OPERATING DECISIONS IN THE AFTERGLOW OF A SPIKE IN BUSINESS ACTIVITIES: EVIDENCE FROM BANKS

By

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ABSTRACT

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Firms are required to make resource adjustments and product mix changes in response to an unexpected change in the operating environment. Despite the ubiquitous nature of such changes, little is known about the nature of such resource adjustments and product mix decisions when firms move from one steady state to another but face an intermediate period of uncertainty. Using shale oil and natural gas extraction as an exogenous positive economic shock to the operations of local banks, I find that banks reduce labor cost elasticity and increase labor employee elasticity in response to an unexpected positive change to their operating environment. Further, labor employee elasticity increases during the later periods of the shale development when there is lower uncertainty regarding the persistence of the positive economic shock. Banks with higher forecasting ability undertake labor adjustments earlier than banks with lower forecasting ability, highlighting the importance of the internal information environment in resolving uncertainty in the operating environment. During the later periods of the shale boom, banks reduce product diversity when their downside demand risk reduces reliably. Overall, results suggest that managers make dynamic adjustments to their operations in response to an unexpected change in the operating environment.

To my family & friends

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INTRODUCTION

Accounting researchers and practitioners alike recognize the importance of cost structure decisions and acknowledge their effects on firm performance. Decisions related to cost structures, i.e., the mix of variable and fixed costs, are influenced by a variety of factors, including demand uncertainty, capacity utilization, congestion costs, industry factors, regulatory pressures, and managerial incentives.[1] In the short run, cost structure decisions are affected by capacity planning that occurs before actual demand is realized. During the capacity planning phase, firms pre-commit to the extent of fixed inputs they will hold, to satisfy the demand for their products or services (Banker, Byzalov, and Plehn-Dujowich [2014]). During this phase, firms estimate the tradeoff between excess capacity costs resulting from low demand realizations, and the opportunity costs of inadequate capacity such as lost sales or premium prices for inputs ordered on a flexible basis. Prior accounting research has examined firms' capacity and resource procurement choices that influence cost structure decisions (Banker, Byzalov, and Plehn-Dujowich [2014]; Holzhacker, Krishnan, and Mahlendorf [2015]b; Kallapur and Eldenburg [2005]), the real effects of firms' capacity decisions (Brüggen, Krishnan, and Sedatole [2011]; Roychowdhury [2006]), and how operating costs behave in response to changes in cost drivers (Anderson, Banker, and Janakiraman [2003]; Noreen and Soderstrom [1994]).[2]

While extant literature in accounting has examined resource adjustment decisions by managers in response to a decrease in demand, resource adjustment decisions in response to an

[1] Examples of studies include Balakrishnan, Petersen, and Soderstrom [2004]; Banker, Byzalov, and Plehn-Dujowich [2014]; Dierynck, Landsman, and Renders [2012]; Hall [2016]; Holzhacker, Krishnan, and Mahlendorf [2015b]; Kallapur and Eldenburg [2005].

[2] Extensive research in accounting has examined the drivers of asymmetric responses of cost changes to contemporaneous changes in cost drivers (see Banker and Byzalov [2014] and Banker et al. [2018] for a review).

increase in demand have not been well-documented.[3] A few notable exceptions are Banker, Byzalov, Ciftci, et al. [2014] and Chen, Kama, and Lehavy [2019]), which examine resource adjustment decisions when managers are optimistic about a future increase in activity. Managerial optimism stems from an expected increase in activity during the ordinary course of business. Both studies explore resource adjustments undertaken by managers when they can forecast future increases in activity with reasonable accuracy. Since managers are familiar with the operating environment, they are less concerned about uncertainty while making resource adjustment decisions.

In this paper, I investigate how firms adjust their cost structures and operations in response to an unexpected change in their operating environment resulting from an exogenous positive economic shock. I label the exogenous shock as "positive" because it has a favorable effect on firms' revenue functions. A sudden, unexpected change in the operating environment causes difficulty in forecasting the magnitude and persistence of the positive shock especially when managers are unfamiliar with the shock (Bloom [2014]). During the intermediate period, managers face uncertainty over the permanence of the shock. Uncertainty adds noise to the estimates of future cash flows and optimal resource adjustments required to meet the increase in demand in the current period. The dramatic change in the operating environment and the attendant requirement for adjustments during the current period before the persistent effect of the shock is observed can lead to errors in managerial judgments (Tversky and Kahneman [1974]). Managers' inability to differentiate whether the change in operating environment is persistent or transitory increases the option value of waiting to observe if the change reverts. This option to wait allows Bayesian updating or learning over time about the nature of change in the operating

[3] Some of these studies include Anderson et al. [2003]; Chen, Lu, and Sougiannis [2012]; Dierynck, Landsman, and Renders [2012]; Kama and Weiss [2013]; Pinnuck and Lillis [2007]; Weiss [2010] among others.

environment to resolve uncertainty about the permanence of such change (Grenadier and Malenko [2010]).

Based on real options theory, I expect that managers' resource adjustments will systematically vary during the initial periods versus the later periods of the shock. During the initial periods when future uncertainty about the effects of the shock is high, managers will increase capacity utilization as permitted by the relevant range (e.g., increase the hours per employee) or invest in resources with relatively low adjustment costs to meet the increase in demand. Temporary labor is an example of a resource with low adjustment costs because such employees are not on the payroll of the firm, are hired on a contract or fee basis (such as per diem) and can be hired and terminated as required.[4] During the later periods when future uncertainty about the effects of the shock is low, managers will be better able to estimate the magnitude of the shock and therefore undertake operