardized* loans, that is loan products that are fairly standard in their characteristics and amounts over the US territory.



A prominent feature of lending rate distributions is that they present high positive skewness, or in figurative terms a *long* and *fat* right tail. This means that (i) the distribution is highly asymmetric, (ii) there is a relatively big mass of banks that is able to offer particularly high rates by staying in business. This features of the data appears at the county level as much as at the state and national level. Figure 2 displays two different skewness measures for a sample yet representative loan category from the Branch-Level data: the loans for purchase of Personal Recreational Vehicles. Panel (a) of Figure 2 the cross-sectional skewness of lending rates at the national level at each month since 1999 (meaning when all branches from all counties are pulled together in a unique distribution). Two main stylized facts can be observed. First, the time series fluctuates considerably between the values of 0.3 which corresponds to an almost symmetric distribution, to above 1, which is conventionally considered as a rule of thumb value for a “*highly*” asymmetric distribution. Second the time-series shows considerably volatility over time. Panel (b) displays instead the mean of the cross-county distribution skewness (i.e. first for each county the within-county skewness is computed, and then for each month the mean across counties is computed). As it is possible to observe the whole distribution of skewness shifts considerably across time in a similarly volatile way. Combining Panel (a) and Panel (b) two observations can be made. First the variation in the aggregate national skewness is not driven by a subset of counties having particularly high rates but rather by all counties shifting up or down in their skewness measures. In other words the right tail of the cross-sectional distribution of lending rates grows in mass and length as a result of the single within county tails growing in length and mass as opposed to a few counties charging particularly high rates as a whole. Second, the variation in the mean county skewness, as captured by Panel (b), exhibit a some correlation with the business cycle with a few caveats, (i) it grew considerably during the great financial crisis, but it did not grow as much during the 2001 recession (ii) at the end of each of the recessions it also decreased considerably, (iii) contrary to the post 2001 recession period, the mean county skewness stayed low for a considerable amount of time after the great financial crisis. This latter three facts combined suggest (i) that the cross-sectional skewness of lending rates may not be a pure tracker of the business cycle but rather carry important independent information for the state of the economy, (ii) it seems correlated with the stance of monetary policy decreasing with the two post-crisis easing periods, increasing with the tightening monetary policy applied in the build up of the great financial crisis and finally remaining relatively low in the zero lower bound period. Given lending rates are bound by zero it might be intuitive that the cross-sectional skewness of lending rates decreases in periods where the central bank pushes interest rates down, however the opposite is less intuitive. In addition, the higher is the peak of the skewness reached within each crisis, the steeper is the descent following a monetary policy tightening. These observations seem to suggest that there might be scope for an inverse direction of causality between the cross-sectional skewness of lending rates and the strength of monetary policy which motivates the empirical analysis of this paper.

## 4 Empirical Model

The next two sections present respectively the econometric framework and empirical results of the paper documenting the presence of state-dependence in the response of economic activity and lending rates to changes in the monetary policy rate based on the level of the initial cross-sectional skewness of lending rates. Building on [Jorda \(2005\)](#)'s Local projection framework, I will estimate the response of various outcome variables to an exogenous monetary policy shock. Local projections are widely used for the empirical estimation of monetary policy responses in the literature. The approach amounts to the following regression specification:

$$y_{t+h} = \alpha_h + \beta_h X^{MP} + \gamma_h X^{Controls} + \varepsilon_t^h \quad \text{for } h = 0, 1, 2, \dots \quad (1)$$

where  $y$  is the variable whose response of monetary policy we are interested in,  $X^{MP}$  is a variable capturing monetary policy changes and  $X^{Controls}$  is a vector of relevant controls.<sup>24</sup> Typically monetary policy is highly endogenous which implies that  $X_t^{MP}$  is correlated with the error term  $\varepsilon_t^h$  resulting in a biased estimates of  $\beta_h^1$ . One of the most popular approaches to these issues is to rely on proxy variables that identify the exogenous variation in monetary policy, i.e. exogenous monetary policy shocks. In particular, I use high frequency proxies, that are variables constructed starting from the change in price of highly liquid financial instruments in a narrow window around the FOMC announcement. The underlying assumption required for the use of this category of proxies for the estimation of responses to monetary policy is that financial market prices already correctly predict and incorporate the endogenous response of monetary policy to the economy before the FOMC announcement. Any change in prices happening during the FOMC announcement captures the exogenous un-predicted variation in monetary policy. More on this literature in the next section. If the model monetary policy shock is well identified, then  $\beta_h$  will be an estimate of how much  $y$  changes at  $t+h$  following an increase in  $X^{MP}$ , i.e.  $\beta_h = \frac{y_{t+h}}{X^{MP}}$ . The complete impulse response function will be hence the vector  $\beta_{h=0}^{HMAX}$  where HMAX is the maximum horizon of the response function we are interested in.

The focus of this paper is (i) to test if  $\beta_{h=0}^{HMAX}$  changes with the level of the cross-sectional skewness of lending rates before the monetary policy change happens (i.e. in  $t-1$ ), (ii) to estimate the direction of change which is a priori unclear, (iii) finally to quantify the magnitude of the change. I extend the econometric framework to allow the impulse response to vary with the level of the cross-sectional skewness of lending rates prior to the monetary policy shock. As a result the outcome variable response to monetary policy is allowed to be dependent on the state of the cross-sectional skewness, i.e. state-dependent. To do so I estimate a regression of the following form:

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<sup>24</sup>Note that the variable  $X^{Controls}$  doesn't have a  $t$  index because it includes lags of the outcome variable  $y$ , of the main regressor  $X^{MP}$  and other potentially relevant control variables (contemporaneous and lagged)

$$y_{t+h} = \alpha_h + \beta_h^0 X_t^{MP} + \beta_h^1 [X_t^{MP} \times \mu_{t-1}^3] + \delta_h \mu_{t-1}^3 + \gamma_h X^{Controls} + \varepsilon_t^h \quad \text{for } h = 0, 1, 2, \dots \quad (2)$$

where  $[X_t^{MP} \times \mu^3]$  is an interaction term between the monetary policy variable  $X_t^{MP}$  and the cross-sectional skewness of lending rates  $\mu_{t-1}^3$  prior to the new monetary policy innovation, i.e. in (t-1). The non-interacted term  $\delta_h \mu_{t-1}^3$  is added to the specification to avoid bias in  $\beta_1$  due to potential direct relationships between  $y$  and  $\mu_{t-1}^3$ . Under this new specification the response of  $y$  to  $X_t^{MP}$  is now  $\frac{\partial y_{t+h}}{\partial X_t^{MP}} = \beta_h^0 + \beta_h^1 \mu_{t-1}^3$ . If the model is well identified and  $\beta_h^1$  is positive, then the response of  $y$  to  $X_t^{MP}$  at horizon  $h$  is increasing in  $\mu_{t-1}^3$ . On the contrary if  $\beta_h^1$  is negative then the response of response of  $y$  to  $X_t^{MP}$  at horizon  $h$  is decreasing in  $\mu_{t-1}^3$ . Finally, if  $\beta_h^1$  is found to be not statistically different from 0 then the response of  $y$  to  $X_t^{MP}$  at horizon  $h$  will not depend on  $\mu_{t-1}^3$ . As argued in [Balli and Sørensen \(2013\)](#), if we have a monetary policy proxy capturing identifying the exogenous variation in  $X_t^{MP}$  then the interaction term between the proxy and  $\mu_{t-1}^3$  will also work for an unbiased estimation of  $\beta_h^1$ . Importantly all terms entering the interaction terms are subtracted their long run mean. This is done in order to capture the impact of short run variations in the cross-sectional distribution of lending rates on the strength of the responses to monetary policy. Consequently  $\beta_h^1$  will be interpreted as the average response of the outcome variable  $y$  at horizon  $h$  to a monetary policy change depending on the distance of the long run skewness from its long run mean over time. Tangentially, this procedure allows to control to biases in the coefficients do to co-variation between the interaction terms and the other linear terms of the regression as explained in [Balli and Sørensen \(2013\)](#).

The regression equation 2 would be typically estimated using aggregate data about GDP, CPI, etc. This amounts to roughly 25 years of data (at either quarterly or monthly frequency) if one focuses on the last two recent decades and excludes the latter Covid crisis from the sample. This is hardly enough observations. In addition using aggregate data does not allow to test whether the cross-sectional skewness of the distribution of lending rates at the local regional level plays a role. In order to include the latter consideration the framework is further extended for use in a panel dataset, by adding an  $s$  subscript to each variable.

$$y_{s,t+h} = \alpha_h + \beta_h^0 X_t^{MP} + \beta_h^1 [X_t^{MP} \times \mu_{s,t-1}^3] + \delta_h \mu_{s,t-1}^3 + \gamma_h X_s^{Controls} + \varepsilon_{s,t}^h \quad \text{for } h = 0, 1, 2, \dots \quad (3)$$

The only change with respect to the regression equation 2 is that now at each time  $t$  there is a separate observation for each of the left and right-hand-side variable for each region of the US (state, county or MSA depending on the dataset used). Importantly the coefficients  $\beta_h^0$  and  $\beta_h^1$  do not vary across regions which means that they will capture the average regional response of the relevant outcome variable to  $X_t^{MP}$ . The next subsections presents a brief literature review of the strand dealing with the

estimation of Monetary Policy Shock responses and the complete empirical model used with a complete description of the controls used and the specification of the interaction terms.

#### 4.1 Literature review on the estimation of Monetary Policy Shocks

Most of the variation in monetary policy rates is due to the systematic response of policy to current or expected future economic conditions. To identify the causal effects of monetary policy, it is therefore necessary to isolate shifts in monetary policy instruments that are orthogonal to policy responses to the behavior of the economy. The identification strategy adopted in this paper for the estimation of monetary policy effects draws from the large empirical literature on high frequency proxies starting from the seminal works of [Rudebusch \(1998\)](#) [Kuttner \(2001a\)](#) who pioneered the idea of extracting the exogenous component of monetary policy movements by looking at the financial markets response to Monetary Policy announcements. The literature developed through the contributions of [Bernanke and Kuttner \(2005\)](#), [Gürkaynak et al. \(2005\)](#) and [Gertler and Karadi \(2015\)](#) among others up to the most recent contributions from [Jarociński and Karadi \(2020\)](#) [Nakamura and Steinsson \(2018\)](#) [Bauer and Swanson \(2022\)](#) focusing on disentangling Information and Pure Monetary policy effects in high frequency proxies. This paper improves the understanding of this type of identification by showing how it remains robust in the study of monetary policy effects over sub-national geographical units such as counties and MSAs, dis-aggregated targets such as loans of a specific category or in a specific area and state-dependent effects.<sup>25</sup>

Local Projections represent an ideal framework for the empirical question at hand. Its simple linear structure allows for the study of state-dependence of monetary policy impulse responses in a panel environment with high degree of dis-aggregation. While first example of the methodology can be traced back to [Christiano et al. \(1996\)](#) and [Romer and Romer \(1989\)](#), the widespread use of local projections for the study of monetary policy effects is due to the seminal work of [Jorda \(2005\)](#). Following its contribution several different works have As recently proven in [Plagborg-Møller and Wolf \(2021\)](#) given an identification strategy, Local Projections estimate the same impulse responses as VARs as the number of lags goes to infinity. Even in finite sample with a finite number of lags the two methodologies deliver the same result for the horizon corresponding to the minimum between the two lag orders. The bias-efficiency trade-off stays however for horizons longer than the lag structure of either of the two methodologies. Local Projections are less prone to mis-specification bias while VARs are more efficient in long run estimation. Given the nature of the question at hand we select the first over the second. More closely to this paper, Local Projections have been popular in the study of the dependence of monetary policy responses on the state of the economy. Among others [Santoro et al. \(2014\)](#), [Tenreyro and Thwaites \(2016\)](#), [Angrist et al. \(2018\)](#), [Barnichon and Matthes \(2018\)](#) and [Mavroeidis \(2021\)](#) and

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<sup>25</sup>The use of instrumental variables in the identification of policy shocks is not limited to local projections nor to monetary policy. See [Mertens and Ravn \(2013\)](#) for an early example of Fiscal Policy shocks identified in a VAR model through external instruments. [Stock and Watson \(2012\)](#) use external instrument identification strategies to disentangle the various channels of the 2007-2008 Recession.

Klepacz (2021).<sup>26</sup> In line with these studies, this paper shows evidence of state-dependence in the responses to monetary policy. It contributes to the literature by providing an entire new dimension of state-dependence based on the micro-structure of bank competition. Notably, contrary to the other suggested state variables, this dimension is able to reconcile the joint time and space variation of monetary policy effects in the US.

The High frequency identification and Local Projections methodology are only one of the many ways adopted by the literature to study the macroeconomic effects of monetary policy shocks, see Ramey (2016) for a wonderful critical survey of literature on the topic comparing various identification and econometric models, their performance and robustness of the results.

## 4.2 Final specification

Three different dataset are used in this analysis. The first dataset is a State-Quarterly Level Dataset obtained by merging National and State Level macro indicators of economic activity to banking variables from the Call Reports. The second dataset is at the county/monthly level. It merges the national and county macro aggregates available with the branch level data from S&P Global Market Insights database. Finally the third dataset is at the MSA/Quarterly level and will encompass macroeconomic information at the national and MSA level with loan level data on the Single-Family Home Mortgages as contained in the public dataset of Freddie Mac. The second dataset will be the one used in the analysis in the main text the results of the other two datasets will be discussed briefly at the end of this section and left to the appendix. As discussed in the previous session the methodology chosen is local projection and the identification is achieved through high frequency proxies (Bauer and Swanson (2022)). As shown by Plagborg-Møller and Wolf (2021) for impulse response estimation the approach, in population, is equivalent to estimating VARs. The choice is here made in order (i) to have a more flexible structure for the estimation of panel regression with instrumental variable and interaction terms and (ii) to have be robust to mis-specification of the model in hand. The general form of the local projection equation is as follows:

$$y_{s,t+h} = \alpha_{s,h} + \beta_h^0 X_t^{MP} + \beta_h^1 [X_t^{MP} \times \mu_{t-1,s}^3] + \beta_h^2 [X_t^M P \times \mu_{t-1,s}^1] + \beta_h^3 [X_t^{MP} \times \mu_{t-1,s}^2] + \quad (4)$$

$$+ \rho_{1,h} \mu_t^1 + \rho_{2,h} \mu_t^2 + \rho_{3,h} \mu_t^3 + \gamma_h X_{BANK,t} + \delta_h X_{s,t} + \delta_h X_{US,t} + \quad (5)$$

$$+ B(L)_h [X_t^{MP} + X_t^{MP} \times \mu_{t-1,s}^3 + X_t^M P \times \mu_{t-1,s}^1 + X_t^{MP} \times \mu_{t-1,s}^2] + \quad (6)$$

$$+ C(L)_h [\mu_t^1 + \rho_{2,h} \mu_t^2 + \rho_{3,h} \mu_t^3] + D(L)_h [X_{BANK,t} + \delta_h X_{s,t} + \delta_h X_{US,t}] + \varepsilon_{s,t,h} \quad (7)$$

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<sup>26</sup>See Ramey and Zubairy (2018) for an example of state-dependent local projections applied to the study of fiscal multipliers. See Gonçalves et al. (2022) for a more rigorous consideration of the asymptotic validity of state-dependent local projections.

where the  $t$  is the time index and  $s$  is the region index (state, county or MSA depending on the dataset). With respect to equation 3 the final specification extends into two directions. First, two new interaction terms are added, namely the interaction  $[X_t^M P \times \mu_{t-1,s}^1]$  between the monetary policy proxy  $X_t^M P$  and the demeaned first moment of the cross-sectional distribution of lending rates in county  $s$   $\mu_{t-1,s}^1$  and the interaction term  $[X_t^{MP} \times \mu_{t-1,s}^2]$  the monetary policy proxy  $X_t^{MP}$  and the demeaned first moment of the cross-sectional distribution of lending rates in county  $s$   $\mu_{t-1,s}^2$ . The cross-sectional skewness of lending rates at the regional level covaries with the mean and variance. These two terms are added in order to control for such variation. Second the full set of controls is spelled out in this specification. Since the regression is at the regional levels controls for bank specific balance sheet variables and for county level macros are added in addition to the usual controls at the national level. The next paragraphs will discuss more in details the choices for each of the variables in the specification.

### 4.3 Outcome Variables

The outcome variable is going to be the Real Personal Income for the first State-Bank Level dataset, Unemployment and Lending Rates for the County-Branch Level dataset and finally Unemployment, Refinancing rates and Mortgage interest Rates for the MSA-Loan Level dataset. At the State-Level Personal Income is the only variable available with a long enough time-series. It is used in place of state-level output which is not available at quarterly frequency starting from 2005. Personal Income and Output have high correlation across the sample in common, which is why the former variable is chosen. At the county and MSA level unemployment is the only available proxy for Economic Activity at the monthly and quarterly frequency. For the branch level data the average advertised rate by county/category of loan will be used. As discussed in the data section the branch-level dataset contains information on various categories of loans such as new auto loans, new personal recreational vehicles or new boat loans together with the more conventional house mortgage loans at maturities 3,5 and 10 years. For each category, county and time the average of all offered lending rates is considered. For this specific regression county/category fixed effects will be used in place of standard fixed effects. Finally for the MSA-Loan level data Lending Rates of House Mortgages will be used. In this case for each county and time the average lending rates by maturity will be used.

### 4.4 Main Regressors

The monetary policy shock variable  $X_t^{MP}$  is the high frequency proxy proposed in [Bauer and Swanson \(2022\)](#). Similarly to the previous literature the proxy is similarly constructed from price changes over narrow windows around FOMC announcements. Differently from previous literature the proxy is orthogonalized with respect to public information about economic and inflation outlook at the time of the FOMC announcement. Following are its interaction terms respectively the cross-sectional skewness,

mean and variance of lending rates computed at the county level in the previous period (quarter or monthly depending on the frequency of the dataset). As for the skewness, the cross-sectional variance and mean entering the interaction terms will be also demeaned of their long run mean over time.

## 4.5 Other Regressors

Finally the specification is saturated with controls at the bank level, county-level and national level. The controls at the bank level are computed as the county average of three main balance-sheet variables. The average is weighted by the local presence in the county as measured by the volume of deposits of the branches in the county by bank.<sup>27</sup> The main controls used are average interest rate expense, return on assets and loan loss provisions. The first variable controls for idiosyncratic variation in banks cost of funds which might introduce confounding variation in the lending rate behaviour across counties. The return on assets variable is capturing bank specific idiosyncratic variation in lending rates due to capital constraints on the banking side. As bank returns increase, so does their net-worth and hence relaxes capital and regulation constraints limiting the issuance of new loans. Finally the Loan Loss Provision variable controls for banks' heterogeneous expected future probability of default of loans. Intuitively the more banks expect future losses the more they will increase lending rates, so controlling for this expectation is important to isolate the response to monetary policy. The county level controls are unemployment rate, available at the county/monthly level and log of total wages available at the MSA level and matched to the county closest to the MSA level by definition. Counties for which total wages are not available are assigned with the mean state level wage average. House price indexes are also available and used at the county level in order to control for housing market factors which might vary heterogeneously across counties. These controls are standard measures of Finally at the national level four main variables are used consistent with the analysis in [Bauer and Swanson \(2022\)](#) namely US aggregate unemployment rate, the log of CPI index, the 2 year Treasury rate and the Excess Bond Premium as in [Gilchrist and Zakrajšek \(2012\)](#). These are among the usual variables used in Local Projection and VAR estimations of monetary policy effects.

## 4.6 Identifying Variation

: In each of the three data panels both cross-county and time-variation can be used. The empirical exercise is meant to test whether counties in a state characterized by particularly high lending levels

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<sup>27</sup>This information is available from the FDIC summary of Deposits dataset presenting information on the number, location and total deposit volume of each branch of US and Foreign Banks in the US. An alternative weighting could be through the volume of loans by bank and county as available from the House Mortgage Disclosure Act Data. These data is however only concerning House Mortgage Loans while the analysis of the paper is rather devoted to C&I and consumer durable loans in addition to house mortgage loans. I hence adopt the first weighting scheme for the main results and use the second as a robustness. In the appendix there are also results using the simple number of branches by county or simple unweighted averages by counties. The resulting time series do not vary much across different weighting schemes.



of cross-sectional skewness with respect to their long run mean experience a stronger pass-through in the following monetary policy movements. Both county and time variation is hence used. Recall that the relevant variable is the nation-wide monetary policy shock  $X_t^{MP}$ . At each point in time different counties will have their cross-sectional skewness differentially far from their long run county mean. Counties with an initial cross-sectional skewness that is further away from the long run mean vary in the response of their economic activity and lending rates to a monetary policy shocks. At the same time each county will be differently far from its long run mean at different point in time and its activity measures and lending rates will respond differently to the monetary policy shock. This specific time variation will also allow to identify the differential effect of skewness over the responsiveness of economic activity and lending rates to monetary policy.

## 5 Empirical Results

This section will present the flagship results of the paper obtained using the Branch/County Level dataset at the monthly Frequency. The last part of the section provides an extensive summary of the long battery of robustness checks and results from the use of the other data-sets. The result tables are contained in Appendix C. The empirical question this paper asks is whether the initial cross-sectional skewness of lending rates influences the response of economic activity and lending rates to following monetary policy shocks. The analysis is performed here at the county level and monthly frequency.

### 5.1 Economic Activity

The results of the regression analysing the response of economic activity are presented first. As anticipated in the description of the Specification, at the county/month level unemployment is normally the best available measure of economic activity. The analysis focuses on the short run response of unemployment to monetary policy, namely the first 10 months.<sup>28</sup> Table 1 below presents the results of the estimation. For clarity the table only reports the main coefficients of interest, the reader should note however that all controls spelled out in the previous section are present. The dependent variable is the county/month total civilian unemployment rate. Each column of the table reports the set of estimated coefficients at horizon  $h$ . Each row reports the right-hand side variable that the estimated coefficient belongs to. In other words the first row reports the set of coefficients  $\beta_h^0$  for  $h = 1, 2, \dots, 10$ . The second one reports  $\beta_h^1$  for  $h = 1, 2, \dots, 10$ . And so on. The unemployment rate is expressed in percentage points. The monetary policy shock is in percentage points and three moments part of the interaction terms displayed are standardized. This implies that the coefficient  $\beta_h^0$  represents the change in percentage points of unemployment due to a 1 percentage point positive monetary policy

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<sup>28</sup>This is due to the fact that branch level data presents important gaps and structural breaks in the time series at the county-category level which prevents inference on longer horizons.

shock at horizon  $h$ . This response increases by  $\beta_h^1$  when the skewness is one standard deviation above the long-term regional mean.

Table 1: Unemployment

Month	0	1	2	3	4	5	6	7	8	9	10
[1em] $X_t^{MP}$	0.04*** (4.96)	0.28*** (20.15)	0.36*** (24.02)	0.26*** (17.23)	0.21*** (13.41)	0.23*** (14.27)	0.37*** (21.92)	0.49*** (26.25)	0.56*** (29.86)	0.57*** (31.73)	0.19*** (11.42)
$[X_t^{MP} \times \mu_{t-1}^3]$	0.04*** (3.12)	0.12*** (6.67)	0.11*** (5.50)	0.09*** (4.58)	-0.05** (-2.38)	0.02 (0.91)	0.04* (1.91)	0.09*** (3.54)	0.05** (2.00)	0.02 (0.67)	0.02 (1.01)
$[X_t^{MP} \times \mu_{t-1}^1]$	0.09*** (14.53)	-0.04*** (-4.12)	-0.11*** (-10.29)	-0.02* (-1.71)	-0.03** (-2.44)	-0.00 (-0.26)	-0.18*** (-14.68)	-0.18*** (-13.21)	-0.17*** (-12.38)	-0.28*** (-21.11)	-0.05*** (-3.81)
$[X_t^{MP} \times \mu_{t-1}^2]$	-0.00 (-0.12)	0.04* (1.70)	-0.02 (-0.65)	-0.11*** (-3.80)	-0.03 (-1.06)	-0.11*** (-3.77)	0.07** (2.39)	-0.05 (-1.38)	0.02 (0.53)	0.08** (2.45)	-0.04 (-1.48)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	121832	110059	107270	104565	99944	97147	95369	91929	90388	88241	85016
$R^2$	0.969	0.939	0.928	0.929	0.931	0.928	0.920	0.909	0.907	0.920	0.933

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

The first line of the above table reports the estimated values and  $t$  statistic for the coefficients of the monetary policy shock variable alone at each month  $h$ . According to the first value unemployment on average grows by 0.04 percentage points in the first month after a monetary policy shock of 1 percentage point (p.p.). The increase in the following month is going to be 0.28 percentage points and following 0.36 and so on. Recall the definition of the interaction terms as the interaction between the monetary policy shock variable and the distance from the long run mean of the first three moments of the cross-sectional distribution of interest rates. The collection of all the coefficients in the first row hence represents the impulse response function of unemployment to a monetary policy shock of 1 p.p. when all three moments are at their long run mean in the first 10 months. In terms of significance the impulse response function is significantly different from 0. In line with conventional monetary policy theory the response is also positive, meaning that an exogenous increase in the monetary policy rate has contractionary effects on the economy as captured by the positive change in unemployment. As it is possible to observe the contemporaneous response not unexpectedly is very close to 0 as unemployment tends to have a lagged reaction to monetary policy shocks. In the following 7 months unemployment increases by a quarter of a percentage point each month reaching a peak of half of a percentage point in the eight month. By the end of the horizon the response starts to decrease while still remaining positive.

The second row contains the first core result of the paper. The coefficients of the second row represent the change in the response of unemployment to monetary policy shocks when the skewness is one standard deviation above its long run mean. The results reported in this second row answer to

three main questions: (i) is the initial cross-sectional skewness of lending rates a relevant state variable for the responsiveness of economic activity to monetary policy shocks, (ii) if yes, is the responsiveness increasing or decreasing in the skewness, (iii) by how much is it increasing or decreasing. We answer the first question by performing an F-Test on the set of coefficient of the second row for each horizon  $h$ . The null hypothesis is that the coefficient is not statistically different from 0. The F-Test performed rejects the null hypothesis which in turn suggests that the initial cross-sectional skewness of lending rates does indeed impact the responsiveness of unemployment to monetary policy shocks. Questions (ii) and (iii) can be directly inspected by looking at the results of the table. As regards question (ii) the coefficients of the second row are all significantly positive. This implies that a 1 standard deviation increase above mean of the cross-sectional skewness of lending rates predicts an increase in the responsiveness of unemployment to a monetary policy change. Finally as regards question (iii) the magnitudes of the coefficients in the second row are roughly  $1/3$  of the coefficients in the first row for the first 4 horizons while becoming  $1/10$  after the fifth horizon. This suggests that skewness has a strong but short lived increasing effect on the responsiveness of unemployment to monetary policy shocks. Indeed in the first three months the response of unemployment for counties that are 1 standard deviation above their long run mean tend to double in the month the monetary policy shock hits, be  $1/3$  higher in the following three months and  $1/10$  higher up to month 8 where the coefficient becomes insignificant.

A last remark concerns the last two rows of the regression table presented. The third row represent the coefficients on the interaction terms between the monetary policy shock and the distance from the mean of respectively the first and the second moments of the initial cross-sectional distribution of lending rates. As it is possible to observe the coefficients multiplying interaction with the first moment are all highly significant and negative. This implies that when the interest rates are particularly high to begin with, an increasing monetary policy shock is going to be less effective on average. On the opposite when the interest rates are particularly low with the respect to the long run average, then unemployment is going to respond more to a monetary policy shock. For the last row of coefficient the picture is different. Almost no coefficient in the last row is significantly different from 0. In addition, both sign and magnitude are relatively dispersed. This implies that overall the second moment doesn't seem to play a role in the way economic activity responds to monetary policy shocks. Overall this results suggest the presence of an important form of state-dependence in the responsiveness of unemployment to monetary policy shocks. First, this response is highly state-dependent on the properties of the initial distribution of interest rates (initial, i.e. prior to the change in monetary policy). Second, the response of unemployment is increasing in the cross-sectional skewness of the distribution. Recall that, as shown in Section 3 the cross-sectional skewness of lending rates is mainly positive. This implies that whenever the distribution is particularly skewed with respect to its long run mean, the response of the following monetary policy shocks to skewness are negative.

What is driving this result? High positive skewness in the cross-sectional distribution of lending

rates can be interpreted as a distribution with a long and fat right tail: i.e a considerable mass of banks charges high lending rates with respect to the rest of the banks in the distribution. The natural candidate driver of the results presented above is hence to be searched in the way lending rates themselves respond to monetary policy when the initial distribution is particularly skewed. The next subsection will present the results of the local projection of lending rates onto the same specification of the table just presented.

## 5.2 Lending Rates

The local projections estimated in this subsection have exactly the same specification outlined in equation 3. They vary with respect to the estimated equation in the previous subsection across two dimensions. First the outcome variable is now going to be the nominal lending rate offered by each branch in the dataset in county  $s$  and month  $t$  for the category of loan  $f$ . Indeed, as already discussed in Section 3, the Branch-Level Dataset contains information on offered rates by Branch/County/Month on multiple categories of loans such as New Auto Loan or Personal Recreational Vehicle etc. The panel dataset in this case hence has an additional dimension with respect to the one used in the previous analysis. The outcome variable in this case is going to be for each month and category of loan the average within county average lending rate. Symmetrically the regressors represented as the moments of the distribution are going to be computed at the county/month and category level. For instance, when the outcome variable is the mean monthly lending rate for county  $s$  and loan category  $f$ , the corresponding cross-sectional skewness in the regressors will be computed as the cross-sectional skewness of the distribution of lending rates in county  $s$  and loan category  $f$ . The following table report the results.

Lending Rates

Month	0	1	2	3	4	5	6	7	8	9	10
$X_t^{MP}$	0.22*** (8.44)	0.34*** (10.84)	0.48*** (13.62)	0.44*** (11.87)	0.37*** (8.95)	0.23*** (5.55)	0.29*** (6.67)	0.55*** (12.54)	0.38*** (8.62)	0.44*** (8.87)	0.52*** (10.12)
$[X_t^{MP} \times \mu_{t-1}^3]$	0.15*** (3.73)	0.12** (2.48)	0.22*** (3.95)	0.20*** (3.37)	0.18*** (2.91)	0.17*** (2.59)	0.24*** (3.40)	0.12* (1.77)	0.16** (2.34)	0.00 (0.06)	-0.00 (-0.03)
$[X_t^{MP} \times \mu_{t-1}^1]$	-0.13*** (-6.14)	-0.04** (-2.03)	-0.17*** (-6.72)	-0.28*** (-9.33)	-0.31*** (-9.16)	-0.15*** (-4.01)	-0.27*** (-7.27)	-0.22*** (-5.38)	-0.18*** (-4.67)	-0.30*** (-7.56)	-0.32*** (-7.90)
$[X_t^{MP} \times \mu_{t-1}^2]$	0.04 (0.73)	0.09 (1.25)	-0.21*** (-2.73)	-0.02 (-0.18)	-0.05 (-0.53)	0.14 (1.32)	-0.16* (-1.67)	-0.00 (-0.00)	-0.23** (-2.45)	-0.34*** (-3.29)	-0.13 (-1.16)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	123775	111611	108658	105835	101058	98156	96266	92717	91096	88863	85569
$R^2$	0.974	0.967	0.963	0.956	0.950	0.947	0.942	0.937	0.935	0.931	0.927

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

In interpreting the result of this table it is important to note that the reported coefficients represent the average responsiveness of lending rates belonging to different loan categories. Likely lending rates belonging to some loan categories will be more responsive and lending rates belonging to other loan categories will be less responsive. the response will be here indicative of the mean responsiveness across all loan categories. In the appendix two subsets of the dataset will be considered. Namely one subset in which only Loans for Consumer Durable Goods are allowed and one in which only loans for House related mortgages are considered (House Purchase and Home Equity).

Similarly to the previous table the first row represents the impulse response function of lending rates to a monetary policy rate change when each of the first three moments of the initial distribution of lending rates is exactly at its long run mean. As it is possible to observe the impulse response function of lending rates highly significant and positive, in line with textbook monetary responses of lending rates. The average lending rate responds by 0.22 percentage points on impact to a 1 percentage point monetary policy shock, in the following three months its response grows to almost 0.5 percentage points peaking at the seventh month and then shows signs of decline after. Compared to the response of unemployment, lending rates seem to respond faster to monetary policy and to also peak faster. The coefficients in the second row contain the main take-aways of the analysis. The significance, sign and magnitude of those coefficients are evidence of the role played by the initial cross-sectional skewness of lending rates on the response of lending rates themselves to following monetary policy shocks. As above we test the significance of the coefficients by running an F-Test for each horizon. The test rejects the null hypothesis confirming that the cross-sectional skewness plays indeed a role in the responsiveness of lending rates to monetary policy. The of al coefficients is positive. This implies that everything else equal if the state of the cross-sectional distribution at the moment in which a monetary policy shock hits, is particularly skewed, the monetary policy shock will have higher impact on lending rates. Finally, as concerns the magnitude of the coefficients, the coefficients in the second row are are roughly between 1/2 and 1 of the coefficients in the first row. This implies that whenever the cross-sectional skewness in 1 standard deviation above its mean the responsiveness of lending rates to a 1 percentage point monetary policy shock increases by 50% to almost 100% depending on the horizon considered. As for the unemployment table, the effect of the cross-sectional skewness also appears to be front loaded. Most effect comes from the first 5/6 periods while already in the 9th and 10th month the effects seems disappearing.

Analysing the following last two rows of the table similar conclusions with respect to the previous section can be reached. First the row containing the coefficients of the interaction term with the first moment of the cross-sectional distribution are again all significant and negative. In this case this might suggest the presence of mean reversion forces in lending rates. The response of lending rates tends to dampen when lending rates are much higher than their long run mean and viceversa. This might in turn explain the negative and significant coefficients of the third row in the previous table 1. As lending rates tend to respond less to a new monetary policy shock when their level is already high,

the pass-through of monetary policy to the real economy also dampens through textbook interest rate channel types of mechanisms.

The main take-away of this subsection is similar to the one of table 1. The average responsiveness of lending rates at the local branch-month level is state-dependent and the third moment is an important state variable. If prior to a new monetary policy shock the cross-sectional distribution of lending rates is particularly skewed (1 standard deviation above its mean) the following monetary policy shock will have 50% to 100% more impact on Lending Rates on average. In the following subsection a battery of robustness checks along several dimensions will be discussed in order to establish the solidity of this result.

### 5.3 Robustness

The robustness of the two main results presented above is in this section tested along several dimensions, namely set of interaction terms to control first, monetary policy proxy, estimation methodology and clustering, and aggregate moments.

#### 5.3.1 Increased Set of Interaction Terms

First, I augment the set of interaction terms to account for potentially confounding factors. I consider interaction terms between the monetary policy proxy and: (i) a dummy variable capturing the periods in which the Zero Lower Bound was perceived as binding (identified as periods in which the Federal Funds Rates close to zero), (ii) a dummy variable capturing the NBER monthly recession dates, (iii) a dummy variable capturing local recessions at the county level (identified as two quarters of negative growth in the county measure of unemployment), (iv) a proxy of the bank market concentration at the county level (computed as the Herfindal Index based on data on the deposit volume by branch from the FDIC summary of deposits data). The four interaction terms are either introduced separately or all together. The results are contained in Appendix C. Overall the significance, sign and magnitude of all coefficients presented in the previous subsections remains to large extent unchanged. It is worth nothing that among all interaction terms only the interaction term between the monetary policy shock and the zero lower bound seems particularly relevant. Indeed the whole collection of the coefficients multiplying this interaction term are significant and negative. This seems to suggest that the basic responsiveness of lending rates and unemployment to monetary policy is considerably dampened during zero lower bound periods. Although less significant the coefficient on the local recession is on the contrary positive. This in turn suggests that during recessionary periods monetary policy is indeed more effective on the economy, in line with the results of [Tenreyro and Thwaites \(2016\)](#).

### 5.3.2 Different High frequency Proxy

In order to test the robustness of the results with respect to the choice of the high frequency proxy I re-estimate the baseline specification augmented with the interaction terms outlined above using the high frequency proxy from [Jarociński and Karadi \(2020\)](#). The authors of the paper note that the change in prices in a narrow window around the FOMC announcement might be driven by two shocks: (i) a pure monetary policy shock and a central bank information shock. Central banks might have either privileged or more accurate information about the state of the economy. For instance they might decrease the monetary policy rate because they expect more deteriorated economic conditions. The proxy they suggest parses out this latter effect. When the latter proxy is substituted to the one from [Bauer and Swanson \(2022\)](#) used in the main specification the results are largely unchanged.

### 5.3.3 Internal Instrument vs Two Stage Least Squares

While the baseline results presented adopt an internal instrument approach, where the proxy is directly introduced in the specification, a more standard approach would be to run a two stage least square regression. In this approach  $X_t^{MP}$  is the interest rate on a high liquid and highly dependent on monetary policy instrument such as the federal funds rate or the short term treasury rate. The proxy will be used as external instrument in order to estimate unbiased coefficients for  $X_t^{MP}$  and its interaction terms. The results in the appendix show that the main result remain robust to this approach.

### 5.3.4 Bank specific average interest expense

Throughout the paper the direct responsiveness to a monetary policy shock has been analyzed. One might however be concerned with the fact that different banks have different cost structures. If this is the case when monetary policy changes, the average cost of funds might change differently across banks. According to textbook banking models this would imply an heterogeneous response of lending rates to monetary policy. If different banks populate different countries part of the results presented might hence be driven by this source of heterogeneity. In the baseline specification we control for this source of heterogeneity by introducing a variable capturing bank average interest rate expense into the specification. However in this robustness we substitute such variable directly to  $X_t^{MP}$  and run a two stage least square local projection using the high frequency proxy from [Bauer and Swanson \(2022\)](#) as external instrument. The interpretation of the coefficients slightly varies. In this case a positive significant coefficient on  $X_t^{MP}$  implies that the outcome variable  $y$  changes positively and in the same direction following an exogenous increase in the average interest rate expense of the bank owning the branch of the observation. Importantly in this case the regression is at the Bank/Month/Branch level rather than at the County level. The results are largely robust, one main difference with the baseline results should be noted. The first row of coefficients, i.e. the coefficients on the non-interacted term  $X_t^{MP}$ . Is much higher than in the baseline specification. This is reassuring because, as shown by



Drechsler et al. (2017) among others, deposit rates, a big component of the banks average cost of funds are much less responsive than lending rates to monetary policy due to bank market power in deposit markets. In our results and exogenous increase of one percentage point of the interest expense by the bank owning the branch of observation results in a higher than 1 pass-through to lending rates. The relationship between first and second row is roughly the same. In counties in which the cross-sectional skewness of lending rates is particularly high, lending rates tend to react 50% to 100% more to an exogenous increase in banks' average interest expense caused by monetary policy.

### 5.3.5 Robustness with respect to aggregate skewness

The baseline specification relates the county unemployment and county average lending rate to the county specific cross-sectional skewness of lending rates. As shown at the end of section 3 however, part of the county variation in skewness correlates with the aggregate cross-sectional skewness at the national level. In order to inspect which one is the main driver of the result we augment the set of interaction terms with one more term interacting the baseline monetary policy proxy with the aggregate average cross-sectional skewness of lending rates. The results show that the first two coefficients (first two rows of the tables presented above) are largely unchanged when the new interaction term is added. Inspecting instead the coefficients on the latter interaction term they result to be highly volatile ranging from significant negative values for the first two horizons to positive significant in the latter two horizons, which makes any inference difficult to make.

## 5.4 State/Quarterly Dataset

As mentioned in Section 4, this paper further tests the robustness of the presented results on two additional datasets. The first dataset contains State level information on Personal Income, Inflation and Home Price Indexes at the state level, and Interest Rates at the Bank Level. For lack of other sources the interest rates in this dataset are computed as the ratio between Interest Income by Loan category (from the Call Reports - Income statement) and the corresponding Loan volume by loan category (from the balance sheet section of call reports). As most of the banks are present in 1/2 state while a few banks have a national presence, different banks are allocated to different states depending on their local presence in terms of branches by deposit volume. The moments are hence computed at the state level by using the branch deposit volume as weight. The dataset allows to expand the analysis along two dimensions: (i) it allows to analyze the effect on Real Personal Income as outcome variable rather than on unemployment, (ii) it contains information on C& I loans which are largely absent in the other two datasets. The local projection specification is largely the same with the only difference that the regional control variables are now at the state level rather than at the county level. The results in the appendix show that the response of Real Personal Income to standard monetary policy shock is indeed negative and significant. A 1 percentage point monetary policy shock increases Real

Personal Income by roughly 1 percentage point at the peak. The set of local projection coefficients on the interaction between monetary policy and cross-sectional skewness in the initial distribution of lending rates at the state level is also significant and roughly 1/4 of the response to the monetary policy shock alone. This implies that whenever skewness is 1 standard deviation higher than its state-level long run mean monetary policy is 33% more effective on Real Personal Income than otherwise.

#### 5.4.1 Loan/Quarterly Dataset

A last battery of robustness checks is performed using the Loan-level dataset from Freddie-Mac. In this case we restrict the attention to two outcome variables, the average lending rate by loan category (maturity, house value, etc) and county, and the Refinancing Rates computed as the volume of loans that are refinanced with respect to the previous period. Differently from the baseline results lending rates are realized rates on existing loans rather than advertised rates at the branch level. This means that a big part of the interest rate determination will be played by the borrower and loan specific characteristics. I control for this by first residualizing all lending rates through a time-varying regression on all borrower and loan type characteristics observable in the dataset. This procedure is used in [Hurst et al. \(2016\)](#). If the model is well identified and there are no omitted variable the so residualized rates became homogeneous rates charged on a riskless borrower and shortest term loan. The results from running the local projections above are largely consistent with the evidence presented. Both new lending rates and refinancing rates respond more to a monetary policy shock if the initial cross-sectional skewness of lending rates is higher.

#### 5.4.2 Horse Race with the Refinancing Channel

As discussed in the section on the literature a couple of works have argued that one source of state-dependence specific to the response of lending rates in house mortgage markets can be retrieved in the sluggishness of the response of mortgagees in refinancing their loans when new better conditions arise. This channel is empirically traced by [Eichenbaum et al. \(2022\)](#) through an interaction term between a monetary policy instrument and the average interest rate gap at the county level, i.e. the average difference between existing mortgage interest rates originated in the past and not refinanced and interest rates on new mortgages offered by banks in the current period. In this last robustness check I add to the baseline specification the interaction between the monetary policy instrument and the interest rate gap. The results in the appendix show that even when controlling for the interest rate gap interaction term, the interaction between skewness and monetary policy is highly significant and positive. At the same time the interaction between monetary policy and Mean Interest rate gap is also positive and significant. I conclude from this result that the cross-sectional skewness and the mean interest rate gap capture two important complementary yet different sources of state-dependence in the effects of monetary policy.

## 6 Theoretical Framework

The objective of this section is to develop a Bertrand Competition framework with the objective to rationalize the main empirical take-away of the paper. Within the Industrial Organization Literature the lending rate pass-through of monetary policy can be viewed as a specific case of a cost pass-through mechanism, where monetary policy shock map into exogenous shifts in banks' marginal cost of producing a loan and lending rates are the prices affected by this shock. The purpose of the model is threefold. First, it represents a theoretical effort to identify a parsimonious set of *ingredients* necessary in order to capture the state-dependence of the cost pass-through, while abstracting from bank ex-ante heterogeneity in costs and demand ex-ante heterogeneity in price elasticity. The task is not trivial as normally the heterogeneity in the cost pass-through is achieved from the sources we are here abstracting from.

Second, it aims at micro-funding the observed skewness based state-dependence with a novel mechanism arising from the combination of search and switching costs on the demand side and the strategic complementarity in bank pricing decision. Third, the framework will be used to derive sharp theoretical implications for the cross-sectional heterogeneity and time-variation of the cost-pass-through following different combinations skewness and monetary policy shocks signs and magnitudes: high vs low skewness states with positive vs negative and high vs low monetary policy shocks. In general the model is to be viewed as a potential substitute for other state-dependent frictions, such as menu-costs, in firms price-setting behaviour. As such in further research it will be included in broader structural dynamic general equilibrium model to analyze the general equilibrium properties of Mark-ups and prices responses to aggregate shocks in presence of such friction in lending markets specifically, but also more broadly in the non financial business sector.

for the bank maximization problem to give rise to asymmetric equilibrium interest rates in a Bertrand Competition setting (Bertrand (1883)). The task is non-trivial. As surveyed in Farrell and Klemperer (2007) most of the analysis of Bertrand Nash Equilibria and various settings either restricts the attention or finds that only Symmetric Equilibria are possible. In the few settings where asymmetric equilibria arise either those are mixed strategy Nash Equilibria or "winner takes it all" result arises, i.e. one bank attracts all potential customers and the others loose all their customers, zero net profits (Bernhardt and Graham (2015)). Informed by the observed evidence on banks pricing behaviour this paper goes in the opposite direction. As shown by a great body of literature on lending rate pass-through discussed in Section 2 the banking sector provides a good example of an environment in which a uniform cost shock across firms produces highly asymmetric and time-varying pass-through to lending rates. This can be the result of three things: the nexus between the initial shock and banks marginal cost is heterogeneous depending on banks funding structure, size, etc, or the response of local demand reacts heterogeneously to a given change in the offered interest rate. Both routes would not allow to explain the observed joint variation in time and space. This paper argues there is there is a third route:

search and switching inertia of consumers is state-dependent. In states of the world in which search and switching inertia is high, consumers will be relatively loyal, banks will not have incentives to poach customers and will be have more closely to local monopolists. Viceversa in the opposite states. identify the necessary and sufficient ingredients for microfunding the documented state-dependent channel in the lending rate pass-through of monetary policy. For this reason I abstract from all other sources of friction that the literature has argued for in the study of the Bank Transmission Channels of Monetary Policy (for instance Borrower Risk, or Bank Balance Sheet frictions). Second, the model is targeted at getting at the root a largely unexplored source stickyness in price adjustments to macroeconomic shocks characterized by an asymmetric and time-varying cost-pass-through. For this reason, the model is partial equilibrium its horizon is two periods. Its generalization is left to follow up papers. In general the model is to be viewed as a potential substitute for the module capturing firm and bank price-setting behaviour in broader structural dynamic general equilibrium models. <sup>29</sup>

## 6.1 Environment and Timeline

I consider a static repeated Bertrand Competition Game  $\Gamma$  among two banks. The two banks produce differentiated loans and compete in interest rates. Loan differentiation is modelled through a Hotelling structure: bank H loans and bank L loans sit at the two extremes of a line on the interval  $[0, 2]$ . Each potential borrower will be sitting at a specific point on the interval. The distance from 0 captures how much he/she dislikes the characteristics of bank H the distance from 2 represents how much he/she dislikes the characteristics of bank L. Each borrower also has a utility of taking out a loan of  $v$  that is exogenous and fixed. The net utility of getting a loan from either bank will be:

$$\begin{aligned} U &= v - z - r_t^H && \text{if loan from bank H} \\ U &= v - (2 - z) - r_t^L && \text{if loan is from bank L} \end{aligned}$$

A borrower with distance  $z$  from bank H and  $(2 - z)$  from bank L will take out a loan from bank H iff  $v - z - r_t^H \geq v - (2 - z) - r_t^L$ .

Each period a cohort of new customers will be in need for a new loan. They first have to learn the interest rate that is offered by banks and then decide whether and from which bank to take the loan. Each cohort of customers has already a relationship with either of the two banks. I refer to bank's H(L) courtyard as the pool of borrowers in the cohort that have a relationship with bank H(L). Borrowers' have to pay search cost to learn current interest rates but they can learn the newly offered interest rate of the bank they have a relationship with for free. The timeline is hence as follows. First borrowers decide whether they pay the search cost or not. Then banks observe borrowers decisions and decide their interest rates. Finally borrowers observe the interest rates and decide whether to

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<sup>29</sup>We further abstract from third degree price discrimination based on [Bouckaert et al. \(2013\)](#)

apply for a loan. At the beginning of each period borrowers can observe the equilibrium prices that prevailed in the previous period and this is the only information that they have. Finally borrowers are heterogeneous in their search and switching frictions. Customers have heterogeneous search costs uniformly distributed over the interval  $[0, \bar{\theta}]$ . They also have heterogeneous switching costs that are distributed over the  $[0, \bar{\Psi}]$  interval.

## 6.2 First Stage Borrowers Decision to Search

At the beginning of the period borrowers need to decide whether to just wait and observe the new interest rate offered by their courtyard bank or pay the search cost in advance and observe also the other bank's interest rate. In order to take this decision they need to evaluate what are the expected gains from searching. The decision of borrower  $j$  belonging to bank  $H$ 's courtyard will be :

$$\text{Search} \quad \text{if} \quad \mathbb{E}[v - z_j - r_t^H] < \mathbb{E}[\max\{v - z_j - r_t^H, v - (2 - z_j) - r_t^L\} - \theta] \quad (8)$$

$$\text{Don't Search} \quad \text{if} \quad \mathbb{E}[v - z_j - r_t^H] \geq \mathbb{E}[\max\{v - z_j - r_t^H, v - (2 - z) - r_t^L\} - \theta_j] \quad (9)$$

Where  $\theta_j$  is the search cost for borrower  $j$ . The decision rule for borrowers of courtyard  $L$  will be the same. Recall that borrowers learn their  $z$  only after they pay the search cost hence ex-ante they just formulate their expectation to be:

$$\mathbb{E}[z] = \mathbb{E}[(2 - z)] = 1 \quad (10)$$

As for the interest rates, recall that borrowers do observe the previous period equilibrium interest rates. For simplicity I assume they have a simple random walk forecasting model in mind, i.e.:

$$\begin{aligned} r_t^H &= \gamma c_t \\ c_t &= c_{t-1} + \varepsilon_t^{MP} \end{aligned}$$

I assume that  $\mathbb{E}[\varepsilon_t^{MP}] = 0$ . This combined with the random walk forecasting model above amounts to borrowers having simple naive expectations

$$\mathbb{E}[r_t^i] = r_{t-1}^i \quad \text{for } i = H, L \quad (11)$$

Combining 10 and 11 with 8 the search decision will be defined by the following policy function:

$$\text{Search} \quad \text{if} \quad \theta_j < r_{t-1}^H - r_{t-1}^L \quad (12)$$

$$\text{Don't Search} \quad \text{if} \quad \theta_j \geq r_{t-1}^H - r_{t-1}^L \quad (13)$$

$$(14)$$

Without loss of generality assume  $r_{t-1}^L < r_{t-1}^H$ , i.e. bank L identifies the bank charging the lower rate in the previous. Now recall that search costs are uniformly distributed over the interval  $[0, \bar{\theta}]$ .

**Remark 6.1.** *Borrowers belonging to bank L's courtyard will not decide to search.*

**Remark 6.2.** *Borrowers who search will observe both  $r_t^H$  and  $r_t^L$ , and  $z$ . Borrowers who don't search will only observe their own courtyard  $r_t^i$  and  $z$  (2-z).*

### 6.3 Third Stage Borrowers' Decision to Borrow

The third stage decision is presented before banks' decision because banks know how many borrowers on aggregate decide to search given the past interest rates  $r_{t-1}^H$  and  $r_{t-1}^L$  and also know the distribution of switching costs  $z$  over loan characteristics. Borrowers' are price-takers. In the third stage they observe the interest rates and their realized  $z$  and decide whether to take a loan or not. If they payed the search cost in the first period then they will also have to decide from whom to take the loan. Consequently their decision rule will be (for borrower of courtyard H):

$$\begin{aligned} \text{Take loan} & \quad \text{iff} \quad v \geq z_j + r_{t-1}^H & \quad \text{if no search in stage 1} \\ \text{Don't take loan} & \quad \text{iff} \quad v < z_j - r_{t-1}^H & \quad \text{if no search in stage 1} \\ \text{Take loan from Bank H} & \quad \text{iff} \quad v - z_j - r_{t-1}^H \geq \max\{v - (2 - z_j) - r_{t-1}^L, 0\} & \quad \text{if search in stage 1} \\ \text{Take loan from Bank L} & \quad \text{iff} \quad v - (2 - z_j) - r_{t-1}^L > \max\{v - z_j - r_{t-1}^H, 0\} & \quad \text{if search in stage 1} \\ \text{Don't take loan} & \quad \text{iff} \quad \max\{v - z_j - r_{t-1}^H, v - (2 - z_j) - r_{t-1}^L\} < 0 & \quad \text{if search in stage 1} \end{aligned}$$

Intuitively the borrower will chose whether to borrow or not from his/her bank if he/she didn't search in the previous period. The borrower might still decide not to borrow if the sum of  $r$  and  $z$  is too high with respect to  $v$ . On the other hand, if the borrower did pay the search cost in the previous period then the bank offering the lowest cost for the borrower will capture that borrower.

**Remark 6.3.** *Banks will compete only over customers that paid the search cost in the first stage.*

## 6.4 Demand Derivation and Properties

The key addition to the standard Bertrand Competition Game is to incorporate Search and Switching frictions into Borrowers demand. Imagine in county H there is a continuum of agents on the  $[0,1]$ .  $\lambda_H$  customers are in Bank H's courtyard and  $\lambda_L = 1 - \lambda_H$  are customers of Bank L. The aim is to now construct the aggregate demand that bank H and bank L face. As specified by Remark 6.3 bank H (L) demand will be made of two components: (i) the demand of customers that did not search and belong to H (L) courtyard and the mass of customers that searched from either courtyard. I assume each loan to be of value 1. This means that for banks the demand will purely vary with the number of borrowers that select to search and or to switch. Let's start from the first stage decision. Recall customers have heterogeneous search costs drawn each period from a uniform distribution  $[0, \bar{\theta}]$ . Recall from 6.2 the mass of borrowers deciding to search comes purely from the bank that was charging the higher rate in the previous period, in this case bank H. The total mass of consumers of courtyard H not searching will be derived as:

$$X_t^{H,NS} = \lambda_H \int_0^{\bar{\theta}} \frac{1}{\bar{\theta}} \mathbb{1}_{\{\theta \geq r_{t-1}^H - r_{t-1}^L\}} d\theta = \lambda_H \frac{1 - (r_{t-1}^H - r_{t-1}^L)}{\bar{\theta}} \quad (15)$$

The total mass of consumers of courtyard H searching will be the residual:

$$X_t^{H,S} = \lambda_H \frac{(r_{t-1}^H - r_{t-1}^L)}{\bar{\theta}} \quad (16)$$

I will redefine these expressions as:

$$X_t^{H,S} = \lambda_H [1 - S(r_{t-1}^H - r_{t-1}^L)] = \lambda_H [1 - S] \quad (17)$$

$$X_t^{H,NS} = \lambda_H [S(r_{t-1}^H - r_{t-1}^L)] = \lambda_H [S] \quad (18)$$

For bank L, given Remark 6.2 the mass of borrowers will be:

$$X_t^{L,S} = 0 \quad (19)$$

$$X_t^{L,NS} = \lambda_L \quad (20)$$

In the third stage consumers observe the new interest rates  $r_t^H$  and  $r_t^L$  (either one or two interest rates depending on whether they paid the search cost in the first period) and their  $z_j$ . Recall  $z_j$ s are uniformly distributed over the  $[0, \bar{\Psi}]$  interval. The final demands faced by each of the two firms will have the following structure.



$$X_t^{H,S}(r_t^H, r_t^L) = \lambda_H [1 - S] \int_0^\Psi \frac{1}{\Psi} \mathbb{1}_{\{v-z-r_t^H \geq v-(2-z)-r_t^L\}} dz = \lambda_H [1 - S] \left[ 1 + \frac{r_t^L - r_t^H}{2} \right] \quad (21)$$

$$X_t^{H,NS}(r_t^H) = \lambda_H [S] \int_0^\Psi \frac{1}{\Psi} \mathbb{1}_{\{v-z-r_t^H \geq 0\}} dz = \lambda_H [S] [v - r_t^H] \quad (22)$$

$$X_t^{L,S}(r_t^H, r_t^L) = \lambda_H [1 - S] \int_0^\Psi \frac{1}{\Psi} \mathbb{1}_{\{v-z-r_t^H < v-(2-z)-r_t^L\}} dz = \lambda_H [1 - S] \left[ 1 + \frac{r_t^H - r_t^L}{2} \right] \quad (23)$$

$$X_t^{L,NS}(r_t^L) = \lambda_L \int_0^\Psi \frac{1}{\Psi} \mathbb{1}_{\{v-z-r_t^L \geq 0\}} dz = \lambda_L [v - r_t^L] \quad (24)$$

where  $X_t^{H,S}$  is the part of demand faced by bank H by potential borrowers of bank H's courtyard who paid the search cost;  $X_t^{H,NS}$  is the part of demand faced from bank H by potential borrowers from bank H's courtyard who didn't pay the search cost;  $X_t^{L,S}$  is the part of demand faced by bank L by potential borrowers of bank H's courtyard who paid the search cost and finally  $X_t^{L,NS}$  is the part of demand faced from bank L by potential borrowers from bank L's courtyard who didn't pay the search cost. We are now ready to derive the respective total demands faced by bank H and bank L.

$$X_t^H(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L) = \lambda_H [S] [v - r_t^H] + \lambda_H [1 - S] \left[ 1 + \frac{r_t^L - r_t^H}{2} \right] \quad (25)$$

$$= \lambda_H [1 + S[v - 1]] - \left[ \lambda_H S + \frac{1}{2} \lambda_H (1 - S) \right] r_t^H + \left[ \frac{1}{2} \lambda_H (1 - S) \right] r_t^L \quad (26)$$

$$X_t^L(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L) = \lambda_L [v - r_t^L] + \lambda_H [1 - S] \left[ 1 + \frac{r_t^H - r_t^L}{2} \right] \quad (27)$$

$$= \lambda_L [v] - \left[ \lambda_L + \frac{1}{2} \lambda_H (1 - S) \right] r_t^L + \left[ \frac{1}{2} \lambda_H (1 - S) \right] r_t^H \quad (28)$$

It is easy to see that the obtained demand system is hence linear in interest rates.

## 6.5 Profit Function

In the second stage banks observe the demand derived in the previous subsection and decide their prices. I assume each bank offers one type of loan with one interest rate and a fixed marginal cost of producing it  $c_t = c_{t-1} + \varepsilon_t^{MP}$ . The cost of funds is shifted around by monetary policy. A positive monetary policy shock  $\varepsilon_t^{MP}$  will increase banks marginal cost of producing a loan, a negative monetary policy shock will decrease banks marginal cost of funds. The profit function of bank H and L will hence be :

$$\begin{aligned}
\pi^H(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L) &= [r_t^H - c_t] [X_t^L(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L)] \\
\pi^L(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L) &= [r_t^L - c_t] [X_t^L(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L)]
\end{aligned}$$

Each banks' maximization problem will be :

$$\begin{aligned}
\max_{r_t^H} \quad & \pi^H(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L) \\
\max_{r_t^L} \quad & \pi^L(r_t^H, r_t^L, r_{t-1}^H, r_{t-1}^L)
\end{aligned}$$

Notice from the latter maximization program that each bank is internalizing and best responding to the interest rate setting rule of the other bank.

## 6.6 Equilibrium Prices and Cost Pass-Through

The equilibrium in pure strategies to the Bertrand-Nash game can be defined as the set of prices  $r_t^H$  and  $r_t^L$  for which neither of the two banks has a profitable deviation. The equilibrium interest rates will have be hence a function of the parameters  $(\lambda_L, \lambda_H, r_{t-1}^L, r_{t-1}^H)$ . While the exact specification is left to the appendix, here is the their general form:

$$r_t^{A*} = f^H(\lambda_L, \lambda_H, r_{t-1}^L, r_{t-1}^H) + g^H(\lambda_L, \lambda_H, r_{t-1}^L, r_{t-1}^H)c_t \quad (29)$$

$$r_t^{B*} = f^L(\lambda_L, \lambda_H, r_{t-1}^L, r_{t-1}^H) + g^L(\lambda_L, \lambda_H, r_{t-1}^L, r_{t-1}^H)c_t \quad (30)$$

The focus of this paper will be on the response of lending rates to monetary policy shocks. This will amount to study the functions  $g^H(.)$  and  $g^L(.)$  of the above expressions.

## 6.7 Results

The model produces three main results which will be outlined in three propositions.

**Proposition 6.4. :**

$$(1) \quad \left[\frac{1}{2}\lambda_H(1-S)\right] < [\lambda_H S + \frac{1}{2}\lambda_H(1-S)] \Leftrightarrow \frac{1}{2} < \frac{\partial r_H}{\partial c} < 1$$

$$(2) \quad \left[\frac{1}{2}\lambda_H(1-S)\right] < [\lambda_H S + \frac{1}{2}\lambda_H(1-S)] \Leftrightarrow \frac{1}{2} < \frac{\partial r_L}{\partial c} < 1$$

The above proposition contextualises the presented game into the wider class of Bertrand Competition Games with Linear demand. The lower bound  $\frac{1}{2}$  would be the counter-part partial derivative if

no borrower was searching and banks could just behave as monopolists. On the other hand 1 would be the cost-pass-through if all borrowers were searching and banks would hence behave as standard Bertrand competitors and pass-through any cost shock 1 to 1. In this case banks are facing heterogeneous demands part of which they can behave as perfect Bertrand competitors and part as local monopolists. The resulting cost-pass-through derivative will be hence in between the two values.

The following proposition is the central result validating the model for the purpose is built for.

**Proposition 6.5.**  $\frac{\partial r_i}{\partial c}$  is increasing in  $(r_{t-1}^H - r_{t-1}^L)$ .

The proposition shows how both banks tend to have a stronger pass-through when the distribution of interest rates is more dispersed at the beginning of the period. Recalling the previous discussion, as the gap among t-1 interest rates increases more and more borrowers of bank H courtyard will find convenient to search. This will increase the coefficient multiplying the opponents bank rate in the demand function which in turn implies that the price complementarity among the two banks increases. The build intuition let's start from a situation in which banks are local monopolist. In this case an increase of 1% in  $c_t$  will cause an increase of  $\frac{1}{2}\%$  in the equilibrium interest rates of both banks. Now let's imagine that banks can compete on a small group of customers both banks will make an extra effort and pass-through more of the change in the monetary policy shock due to heightened complementarity among the two banks. As this group of borrowers increases so does the pass-through of monetary policy. Notice that the derivative will be also an increasing function of  $\lambda_H$ . Take again the limit of  $\lambda_H \rightarrow 0$  then the Bank L will again just behave as a monopolist because the net gain from acquiring any small fraction of Bank H courtyard is less than the net loss of charging a lower interest rate on customers from own L courtyard.

The third proposition explores the model implications for how the cost-pass-through of the two banks.

**Proposition 6.6.**  $\lambda_L > \lambda_H \mathbb{S}(r_{t-1}^H - r_{t-1}^L) \Rightarrow \frac{\partial r_H}{\partial c} > \frac{\partial r_L}{\partial c}$ .

The cost-pass-through will be different between the two firms. When the mass of consumers not searching for the other banks rates are such that the L mass is higher than the H mass then the cost-pass-through of Bank H will be higher than Bank L. The intuition for this result is that when the two banks have non-symmetric pools of customers on which they can behave as local monopolists the bank with the higher pool of non-searching customers will behave closer to a monopolist and hence be less responsive to a cost shock. On the opposite the bank with the lower pool of local monopoly customers will be closer to a symmetric Bertrand competitor with perfect pass-through.

## 6.8 Empirical Test of Proposition 3

In this subsection, the baseline specification used in Section 5 is recovered and augmented with an additional term in order to test the theoretical implication driven by proposition 3. While proposition

2 implies that in counties where skewness is higher (the  $r_t^H$  is more distant from  $r_t^L$  and  $\lambda_H/\lambda_L$  is higher) both banks tend to pass-through more of a change in the monetary policy rate to a change in their respective lending rates, proposition three goes beyond and implies that the banks that were ex-ante charging the higher rate will pass-through more of the change in the monetary policy rate. In order to test this latter implication the specification is augmented with a triple interaction term between (i) Monetary Policy shock, (ii) Cross-sectional skewness of lending rates and (iii) a dummy variable that takes value one when the branch has its lending rates in the upper half of the distribution (above median).

Lending Rates. Interaction With Skewness, and with Skewness and Dummy for High Rate Banks.  
(Testing Proposition 3 of Model)

Month	0	1	2	3	4	5	6	7	8	9	10
MP	-0.13*** (-13.23)	0.30*** (25.65)	0.24*** (17.59)	-0.02 (-1.60)	0.16*** (10.42)	0.04*** (2.78)	-0.24*** (-13.49)	-0.21*** (-12.21)	-0.20*** (-11.30)	-0.31*** (-16.49)	0.07*** (3.92)
Skew	-0.01 (-0.69)	-0.01 (-0.39)	0.03 (1.25)	0.04* (1.89)	0.06** (2.35)	0.08*** (3.40)	0.42*** (16.37)	0.45*** (17.43)	0.38*** (14.81)	0.09*** (3.41)	0.20*** (7.91)
H Skew H Rate	-0.06* (-2.56)	-0.04 (-1.24)	0.01 (0.40)	0.13*** (3.46)	0.15*** (3.91)	0.13*** (3.31)	0.10*** (2.61)	0.07* (1.69)	0.09** (2.21)	0.20*** (4.90)	0.14*** (3.52)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>N</i>	2317536	2200605	2139583	2080359	2028567	1983506	1943036	1898621	1860857	1823443	1784944
<i>R</i> <sup>2</sup>	0.977	0.968	0.961	0.955	0.950	0.946	0.943	0.940	0.938	0.936	0.934

*t* statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

The first row of coefficients represents the baseline response of lending rates to a monetary policy shock of 1 percentage point when the Cross-sectional skewness is at its long run mean. The second row coefficients instead represent the increase, for each horizon *h* in the responsiveness of lending rates to the same monetary policy shocks when the skewness is 1 standard deviation above mean. Finally the third row represents the additional responsiveness in the lending rates to monetary policy changes when both the initial cross-sectional skewness of lending rates is one standard deviation higher than its long run mean and the branch was charging a high rate in the previous period. According to the theoretical prediction all three coefficients are overall significant and positive. The empirical evidence suggested that the theoretical prediction is therefore correct. Whenever the cross-sectional skewness of lending rates is higher, all banks do indeed respond more to a monetary policy shock, but among them, the ones that respond the most are the ones in the tail of the distribution.

## 7 Conclusion and Future Research

In this paper I show that the efficacy of monetary policy in shaping economic outcomes crucially depends on the way financial intermediaries respond to it. I document empirically that this response is state dependent. The key state variable is the skewness of the cross-sectional distribution of lending rates across banks at the local level prior to the change in the policy rate. Contrary to conventional wisdom even after controlling for borrower and loan type characteristics the cross-sectional distribution of lending rates exhibits a highly asymmetric shape as measured by the third moment of the distribution, i.e. the cross-sectional skewness. The cross-sectional skewness of lending rates exhibits high frequency variation both within regions, i.e. states, counties and MSAs and across time. Building on a comprehensive dataset matching macroeconomic and banking variables at various levels of dis-aggregation I show that high initial cross-sectional skewness leads to a (i) roughly 70% stronger response of bank lending rates and a roughly 25% stronger response of economic activity to monetary policy. I develop a model of imperfect competition among banks that accounts for this empirical finding. Banks experience increases (decreases) in their funding costs after an easing (tightening) of monetary policy and strategically compete over borrowers through the interest rates (i.e. they are Bertrand competitors). A key feature of the model is that borrowers face search frictions and switching frictions. Because both searching for a new lender and switching to a new lender is costly, borrowers tend to remain loyal to their *home bank*, i.e. the bank they have a past relationship with. However, if they receive a signal that the returns from searching overcome the cost of searching and switching they will start exploring offers from other banks. A higher degree of skewness among lending rates prior to a new monetary policy shock increases borrowers' expected returns to search. Whenever a larger mass of borrowers is on the search for new lending rates offers banks will know that are larger than usual portion of customers will be easier to poach and the price complementary among interest rates will increase. In these circumstances, strategic behaviour by banks leads to higher responsiveness of lending rates to policy rate changes. Through this channel, the model can also reconcile my finding that conventional monetary policy has stronger effects on economic activity the more skewness there is in bank lending rates. A further implication of the model is that the banks starting with a higher rate at the beginning of the period will adjust their interest rates by more following a new monetary policy shock. When tested empirically this implications is sustained by the data. Two important policy implications are in order. First, whenever local lending markets exhibit low skewness on average, the response of lending rates to a change in monetary policy will be dampened, so will the transmission to economic activity. This was the case after periods of many consequent monetary policy easings. Monitoring the cross-sectional skewness of the distribution of lending rates, would improve the predictability of monetary policy outcomes therefore a lower discrepancy between intended and actual outcomes of a new monetary policy decision. Second redesigning financial regulation to introduce incentives against the exploitation of borrowers search and switching frictions by lenders could reduce the variability of

monetary policy outcomes. This study fosters the development of a new line of study taking more seriously the role of the industrial organization and market structure of financial intermediaries in the amplification of macroeconomic shocks. A key feature missing in the presented model is the consideration of forward looking behaviour when the presented static Bertrand game is extended to dynamic. If banks are perfectly rational and forward looking, the dynamic effects of skewness might be smoothed out over time. However if one accounts the incentives of banks stake-holders and managers to be more short-lived a certain degree of myopia in banks rate setting might appear. In future work I intend to extend the theoretical model from a duopoly to an oligopoly (more realistic) and from static to dynamic. Following I will introduce this model into a quantitatively realistic macro-banking model in order to study its interaction with the other financial frictions already emphasized by the long literature on financial intermediation and more short-lived literature on heterogeneous financial intermediaries. Finally I intend to calibrate the model in order to derive optimal monetary and fiscal policy in presence of a more detailed industrial organization of the financial sector.

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# State-Dependent Pass-Through from Monetary Policy to Lending Rates

Supplementary Material – Online Appendix

## A Extended Literature Review

This paper contributes to three main strands of literature. First it relates to the very recent work uncovering state-dependent effects of Monetary Policy. To my knowledge only two works are involved in this study, namely [Berger et al. \(2021\)](#) and [Eichenbaum et al. \(2022\)](#). The two papers study how prepayment and refinancing decisions on house mortgages lead to state-dependent efficacy of monetary policy. Consumers face a cost in refinancing or prepaying their mortgage which implies they keep their mortgage as it is unless the gains/savings in terms of interest expense from refinancing and/or prepaying their existing mortgage are sufficiently high. This implies that when monetary policy shifts interest rates down only a fraction of the consumers locked in sufficiently high rates will move.<sup>30</sup> The state-dependence comes from the fact that if the distribution of the spreads between the existing and new rates has a high mean a lot of consumers will refinance otherwise only a few will. As a result successive shocks decreasing interest rates will result in almost all consumer refinancing, which in turn decreases the efficacy of next monetary policy shocks going in the same direction. My paper notably innovates in this literature in three different ways. First it relates monetary policy state-dependence to the supply rather than the demand side of Loan Markets by focusing on frictions affecting banks strategic pricing decisions. The two channels are complementary yet reinforcing. If banks do not face incentives from poaching customers from their competition, lending rates would respond by less to monetary policy intervention which in turn implies that less borrowers will have incentives from refinancing. Second the form of state-dependence outlined in this paper works in both the directions of an easing and a tightening of monetary policy. Banks whose rates are standing in the tail of the distribution are constrained by their competition to keep their rates lower than they otherwise would be, as monetary policy shifts marginal costs up, this constrained is progressively released hence leading to an expansion of the distribution up. Third it shows how not only the mean of the past distribution of interest rates is a relevant variable for the evaluation of the monetary policy pass-through but higher order moments of the same distribution carry equally important information. Last the channel outlined in this paper carries also to consumer loans and Commercial and Industrial Loans.

In a similar flavour to [Beraja et al. \(2018\)](#) regional heterogeneity is a key driver in the amplification of monetary policy effects. In their paper the authors argue that regional heterogeneities in the distribution of housing equity significantly impacts the response of refinancing decision following interest rates cuts. Central Banks should hence track the regional distribution of equity over time. Similarly this paper argues that the regional heterogeneity in the cross-sectional distribution of lending rates drives the banks response to successive interest rates. Differently from their paper, I document how the regional heterogeneity in the local market structure of banking industry gives rise to endogenous time-varying intensity in bank price competition and I show its effects on following monetary policy pass-through interest not only for house mortgage decisions but also for several other types of loans. The channel outlined in this paper is related to the literature arguing for the importance of bank's market power in bank's pricing decisions and hence on monetary policy pass-through. Notable recent examples are [Gödl-Hanisch \(2022\)](#), [Scharfstein and Sunderam \(2016\)](#), [Corbae and Levine \(2022\)](#), [Wang \(2020\)](#) and [Wang et al. \(2022\)](#). By using the same branch-level source of data used in this paper, the author is able to disentangle the importance of bank concentration and bank capitalization showing that both channels together with their interaction are greatly important for the monetary policy pass-through. In line with this work, this paper shows that market power plays an important

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<sup>30</sup>a similar loss in monetary policy efficacy working through lumpy consumer spending on durable goods has been proposed by [McKay and Wieland \(2021\)](#).

role in the determination of loan rate pass-through on a broad set of data outside the shared dataset. In contrast with that work this paper focuses on a type of variation that cannot be explained according to standard model of bank market power. Indeed in the model used in that work features local monopolistic competition and bank capital constraints. This would imply that conditional on the level of binding capital constraint the same bank would have the same pass-through across time in a specific region. This is counterfactual with the main stylized fact documented in this paper of asymmetric local Skewness across time. Also again conditional on the level of bank capital the mark-up is a constant multiplier over the policy rate. Finally that model would not explain why the Skewness of interest rates in a certain period would affect the. I am reconciling this three new factors by endogenizing the local bank demand elasticity to own and competition interest rates through Information and Switching costs on the consumer side. Through this mechanism I am able to explain a considerable portion of the variation of bank cross-branch time-variation in the pass-through of monetary policy to lending rates. Importantly this literature would imply that the history of previous monetary policy shocks is irrelevant for the current pass-through of the current monetary policy shock. On the contrary this paper argues that the a sequence of monetary policy easing interventions could have the effect of squeezing the distribution into being less dispersed and more symmetric and could hinder the pass-through of the next monetary policy interventions.

Broadly this paper is related to literature coming from three different fields. First it contributes to the Macro-Finance literature studying how frictions in the financial markets impact the transmission and amplification of macroeconomic shocks and in particular monetary policy shocks. Second it contributes the Industrial Organization literature studying frictions in firms' competition arising from the presence of consumers' switching costs, brand loyalty and product differentiation. Third it is also related to the banking literature analyzing the micro-structure of the banking sector and credit markets and their macroeconomic effects. In general this paper aims at drawing a novel connection between the theory and evidence on competition in presence of customer's frictions (second), bank's asymmetric and heterogeneous behaviour (third), and space/time varying pass-through of monetary policy (first). It does so by introducing state-dependence in customer's switching decisions and showing how this implies an interesting interaction with monetary policy shocks leading to powerful dynamics in banks competition over clients ultimately impacting the effectiveness of monetary policy on credit markets.

**Macro-Banking Literature on Bank Rates pass-through.** Letting aside the papers mentioned above, within this literature the paper relates to various strands. First it relates to the literature studying the lending rates pass-through of monetary policy. The theoretical foundations for interest pass-through models are set in the pioneering works of [Monti \(1972\)](#); [Klein \(1971\)](#), the so called Monti-Klein model, which set the microfoundations of interest rate setting as a profit-maximization of a firm tacking deposits and issuing loans. The standard approach is to assume banks follow a marginal cost pricing model, where monetary policy gets transmitted by shifting the latter cost. Starting with the empirical contributions of [Hannan and Berger \(1991\)](#); [Neumark and Sharpe \(1992\)](#); [Sharpe \(1997\)](#) evidence has been shown of limited or incomplete pass-through to bank retail rates (both deposit and lending rates).<sup>31</sup> Bank interest rates are characterized by a lower variance than money market rates, which suggests that banks typically do not fully adjust retail rates when market rates change. The conventional view on the topic regarded bank balance sheet characteristics such as size ([Kashyap and](#)

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<sup>31</sup>See also [Cottarelli and Kourelis \(1994\)](#); [Angeloni and Ehrmann \(2003\)](#); [Mojon \(2000\)](#) for the similar evidence in the Euro-Area. See [De Bondt \(2005\)](#); [Gambacorta and Mizen \(2019\)](#) for systematic surveys of empirical works on bank rates pass-through.

Stein (1995)), liquidity (Stein (1998), Kashyap and Stein (2000)), capitalization (Peek and Rosengren (1995); Kishan and Opiela (2000)) as the main driver explaining heterogeneity and fluctuation in the response of banks to monetary policy interventions.<sup>32</sup> Since its onset this literature underlined strong evidence of stickiness in pass-through from monetary policy rates to bank rates (De Bondt (2005)) both on the liability side (deposits) and asset side (assets) accompanied with asymmetries and non-linearities (Borio and Fritz (1995); Mojon (2000) find asymmetries in the sign of the change in the wholesale rates, Sander and Kleimeier (2000); Hofmann and Mizen (2004); Driscoll and Judson (2013) for asymmetries in bank responses depending on the relative position with respect to the long run cointegrating relationship, finally Gambacorta and Iannotti (2007) show evidence of asymmetries in the response to monetary policy shocks depending on the sign of the shock).<sup>33</sup> and explored the role of potential explanations due to adjustment costs (Hannan and Berger (1991); Elyasiani et al. (1995); Hofmann and Mizen (2004))<sup>34</sup>, competition and market concentration (Borio and Fritz (1995), Claessens and Laeven (2004), Kahn et al. (2005), De Graeve et al. (2007), van Leuvensteijn et al. (2013)), managerial efficiency (maria Fuertes and Heffernan (2006)), relationship lending (Berger and Udell (1995); Degryse and Van Cayseele (2000); Allen and Gale (2001); Gambacorta and Mistrulli (2014)), affiliation to large bank conglomerates with sizeable internal capital markets (Gambacorta (2005), Bluedorn et al. (2018)), borrowers collateral value (Cerqueiro et al. (2016)), capital and default risk (Gambacorta and Shin (2018); Acharya et al. (2020)), search costs Yankov (2018), asset quality (Kelly and Byrne (2019)), exposure to monetary policy due to maturity mismatch and liquidity premia (Drechsler et al. (2018), Di Tella and Kurlat (2021)) at the bank level, and more on aggregate on the degree of financial development (Cottarelli and Kourelis (1994), financial instability regimes (Humala (2005)).<sup>3536</sup> More recently von Borstel et al. (2016), Illes et al. (2015), Hristov et al. (2014), Krylova et al. (2014) Holton and Rodriguez d’Acri (2018) document a more or less significant fall in the average pass-through relative to the pre-crisis period, Zentefis (2020) shows that the pass-through of monetary policy to loan rates can break down when banks have too little capital to compete with each other in a Salop model, finally Altavilla et al. (2020) provides a comprehensive account of cross-country time variation in the monetary policy pass-through in the Euro-Area.<sup>37</sup> Recently a literature flourished studying the effects of Lending and Deposit Rates transmission when interest rates are around or below zero reaching mixed evidence ( Debortoli et al. (2019), Mendicino et al. (2022), Altavilla et al. (2019),

<sup>32</sup>Wang et al. (2022) identify four main bank related transmission channels: the reserve and capital constraint channel (Bernanke and Blinder (1988); Kashyap and Stein (1995)), the bank capital channel (Van den Heuvel (2002); Brunnermeier and Sannikov (2016)), deposit market power (Drechsler et al. (2017)) and finally loan market power (Scharfstein and Sunderam (2016)) in which banks reduce markups to mitigate effects of monetary policy.

<sup>33</sup>see Fuertes and Heffernan (2009) for a pre-GFC survey of the early works on the topic

<sup>34</sup>Goodhart (1996); Sack (1998); Kuttner (2001b); Hofmann (2002); Banerjee et al. (2013) provide evidence of banks smoothing their responses to monetary policy shocks based on their expectations on the future path of interest rates, Kopecky and Van Hoose (2012) formalize this point theoretically in a Monti-Klein model augmented with quadratic adjustment costs.

<sup>35</sup>Focusing on the volume of granted loans rather than on interest rates Jiménez et al. (2012) or risk-taking Jiménez et al. (2014) provide strong evidence of interactions between monetary policy and bank capitalization and risk-taking behaviour.

<sup>36</sup>Variation in the strength of pass-through was also detected as a function of the maturity of the loan, see e.g. Sander and Kleimeier (2004); De Bondt (2005); Kwapił et al. (2006) on short vs long term loans to firms.

<sup>37</sup>See Gregor et al. (2021) for a meta-analysis of the literature comparing pass-through estimates across different types of loans (corporate, house, consumer loans) different geographical regions and different time periods.

Eggertsson et al. (2019), Ulate (2021)).<sup>3839</sup> Now as pointed out in Scharler (2008); Kwapil and Scharler (2010) limited interest rate pass-through might interfere with the stabilizing role of monetary policy and might even lead to a breaking of the Taylor Principle, hence understanding the variables affecting is of crucial importance to understand the workings of monetary policy. Most of this literature has been focusing on cross-country heterogeneity in order to identify the effects of bank specific factors (Balance Sheet, Market Power, Risk) or sectoral/aggregate factors (market concentration). Using its unique combined County/MSA - Branch/Loan level dataset this paper is able to abstract from identification concerns arising from country-specificity by exploiting instead variation over different loan categories, loan characteristics and borrower’s characteristics across regions of the same country. More importantly previous work focuses on the differences in bank or sectoral characteristics in order to explain heterogeneity in the monetary policy pass-through. Both categories of factors and their interactions hardly explain why there would be variation in the pass-through of a monetary policy interventions across similar regions populated by similar banks in the same given period. In this paper I explore an entire novel dimension that intrinsically has more degrees of freedom i.e. the heterogeneity in local bank specific demands. It’s interaction with bank strategic price behaviour gives rise to heterogeneous local skewness in the bank rates distribution which in turn plays a relevant role in explaining the heterogeneity of monetary policy pass-through across space and time. The evidence and mechanism outlined in this paper proposes to look at a completely different set of characteristics that are at the same time bank and region specific, i.e. the degree of information and switching costs of the local bank demands (specific bank in specific region) which give rise to heterogeneous and time-varying demand interest rate elasticities. In the theoretical framework developed in the second part of the paper the composition and micro-structure of local bank demands are shown to have significant asymmetric impact on the bank pass-through. Intuitively all this work focuses on the factors affecting a higher cost of funds for banks while completely overlook the effects of demand stickiness. The level of activity in searching for better rates and the intensity of switching does play a crucial role in bank pricing models and should hence be accounted for.

**Evolution of Monetary Policy Pass-Through over time.** Several studies have been focusing on the evolution of the monetary policy pass-through within a Monetary Union, (Kuttner and Mosser 2002; Boivin and Giannoni 2006; Canova and Gambetti 2009; Primiceri 2005; Boivin et al. 2010, see e.g.). The evidence on the degree of pass-through is however rather mixed. So far two main sources of time variation have been identified: the business cycle phase and the Zero Lower Bound. As for the first earlier studies such as Peersman and Smets (2001); Lo and Piger (2005) claim it is more effective, later studies such as Tenreyro and Thwaites (2016) claim that is less effective. As for the Zero-Lower bound the same mixed evidence have been found (Eggertsson et al. 2019; Debortoli et al. 2019, see e.g.). Recently a third relevant state has been argued for, i.e. the level of the uncertainty of the economy Aastveit et al. (2017). Despite the evidence of strength of the pass-through one element is in common across all this studies: data seems to suggest that the effectiveness of monetary policy is state-dependent. The current paper shares this view of the literature and aims to contribute by adding a new source of state-dependence, but it is different from previous studies as it aims at providing a mechanism that can explain both high frequency and low frequency variation in the strength monetary

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<sup>38</sup>More literature regards broadly the reaction of the bank lending channel in negative territory (Demiralp et al. (2017), Basten and Mariathasan (2018), Bottero et al. (2020), Bubeck et al. (2020), Heider et al. (2019), Erikson and Vestin (2019), Heider et al. (2021))

<sup>39</sup>See e.g. Hofmann et al. (2020), Banerjee et al. (2019) for further studies on the effects of funding costs and lending rates of unconventional monetary policy shocks.

policy pass-through, together with its geographical variation.

**Heterogeneity of Monetary Policy Pass-Through across Geographical Regions.** There is a very sparse literature documenting the heterogeneity of monetary policy pass-through across different geographical regions. In particular [Carlino and DeFina \(1997\)](#), [Perera and Wickramanayake \(2016\)](#), [Liu et al. \(2008\)](#) and [Georgiadis \(2014\)](#), provides evidence that policy transparency, financial structure, literature, labor market rigidities and industry mix help explain such heterogeneity. As shown in [Hurst et al. \(2016\)](#) and [Beraja et al. \(2018\)](#) for the housing mortgage market, geographical asymmetries in the pass-through may have important yet unintended implications in terms of in terms of inequality of welfare effects of monetary policy.

**Macro-Finance Literature** More generally this paper is related to the well established line of study of financial frictions and their role in the amplification of macroeconomic shocks.<sup>40</sup> The literature of financial frictions dates back to the seminal works of [Bernanke et al. \(1999\)](#) and [Kiyotaki and Moore \(1997\)](#) and has shown several channels through which financial markets produce amplification of macroeconomic shocks, ([Goodfriend and McCallum 2007](#); [Brunnermeier and Pedersen 2009](#); [Gerali et al. 2010](#); [Gertler and Kiyotaki 2010](#); [Adrian and Shin 2010](#); [Jermann and Quadrini 2012](#); [He and Krishnamurthy 2013](#); [Christiano et al. 2014](#); [Brunnermeier and Sannikov 2014](#); [Gertler and Karadi 2015](#); [Adrian and Boyarchenko 2015](#); [Cúrdia and Woodford 2016](#); [Nuño and Thomas 2017](#); [Drechsler et al. 2017](#); [Egan et al. 2017](#); [Gertler et al. 2016](#); [Fernández-Villaverde et al. 2019](#); [Gertler et al. 2020](#); [Bigio and Sannikov 2021](#); [Drechsler et al. 2021](#); [Beganau et al. 2021](#), see e.g.).<sup>41</sup> More closely to related to this paper is the literature studying the role played by the heterogeneity in financial intermediaries, ex-ante as in , or ex-post as in ([Coimbra and Rey 2021](#); [JRios Rull et al. 2020](#); [Jamilov and Monacelli 2021](#); [Rojas 2020](#); [Begenau and Landvoigt 2021](#); [Bianchi and Bigio 2022](#); [Bellifemine et al. 2022](#), see e.g.) and more broadly the heterogeneous agents literature as in ([Buera and Moll 2015](#); [Kaplan et al. 2018](#); [Auclert 2019](#); [Ottonello and Winberry 2020](#); [Auclert et al. 2020a;b](#); [Kekre and Lenel 2020](#); [Kaplan et al. 2020](#); [Ravn and Sterk 2021](#); [Baqae et al. 2021](#); [Bigio and Sannikov 2021](#); [Bilbiie 2021](#), see e.g.) . This paper shares the view of the literature that both ex-ante and ex-post heterogeneity produce quantitatively important aggregate amplification effects of macroeconomic shocks. It contributes to the literature by documenting a new channel of state-dependence of prices reaction to MC shocks based on the heterogeneity firms face in terms of own and cross price demand elasticity. Within this literature only a handful of papers analyze the amplification effects when banks are non-atomistic<sup>42</sup> and feature strategic behaviour by internalizing either their effect on aggregate demand or their effect on other banks’ pricing rules (([Vives 2001](#); [Aliaga-Díaz and Olivero 2010](#); [Cuciniello and Signoretti 2015](#); [Corbae and D’Erasmus 2021](#), see e.g.)). This paper revives and shares the emphasis of strategic behaviour and price complementarities do have high amplification effects in the economy. In particular it contributes in two different ways. First through a theoretical model featuring state-dependent and heterogeneous local demand elasticities and second by studying a Bertrand competition type of game across banks. It also adds by analyzing the interference of monetary policy in the strategic interaction among banks. Empirically it documents how the heterogeneity in local level skewness of the lending

<sup>40</sup>The basic theoretical forces underlying these friction have their roots asymmetric information costs that induce problems of adverse selection and moral hazard both on the asset ([Stiglitz and Weiss \(1981\)](#)) and liability side ([Diamond and Dybvig \(1983\)](#)), [Holmstrom and Tirole \(1997\)](#), [Stein \(1998\)](#)

<sup>41</sup>See [Brunnermeier et al. \(2012\)](#) for a survey of the macro literature on financial frictions.

<sup>42</sup>A large part of the literature assumes Monopolistic Competition which in turn means banks do not internalize the effect of their lending or deposit rates on the market.



rates carries important information for the transmission of monetary policy shocks as predicted by the theoretical framework. This paper also stresses the important aggregate effects of customer capital as a state variable. [Gourio and Rudanko \(2014\)](#) is the first to make this point for firms in general by showing this has important effects on firms' level and volatility of investment, profits, value, sales and markups, most importantly the timing of their responses to shocks. Deep habits literature [Ravn et al. \(2006\)](#)

**Identification and Econometric Modeling.** The identification strategy adopted in this paper for the estimation of monetary policy effects draws from the large empirical literature on high frequency proxies starting from the seminal works of [Rudebusch \(1998\)](#) [Kuttner \(2001a\)](#) who pioneered the idea of extracting the exogenous component of monetary policy movements by looking at the financial markets response to Monetary Policy announcements. The literature developed through the contributions of [Bernanke and Kuttner \(2005\)](#), [Gürkaynak et al. \(2005\)](#) and [Gertler and Karadi \(2015\)](#) among others up to the most recent contributions from [Jarociński and Karadi \(2020\)](#) [Nakamura and Steinsson \(2018\)](#) [Bauer and Swanson \(2022\)](#) focusing on disentangling Information and Pure Monetary policy effects in high frequency proxies. This paper improves the understanding of this type of identification by showing how it remains robust in the study of monetary policy effects over sub-national geographical units such as counties and MSAs, dis-aggregated targets such as loans of a specific category or in a specific area and state-dependent effects.<sup>43</sup>

Local Projections represent an ideal framework for the empirical question at hand. Its simple linear structure allows for the study of state-dependence of monetary policy impulse responses in a panel environment with high degree of dis-aggregation. While first example of the methodology can be traced back to [Christiano et al. \(1996\)](#) and [Romer and Romer \(1989\)](#), the widespread use of local projections for the study of monetary policy effects is due to the seminal work of [Jorda \(2005\)](#). Following its contribution several different works have As recently proven in [Plagborg-Møller and Wolf \(2021\)](#) given an identification strategy, Local Projections estimate the same impulse responses as VARs as the number of lags goes to infinity. Even in finite sample with a finite number of lags the two methodologies deliver the same result for the horizon corresponding to the minimum between the two lag orders. The bias-efficiency trade-off stays however for horizons longer than the lag structure of either of the two methodologies. Local Projections are less prone to mis-specification bias while VARs are more efficient in long run estimation. Given the nature of the question at hand we select the first over the second. More closely to this paper, Local Projections have been popular in the study of the dependence of monetary policy responses on the state of the economy. Among others [Santoro et al. \(2014\)](#), [Tenreiro and Thwaites \(2016\)](#), [Angrist et al. \(2018\)](#), [Barnichon and Matthes \(2018\)](#) and [Mavroeidis \(2021\)](#) and [Klepacz \(2021\)](#).<sup>44</sup> In line with these studies, this paper shows evidence of state-dependence in the responses to monetary policy. It contributes to the literature by providing an entire new dimension of state-dependence based on the micro-structure of bank competition. Notably, contrary to the other suggested state variables, this dimension is able to reconcile the joint time and space variation of monetary policy effects in the US.

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<sup>43</sup>The use of instrumental variables in the identification of policy shocks is not limited to local projections nor to monetary policy. See [Mertens and Ravn \(2013\)](#) for an early example of Fiscal Policy shocks identified in a VAR model through external instruments. [Stock and Watson \(2012\)](#) use external instrument identification strategies to disentangle the various channels of the 2007-2008 Recession.

<sup>44</sup>See [Ramey and Zubairy \(2018\)](#) for an example of state-dependent local projections applied to the study of fiscal multipliers. See [Gonçalves et al. \(2022\)](#) for a more rigorous consideration of the asymptotic validity of state-dependent local projections.

The High frequency identification and Local Projections methodology are only one of the many ways adopted by the literature to study the macroeconomic effects of monetary policy shocks, see [Ramey \(2016\)](#) for a wonderful critical survey of literature on the topic comparing various identification and econometric models, their performance and robustness of the results.

Among the transmission channels of monetary policy as outlined for instance in the early work of [Mishkin \(1996\)](#) the literature has well understood the important role of the so called "credit channels". Contributions focused on this latter channel such as [Bernanke and Gertler \(1995\)](#), [Gertler and Karadi \(2015\)](#) and [Caldara and Herbst \(2019\)](#) have found strong evidence of amplification caused by frictions in credit and more generally financial markets. Notably this line of work focuses on aggregate frictions mainly arising from balance sheet constraints or asymmetric information. This paper contributes to this literature by showing how certain frictions characterizing the demand in this market combined with bank strategic pricing in these markets can lead not only aggregate but also heterogeneous amplification of the monetary policy pass-through.

**Industrial Organization Literature on Switching Costs.** The theoretical framework proposed in the second part of the paper is mainly related to strand studying Bertrand Competition environments in presence of Switching Costs and Product differentiation. The literature has its roots in the pioneering works of [Klemperer \(1987\)](#), [Beggs and Klemperer \(1992\)](#) or [Nilssen \(1992\)](#) who incorporate consumers characterized by costs of switching across different suppliers of goods into the three main workhorse models of competition (Cournot, Bertrand and Stackelberg). The literature is mainly focused on the rationalization of phenomena regarding the industrial organization certain sector, for instance the emergence of teasing rates offered by telecom companies to lock-in customers in the first year followed by consistently higher prices in the following years. Switching costs might be very different in nature [Nilssen \(1992\)](#) describes transactional vs learning switching costs for when one switches to a new product/supplier with a learning curve, or endogenous vs exogenous switching costs (([Shi 2013](#), e.g. see)) Recent contributions extended the baseline model to account for Network Externalities ([Irina and Christian \(2011\)](#), [Weiergraeber \(2022\)](#)), Heterogeneity (([Biglaiser et al. 2013; 2016](#), e.g. see)), interaction with market structure (see e.g. [Fabra and García \(2015\)](#) for High vs Low Concentration Markets and [Lam \(2015\)](#) for the case of two-sided markets) or with product innovation ([Salies \(2012\)](#)).<sup>45</sup> This literature stresses how switching costs fundamentally create a dichotomy between existing locked-in consumers and new consumers. Because of switching costs Firms can extract monopolistic rents from their consumers but their competition on new consumers is much higher exactly because the lock-in has an incredible value for the firm in the following years. The contribution of this paper to the literature is to look at what happens once part of the switching cost is connected to an information cost. Customers not only do not switch easily to other products because cost of adjusting to the feature of the new product but importantly also because they don't want to sustain the cost of informing themselves about price and characteristics of other products in every period. However if they receive a signal from past prices that competition decreased incredibly its prices on a competitive product they will be incentivized to re-enter the market and firms will have to look at them as new customers (so low price to lock them in).

**Industrial Organization on Price Competition.** The theoretical model is most similar in its key insights to two different strands of literature. First to the literature exploring the relevance of search

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<sup>45</sup>[Klemperer \(1995\)](#) and [Farrell and Klemperer \(2007\)](#) Provide extensive surveys on switching costs in various theoretical and empirical settings.



costs in the class of switching costs. Second the literature analysing cost pass-through in environments characterized by heterogeneous and variable demand price elasticities.

To my knowledge there is only a handful of papers relating Search Costs as part of the Switching costs, namely [Moshkin and Shachar \(2000\)](#); [Waterson \(2003\)](#). The key insight of this two works is that a consumer doesn't hold perfect knowledge of the competitor products and hence before switching has to sustain the cost of searching for alternative products to the one he/she is currently using. More recently [Wilson \(2012\)](#) develops a unified model of switching and search cost in order to analyze qualitatively the interaction between this two types of costs and identify them in empirical estimations. On the empirical side [Heiss et al. \(2021\)](#) provide empirical evidence of this latter fact by showing how consumer inattention plays a big role in the choice between two water tariffs. Consumer inertia in switching is not due to learning or transactional costs of switching but rather by the fact that consumers are not informed and do not actively inform themselves of the alternatives. In another study using data from an online grocery retail market [González and Miles-Touya \(2018\)](#) estimate that around two thirds of the consumers using the platform do not compare prices across different supermarkets. Finally [Gamble et al. \(2009\)](#) compare three different deregulated markets in Sweden namely the market for electricity, landline telecom, and home insurance. They find that the differences in consumer inertia not switching to the best option can be pinned down by loyalty, information search costs, and expected economic benefits. [Luco \(2019\)](#) compares Retirement Fund choices using cross-sectional heterogeneity between new potential customers and those already attached to a specific fund in order to isolate search and transactional costs. For the same market in Chile [Illanes \(2017\)](#) estimates a dynamic demand model with switching costs finding that prices are twice as high with respect to the no-switching cost case. Finally [Buso and Hey \(2021\)](#) shows that the reluctance to switch supplier has been shown to affect not only the energy market but also other important economic sectors such as health insurance and investment for retirement. Search and switching costs appear to be the main factors that deter consumers from switching to the best supplier. Now according to [Dube et al. \(2006\)](#) analysis switching costs might actually decrease prices rather than increasing them. This paper shares the view and provides a theoretical framework in which they might have both roles depending on the trade-off between extensive and intensive margin. If the value of poaching new customers is higher then the value of extracting rents from existing loyal customers then prices will be decreasing in the switching costs else they will be increasing in them. A conclusion similar in spirit is also reached in a theoretical dynamic setting by [Cabral \(2016\)](#). In a Swedish randomized experiment where 1.2 million people were sent pamphlets on alternative primary healthcare providers in the area, [Anell et al. \(2021\)](#) document an increase of 10-14% in the percent of switchers, providing further evidence that Information costs do play a big role in Consumer inertia and switching decisions. Second the paper also focuses mainly on the cost price pass-through of shocks to the first. This is similar to the theoretical analysis of this paper that focusing on the pass-through of monetary policy shocks, viewed as a shifter of banks fixed marginal cost of producing a loan to their interest rates. The theoretical foundation model to study this dates back to [Shubik and Levitan \(1980\)](#) but only in the very last years the empirical literature has focused on this problem showing how more differentiation in products leads to lower cost-pass-through. Mapping this to my model when more consumers are on the lookout for a new bank, differentiation decreases and hence the loan pass-through increases and viceversa (([Kim and Cotterill 2008](#); [Loy and Weiss 2019](#); [Pless and van Benthem 2019](#); [Bittmann et al. 2020](#), e.g. see )).<sup>46</sup> In this respect my model is most similar to [Cosandier et al. \(2018\)](#) like their it is a Bertrand duopoly with differentiated

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<sup>46</sup>See [Arkolakis and Morlacco \(2017\)](#) for a theoretical note on variable demand elasticities, cost pass-through and markups.

goods giving rise to asymmetric own and cross-price elasticities. Now while in their analysis they concentrate on the equilibrium price outcomes when the share of informed consumers varies I analyze a framework in which the share of informed consumers comes endogenously from a search cost decision based on previous year prices. On top the share of informed consumers is asymmetric. As only one of the consumers of the two firms decides to become informed. Third I focus on the cost-pass through analysis of equilibrium prices rather than on prices alone. Now note that the model is the first to the authors knowledge able to reconcile increasing price dispersion on online markets. In my model this also happens while this also explains time varying Skewness.....

**Industrial Organization and Banking Literature on Consumer Inertia and Rates Pass-Through.** Finally this paper is related with the IO-Banking literature studying specifically the effects of Market Power arising from customers' inertia (also referred to as brand loyalty, stickyness). The literature dates back to the seminal work of [Sharpe \(1990\)](#) who identify switching costs to be one of the main reasons for consumer inertia and sets the theoretical foundations for the study of the interaction between bank pricing strategies and switching costs. Empirically the topic has been first explored both as concerns deposit rates [Sharpe \(1997\)](#), [Hannan et al. \(2003\)](#) [Hannan and Adams \(2011\)](#), [Carbo-Valverde et al. \(2011\)](#) and lending rates [Ausubel \(1991\)](#)<sup>47</sup>, [Petersen and Rajan \(1994\)](#), [Degryse and Van Cayseele \(2000\)](#), [Ioannidou and Ongena \(2010\)](#), [Barone et al. \(2011\)](#), [Fuster et al. \(2013\)](#), [Brown and Hoffmann \(2016\)](#), [Deuffhard \(2018\)](#), [Brunetti et al. \(2020\)](#), [Allen and Li \(2020\)](#), [Andersen et al. \(2020\)](#).<sup>48</sup> The fundamental take-away of this literature is that banks internalize and exploit consumer inertia in their pricing decisions. Two are the main outcomes shown. First Banks tend to react less than 1 to 1 to a shock affecting their marginal cost. Second Banks tend to offer very low rates to potential new customers in order to attract them from the competition and very high rates on existing already locked-in customers tacking advantage of their switching costs. As stressed previously by the IO literature, part of the consumer inertia is also due to search costs faced by consumers whenever they need to look for a substitute product. In the context of the banking literature this has been recently explored by [Allen et al. \(2019\)](#) who estimate that around 50% of the surplus extracted by banks is actually due to search costs, while only 28% can be associated with discrimination, 22% with inefficient matching.<sup>49</sup> According to the Survey of Consumer Finances [Amel et al. \(2008\)](#) report that the average household borrower lives within 4 miles from lender. In another study based on qualitative interviews and a controlled experiment [Lacko and Pappalardo \(2010\)](#) report that that the mean borrower only checks 2 mortgage providers before making the choice. Focusing more on the importance of search costs [Li and Netessine \(2020\)](#) and [Wang and Yang \(2020\)](#) show respectively that higher market thickness on the supply side of the mortgage market requires higher search intensity hence resulting

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<sup>47</sup>On credit Card Rates

<sup>48</sup>[Kim et al. \(2003\)](#) estimates the average switching cost to be 4.1%, about one-third of the market average interest rate on loans. More than a quarter of the customer's added value is attributed to the lock-in phenomenon generated by these switching costs. About a third of the average bank's market share is due to its established bank-borrower relationship.

<sup>49</sup>The effects of switching costs on consumer decisions are studied more generally in the Household Finance literature see for instance [Iyer and Puri \(2012\)](#); [Iyer et al. \(2016\)](#); [Brunetti et al. \(2016\)](#) for Household deposit account switching or [Campbell \(2006\)](#); [Agarwal et al. \(2015; 2017\)](#); [Scharfstein and Sunderam \(2016\)](#); [Keys et al. \(2016\)](#); [Beltratti et al. \(2017\)](#); [Bajo and Barbi \(2018\)](#); [Carella and Michelangeli \(2021\)](#); [Allen et al. \(2022\)](#) documenting and exploring households inertia in refinancing and/or switching house/mortgage loans (Keys documents 20% fail to refinance when profitable main determinants are financial literacy & education, age, location). [Agarwal et al. \(2020\)](#) explore the role of searching costs on household refinancing decisions. Further see [Dudley \(2012\)](#) and [Fuster et al. \(2013\)](#) for report also partial pass-through of unconventional monetary policy interventions, they consider several explanations such as origination costs, capacity constraints and market concentration but do not find a single factor driving the empirical fact. See [Mian et al. \(2013\)](#) for a notable example of the relevance of household mortgage decisions in the post-2007 crisis US.

in less search, and higher transparency might actually increase rather than decrease bank profits.<sup>50</sup> Ellison and Ellison (2009); Dinerstein et al. (2018) in a theoretical exercise of platform design identify a similar trade-off faced by online retail platform between lowering consumer search costs and lowering prices. Yankov (2018) finds that most of the pass-through of monetary policy in the deposit market can be attributed to search costs. Search Costs in turn are correlated with age and financial illiteracy.<sup>51</sup>

**Macro Literature on Price Stickyness.** Price stickyness is at the root of monetary policy non-neutrality. It is conventionally classified as time-dependent (Taylor (1980), Calvo (1983)) or state-dependent (Rotemberg and Saloner (1987), Reis (2006), Golosov and Lucas Jr (2007), Nakamura and Steinsson (2010), Midrigan (2011), Alvarez and Lippi (2014)).<sup>52</sup> In both types of models firms do not adjust price neither immediately nor necessarily after every macroeconomic shock due to time or menu cost frictions. These models have been employed in understanding the observed variation in mark-ups (Burststein et al. (2020)) or in the pass-through of exogenous aggregate shocks (Nakamura and Zerom (2010); Gopinath and Itskhoki (2010); Amiti et al. (2019)). In a few works, namely Alvarez et al. (2011; 2017a), pricing frictions were hence further combined with Information frictions, as intended in the Rational Inattention literature. On the other hand only one paper, Mongey (2021), analyzes the impact of menu-costs in a model where firms are not monopolistically competitive but rather strategically engaged. In the same spirit the theoretical framework proposed in this paper draws its power from the fact that firms can anticipate each other responses and have an impact both on the market and on the opponents business. Differently from that paper, here however the stickyness is not micro-funded through fixed costs on the bank-side but rather through inaction on the customer side, which in turn strategically implies price inaction. Similarly to Alvarez et al. (2016) in this paper for Skewness as being a statistic that carries information on the degree of stickiness of bank interest rates after the next monetary policy shock. Differently from that paper however, here the Skewness is not computed on contemporary price adjustment but rather represent a state variable capturing what is the relevant mass of potential churners in the next period.<sup>53</sup> Andersen et al. (2020) suggests the idea that informational costs might be at the heart of consumers refinancing inertia. This paper shares this perspective, but differently from previously cited papers on the topic combines it with strategic behaviour of firms and state-dependence. Banks are not sticky in their interest rates because of their own information costs, but because their customers have high information costs, which they will not pay unless they receive a sufficiently strong signal that they would benefit from it. Tangentially to this literature a handful of paper focuses in particular on consumer inertia and its impact on firms price competition. In particular Döpper et al. (2021) shows evidence that the 25% rise in mark-ups observed in consumer products between 2006 and 2019 can be attributed for almost 50% to the reduction in consumers price elasticity. MacKay and Remer (2022) shows how consumer inertia arising from consumer Information/Switching costs, Brand Loyalty or Habit formation create important dynamic rather than static effect on firms pricing decisions.

<sup>50</sup>Hodgson and Lewis (2020) push forward this arguments but developing a spatial learning gives rise to path dependence, as each new search decision depends on past experiences through the updating process

<sup>51</sup>Another cause of consumer inertia is inattention, either rational or behavioural. See for instance Malmendier and Lee (2011) for a notable example of apparent irrationality of consumers overbidding behaviour on online auctions

<sup>52</sup>As shown by Auclert et al. (2022) or Alvarez et al. (2017b) the two models exhibit similar patterns to macroeconomic shock as long as the shock is small

<sup>53</sup>A few works analyze the effects of reference prices on the dynamics of inflation (Eichenbaum et al. (2011)) documenting that firms seem to be changing prices weekly but those are part of a pre-set schedule of prices conditional on the state of the economy and of the market, the schedule however only gets changed a few times.

## B Empirical Robustness: Local Projection Equation

In this section the details of the various robustness checks performed on the empirical part of the analysis are provided. The general extended specification of the empirical model is as follows:

$$\begin{aligned}
\text{Outcome Variable}_{t+h,s} = & \alpha + \underline{\beta}_1 \text{MP Shock}_t + \underline{\beta}_2 [\text{MP Shock}_t \times \text{Skewness}_{t-1,s}] + \\
& + \underline{\beta}_3 [\text{MP Shock}_t \times \text{Mean}_{t-1,s}] + \underline{\beta}_4 [\text{MP Shock}_t \times \text{Variance}_{t-1,s}] \\
& + \underline{\beta}_5 [\text{MP Shock}_t \times \text{County Recess}_{t,s}] + \underline{\beta}_6 [\text{MP Shock}_t \times \text{ZLB}_{t,s}] \\
& + \underline{\beta}_7 [\text{MP Shock}_t \times \text{Bank Concentration (HHI)}_{t,s}] \\
& + \underline{\beta}_8 [\text{MP Shock}_t \times \text{Aggregate Skewness US}_{t,s}] \\
& + \sum_{k=1}^3 \rho_{1,k} \text{MP Shock}_{t-k} + \sum_{k=1}^3 \rho_{2,k} \dots \\
& + \sum_{k=0}^3 \rho_{1,k} \text{Mean}_{t-k} + \sum_{k=1}^3 \rho_{2,k} \text{Var.}_{t-k} + \sum_{k=1}^3 \rho_{2,k} \text{Skew}_{t-k} \\
& + \sum_{k=1}^3 \rho_{2,k} \text{County Rec.}_{t-k} + \sum_{k=1}^3 \rho_{2,k} \text{ZLB}_{t-k} + \sum_{k=1}^3 \rho_{2,k} \text{Concentr.}_{t-k} \\
& + \sum_{k=0}^3 \gamma_k X_{BANK,t-k} + \sum_{k=0}^3 \mu_k X_{s,t-k} + \sum_{k=0}^3 \delta_k X_{US,t-k} + \varepsilon_{s,t}
\end{aligned}$$

The first four interaction terms are the ones included in the baseline specification. Following we have in the order: (i) an interaction of the monetary policy shock and an indicator variable of county specific recession taking value one whenever the county is within a period of 3 consecutive negative growth periods of unemployment (ii) the interaction between the monetary policy shock and an indicator variable representing the years of the zero lower bound, (iii) an interaction of the monetary policy shock and an indicator of local bank concentration computed as the Herfindal index over branch level deposit volumes reported by banks at the county level (as contained in the FDIC dataset) (iv) finally an interaction term of the monetary policy shock with the Aggregate Skewness at the US level in order to control for aggregate national-level moments of the cross-sectional distribution of lending rates. The local projection will be estimated at the county/month level. Errors are clustered at the county and loan category level.

## C Empirical Robustness: Results

In this section the estimation results from the various robustness checks are provided. For each table the title reports the relevant dependent variable and the first columns report the estimated results for the relevant interaction terms. Overall the cross-sectional skewness at the county level has significantly high predictive power over on the strength of pass-through of new monetary policy rate changes.

Table C1: Lending Rates with Variance Only

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.24*** (8.73)	0.37*** (11.65)	0.51*** (14.47)	0.48*** (12.66)	0.42*** (10.05)	0.26*** (6.27)	0.32*** (7.48)	0.57*** (13.07)	0.40*** (9.23)	0.43*** (8.60)	0.53*** (10.31)
Var	0.13** (2.32)	0.16** (2.53)	-0.08 (-1.13)	0.11 (1.44)	0.06 (0.71)	0.23** (2.51)	-0.01 (-0.17)	0.08 (0.95)	-0.12 (-1.40)	-0.33*** (-3.33)	-0.11 (-1.13)
Mean	-0.13*** (-6.02)	-0.04** (-2.04)	-0.18*** (-6.94)	-0.29*** (-9.59)	-0.32*** (-9.40)	-0.15*** (-4.11)	-0.27*** (-7.19)	-0.22*** (-5.45)	-0.18*** (-4.68)	-0.29*** (-7.16)	-0.32*** (-7.72)
County Rec	-0.00** (-2.00)	-0.00 (-0.13)	0.00*** (4.12)	0.01*** (4.55)	0.00*** (4.05)	0.01*** (4.08)	-0.00*** (-2.77)	0.00 (0.76)	-0.00 (-1.14)	-0.01*** (-7.35)	-0.01*** (-4.46)
ZLB	-0.01*** (-6.01)	-0.00 (-0.36)	-0.01*** (-4.80)	-0.01*** (-7.26)	-0.01*** (-3.71)	-0.00* (-1.81)	-0.00*** (-2.67)	-0.01*** (-4.33)	-0.00** (-2.53)	0.00 (0.03)	0.00 (1.23)
Concentr.	0.00 (0.94)	0.00 (0.96)	0.00** (2.24)	0.00 (0.26)	0.00 (0.89)	-0.00 (-1.15)	-0.00 (-1.53)	0.00 (0.45)	0.00 (1.33)	0.00* (1.88)	0.00*** (2.68)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	121832	110059	107270	104566	99946	97149	95371	91931	90389	88242	85018
$R^2$	0.974	0.967	0.962	0.956	0.949	0.946	0.941	0.937	0.934	0.930	0.926

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table C2: Lending Rates with Aggregate Moments

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.13*** (4.29)	0.21*** (5.63)	0.35*** (8.69)	0.38*** (7.89)	0.22*** (4.33)	0.23*** (4.29)	0.16*** (2.96)	0.38*** (7.51)	0.26*** (4.88)	0.44*** (6.74)	0.53*** (8.20)
Skew $\beta_1$	0.20*** (4.79)	0.21*** (4.04)	0.22*** (3.61)	0.24*** (3.72)	0.17** (2.54)	0.22*** (3.13)	0.25*** (3.41)	0.14* (1.96)	0.17** (2.36)	0.13* (1.74)	0.08 (1.00)
Mean	-0.11* (-1.91)	0.06 (0.80)	-0.13* (-1.73)	-0.38*** (-4.27)	-0.27*** (-2.91)	-0.08 (-0.85)	-0.53*** (-5.96)	-0.09 (-0.92)	-0.20** (-2.09)	-0.41*** (-3.99)	0.05 (0.48)
Var	0.01 (0.18)	-0.00 (-0.01)	-0.17* (-1.69)	-0.12 (-1.11)	-0.05 (-0.49)	-0.00 (-0.03)	-0.03 (-0.28)	0.02 (0.14)	-0.29** (-2.37)	-0.08 (-0.64)	-0.40*** (-3.10)
County Rec	-0.13*** (-3.00)	-0.04 (-0.76)	0.16*** (2.84)	0.23*** (3.13)	0.30*** (4.06)	0.25*** (3.17)	-0.25*** (-3.09)	-0.04 (-0.45)	-0.25*** (-2.65)	-0.56*** (-6.11)	-0.39*** (-4.30)
ZLB	-0.17*** (-3.28)	0.12** (1.97)	-0.22*** (-3.35)	-0.46*** (-5.48)	-0.19** (-2.41)	-0.26*** (-3.12)	-0.17* (-1.93)	-0.30*** (-3.77)	-0.13 (-1.61)	-0.21** (-2.27)	-0.05 (-0.52)
Concentr.	0.04 (0.91)	0.05 (0.67)	0.03 (0.25)	0.05 (0.46)	-0.04 (-0.44)	-0.16 (-1.43)	-0.14 (-1.12)	0.04 (0.37)	0.11 (0.86)	0.14 (1.38)	-0.02 (-0.18)
US Skew	-0.15** (-2.52)	-0.15** (-2.25)	-0.20** (-2.01)	0.10 (0.71)	0.01 (0.04)	0.05 (0.32)	0.16 (1.00)	0.29* (1.85)	0.51*** (3.57)	-0.14 (-0.97)	0.02 (0.14)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	111609	102513	99782	96405	92946	90621	88056	85511	83839	81382	79445
$R^2$	0.976	0.970	0.965	0.958	0.953	0.950	0.944	0.941	0.938	0.934	0.932

 $t$  statistics in parentheses\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Lending Rates with Time Fixed Effects. Clustering at Time Level

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)
Skew	1.14** (2.27)	0.98* (1.96)	1.15** (2.25)	0.99** (2.06)	1.16** (2.32)	1.34*** (2.82)	1.29*** (2.77)	1.03** (2.32)	1.16** (2.31)	0.90* (1.80)	0.81* (1.67)
County Rec.	-0.85 (-1.54)	-0.71 (-1.15)	-0.59 (-1.13)	-0.66 (-1.22)	-0.77 (-1.59)	-0.62 (-1.10)	-0.40 (-0.78)	-1.15** (-2.15)	-0.71 (-1.43)	-0.33 (-0.62)	-0.54 (-0.90)
ZLB	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)
concentr.	-0.37 (-0.86)	-0.54 (-1.05)	-0.58 (-1.12)	-0.78 (-1.55)	-0.47 (-0.82)	-0.61 (-1.10)	-0.77 (-1.47)	0.02 (0.04)	-0.09 (-0.29)	-0.13 (-0.42)	-0.34 (-0.99)
Mean	-0.86* (-1.74)	-0.66 (-1.29)	-0.97* (-1.81)	-1.07* (-1.96)	-1.06* (-1.85)	-1.27** (-2.23)	-1.17* (-1.95)	-0.87 (-1.38)	-1.13* (-1.74)	-0.78 (-1.34)	-1.01* (-1.65)
Var	-0.61 (-1.25)	-0.50 (-1.03)	-0.63 (-1.10)	-0.62 (-1.29)	-0.85 (-1.61)	-0.52 (-0.98)	-0.87* (-1.69)	-0.55 (-0.99)	-0.68 (-1.20)	-0.69 (-1.23)	-0.72 (-1.18)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	123962	111776	108880	106049	101259	98372	96469	92949	91273	89048	85752
$R^2$	0.573	0.574	0.572	0.567	0.568	0.567	0.565	0.566	0.564	0.564	0.564

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table C3: Unemployment

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.04*** (4.96)	0.28*** (20.15)	0.36*** (24.02)	0.26*** (17.23)	0.21*** (13.41)	0.23*** (14.27)	0.37*** (21.92)	0.49*** (26.25)	0.56*** (29.86)	0.57*** (31.73)	0.19*** (11.42)
Skew	0.04*** (3.12)	0.12*** (6.67)	0.11*** (5.50)	0.09*** (4.58)	-0.05** (-2.38)	0.02 (0.91)	0.04* (1.91)	0.09*** (3.54)	0.05** (2.00)	0.02 (0.67)	0.02 (1.01)
Mean	0.09*** (14.53)	-0.04*** (-4.12)	-0.11*** (-10.29)	-0.02* (-1.71)	-0.03** (-2.44)	-0.00 (-0.26)	-0.18*** (-14.68)	-0.18*** (-13.21)	-0.17*** (-12.38)	-0.28*** (-21.11)	-0.05*** (-3.81)
Var	-0.00 (-0.12)	0.04* (1.70)	-0.02 (-0.65)	-0.11*** (-3.80)	-0.03 (-1.06)	-0.11*** (-3.77)	0.07** (2.39)	-0.05 (-1.38)	0.02 (0.53)	0.08** (2.45)	-0.04 (-1.48)
County Rec.	-0.00*** (-4.41)	-0.00*** (-11.35)	-0.00*** (-11.53)	0.00 (1.11)	-0.00*** (-7.89)	-0.00*** (-11.58)	-0.00*** (-11.15)	-0.00*** (-2.66)	-0.01*** (-10.75)	-0.00*** (-7.38)	-0.00 (-0.13)
ZLB	0.00*** (5.11)	-0.01*** (-12.73)	-0.01*** (-17.25)	-0.01*** (-23.94)	-0.01*** (-19.78)	-0.01*** (-17.64)	-0.01*** (-20.03)	-0.01*** (-17.06)	-0.01*** (-9.85)	-0.01*** (-12.83)	-0.01*** (-11.46)
Concentr.	0.00 (1.49)	-0.00 (-0.41)	0.00 (1.27)	-0.00 (-0.37)	0.00 (1.27)	0.00*** (2.62)	0.00 (0.39)	0.00 (0.40)	-0.00 (-1.07)	-0.00 (-0.96)	-0.00 (-0.24)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	121832	110059	107270	104565	99944	97147	95369	91929	90388	88241	85016
$R^2$	0.969	0.939	0.928	0.929	0.931	0.928	0.920	0.909	0.907	0.920	0.933

 $t$  statistics in parentheses\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$



Lending Rates. TSLS (Instrumenting Treasury 2Y with HF Proxy)

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.09*** (16.97)	0.17*** (29.00)	0.22*** (32.41)	0.26*** (34.03)	0.28*** (35.92)	0.29*** (37.95)	0.32*** (40.13)	0.32*** (36.51)	0.29*** (30.11)	0.31*** (32.34)	0.32*** (32.15)
Skew	0.34*** (9.85)	0.15*** (4.13)	0.03 (0.68)	0.45*** (9.87)	0.35*** (6.52)	0.11* (1.94)	0.39*** (6.69)	0.53*** (8.01)	0.47*** (7.00)	0.98*** (13.52)	0.98*** (13.36)
Mean	-0.09*** (-8.18)	-0.09*** (-8.07)	-0.06*** (-4.60)	-0.11*** (-8.01)	-0.11*** (-7.05)	-0.11*** (-7.04)	-0.08*** (-4.45)	-0.12*** (-6.47)	-0.11*** (-6.11)	-0.08*** (-4.05)	0.01 (0.32)
Var	-0.21*** (-5.75)	-0.17*** (-4.17)	0.25*** (5.56)	0.00 (0.08)	0.16*** (2.81)	0.17*** (2.78)	0.28*** (3.97)	0.17** (2.45)	0.31*** (4.11)	0.23*** (2.92)	0.36*** (4.24)
County Rec	-0.01*** (-3.19)	0.01*** (2.67)	0.00 (1.17)	-0.01** (-1.97)	0.00 (0.73)	-0.01** (-2.22)	0.01** (2.15)	0.00 (0.18)	0.01* (1.88)	0.01** (2.20)	0.00 (0.83)
ZLB	0.01 (1.33)	-0.01*** (-2.68)	-0.00 (-0.72)	-0.01* (-1.86)	-0.05*** (-8.05)	-0.05*** (-6.63)	-0.05*** (-7.10)	-0.04*** (-5.74)	-0.03*** (-3.88)	-0.03*** (-3.78)	0.02** (2.06)
Concentr.	-0.00 (-0.01)	0.02 (1.17)	0.03 (1.57)	0.02 (0.75)	0.04 (1.44)	0.02 (0.82)	0.01 (0.21)	0.02 (0.66)	0.02 (0.88)	0.04 (1.43)	-0.00 (-0.15)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>N</i>	98955	91574	89291	86453	83539	81538	79402	77111	75668	73602	71895
<i>R</i> <sup>2</sup>	0.976	0.970	0.965	0.958	0.953	0.949	0.943	0.940	0.936	0.932	0.928

*t* statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Lending Rates. With County & Time Fixed Effects

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)
Skew	0.08* (1.95)	0.04 (0.92)	0.10* (1.87)	0.11* (1.91)	0.05 (0.75)	0.18*** (3.14)	0.16** (2.39)	0.08 (1.24)	0.07 (1.17)	-0.14** (-2.26)	-0.12* (-1.83)
Mean	-0.06* (-1.65)	0.12*** (2.78)	-0.00 (-0.09)	-0.06 (-1.33)	-0.09 (-1.59)	0.01 (0.24)	-0.18*** (-3.25)	0.00 (0.06)	-0.14** (-2.25)	-0.12* (-1.93)	-0.04 (-0.60)
Var	0.01 (0.08)	0.08 (1.18)	-0.19** (-2.38)	-0.10 (-1.24)	-0.10 (-1.08)	-0.03 (-0.34)	-0.22** (-2.31)	-0.08 (-0.77)	-0.17* (-1.79)	-0.12 (-1.16)	-0.13 (-1.15)
County Rec	-0.22*** (-3.82)	-0.05 (-0.77)	0.11 (1.52)	0.05 (0.53)	0.21** (2.41)	0.23** (2.30)	0.04 (0.41)	-0.18* (-1.68)	0.02 (0.24)	0.09 (0.90)	0.09 (0.81)
ZLB	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)	0.00 (.)
Concentr.	0.11** (2.57)	0.05 (0.88)	0.08 (0.99)	0.08 (0.96)	0.06 (0.74)	-0.06 (-0.59)	-0.07 (-0.70)	0.06 (0.69)	0.23** (2.33)	0.33*** (3.74)	0.08 (0.97)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	123775	111611	108658	105835	101058	98156	96266	92717	91096	88863	85569
$R^2$	0.976	0.971	0.967	0.962	0.958	0.957	0.954	0.951	0.950	0.948	0.946

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Lending Rates. Jarocinski & Karadi MP Shock (Gertler and Karadi HF Shock separating MP from Info shock)

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.17*** (6.11)	0.20*** (6.44)	0.23*** (6.74)	0.13*** (3.38)	0.37*** (8.36)	0.34*** (7.13)	0.25*** (4.84)	0.17*** (3.19)	-0.02 (-0.39)	0.29*** (4.87)	0.22*** (3.46)
Skew	0.08** (2.10)	0.10** (2.38)	0.11** (2.25)	0.17*** (3.30)	0.16*** (2.62)	0.16** (2.50)	0.22*** (3.25)	0.13* (1.82)	0.11 (1.47)	-0.02 (-0.21)	0.11 (1.43)
Mean	-0.08* (-1.68)	0.05 (0.79)	-0.21*** (-3.12)	-0.26*** (-3.52)	-0.22*** (-2.63)	-0.07 (-0.85)	-0.35*** (-3.91)	-0.14 (-1.51)	-0.13 (-1.48)	-0.32*** (-3.62)	-0.11 (-1.07)
Var	0.11* (1.78)	-0.01 (-0.07)	-0.12 (-1.51)	-0.11 (-1.27)	0.04 (0.43)	-0.02 (-0.16)	-0.11 (-1.01)	0.17 (1.47)	-0.16 (-1.41)	0.04 (0.38)	-0.13 (-1.08)
County Rec	0.00 (0.42)	0.00 (0.54)	-0.00 (-1.21)	0.00*** (3.12)	0.00*** (4.00)	0.00*** (3.86)	0.00 (0.23)	0.01*** (4.03)	0.00 (1.05)	-0.00 (-1.29)	-0.00 (-0.95)
ZLB	-0.00*** (-3.58)	0.00*** (2.82)	-0.00*** (-2.86)	-0.00** (-2.51)	-0.01*** (-4.90)	-0.01*** (-3.76)	-0.00* (-1.73)	-0.00 (-0.52)	0.00 (0.53)	-0.00* (-1.74)	0.01*** (3.39)
Concentr.	-0.00 (-0.66)	0.00 (0.10)	0.00** (1.98)	0.00 (0.93)	-0.00 (-1.39)	-0.00* (-1.75)	-0.00 (-1.54)	-0.00 (-1.43)	-0.00 (-0.13)	0.00 (0.30)	0.00 (0.96)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>N</i>	108685	100467	98395	95671	92305	90058	87564	85097	83481	81073	79183
<i>R</i> <sup>2</sup>	0.978	0.971	0.965	0.958	0.952	0.947	0.940	0.935	0.930	0.925	0.921

*t* statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Lending Rates. Instrumenting Bank Average Cost of Funds (Average by County).

Month	0	1	2	3	4	5	6	7	8	9	10
MP	0.93*** (2.74)	2.86*** (4.10)	4.07*** (5.47)	1.36*** (2.82)	1.27*** (3.25)	0.02 (0.04)	-0.56 (-0.81)	1.62** (2.46)	1.12** (2.44)	1.35* (1.70)	1.36 (1.49)
Skew	1.41** (2.13)	2.14 (1.10)	1.35 (1.21)	2.11** (2.09)	1.34** (1.96)	1.49** (2.20)	2.11* (1.69)	0.58 (0.46)	0.37 (0.58)	-0.89 (-0.74)	-0.51 (-0.51)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$N$	123775	111611	108658	105835	101058	98156	96266	92717	91096	88863	85569
$R^2$	0.893	0.766	0.739	0.798	0.838	0.832	0.769	0.831	0.841	0.814	0.814

$t$  statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Lending Rates. Interaction With Skewness, and with Skewness and Dummy for High Rate Banks.  
(Testing Proposition 3 of Model)

Month	0	1	2	3	4	5	6	7	8	9	10
MP	-0.13*** (-13.23)	0.30*** (25.65)	0.24*** (17.59)	-0.02 (-1.60)	0.16*** (10.42)	0.04*** (2.78)	-0.24*** (-13.49)	-0.21*** (-12.21)	-0.20*** (-11.30)	-0.31*** (-16.49)	0.07*** (3.92)
Skew	-0.01 (-0.69)	-0.01 (-0.39)	0.03 (1.25)	0.04* (1.89)	0.06** (2.35)	0.08*** (3.40)	0.42*** (16.37)	0.45*** (17.43)	0.38*** (14.81)	0.09*** (3.41)	0.20*** (7.91)
H Skew H Rate	-0.06* (-2.56)	-0.04 (-1.24)	0.01 (0.40)	0.13*** (3.46)	0.15*** (3.91)	0.13*** (3.31)	0.10*** (2.61)	0.07* (1.69)	0.09** (2.21)	0.20*** (4.90)	0.14*** (3.52)
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<i>N</i>	2317536	2200605	2139583	2080359	2028567	1983506	1943036	1898621	1860857	1823443	1784944
<i>R</i> <sup>2</sup>	0.977	0.968	0.961	0.955	0.950	0.946	0.943	0.940	0.938	0.936	0.934

*t* statistics in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Specification in First Differences

Month	0	1	2	3	4	5	6
MP shock ( $\beta_0$ )	0.12***	0.21***	0.15***	0.18***	0.12**	-0.09**	0.03
Skewness ( $\beta_1$ )	0.11***	0.12***	0.15***	0.19**	0.19*	0.04	0.23***
Mean ( $\beta_2$ )	0.01	-0.04	0.01	0.04	0.05	0.15***	0.14***
High Concentr	-0.01	-0.11**	-0.16***	-0.19**	-0.25***	-0.21**	-0.09
Avg Loss Prov.	-0.00	0.02***	0.07***	0.11***	0.20***	0.28***	0.31***
Avg Cost Funds	0.06***	0.12***	0.13***	0.14***	0.14***	0.11***	0.09***
Controls	✓	✓	✓	✓	✓	✓	✓
<i>N</i>	87571	85278	82615	78734	76673	74387	72787
<i>R</i> <sup>2</sup>	0.084	0.132	0.159	0.128	0.143	0.167	0.166

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Std. Errors clustered at the County/Category level.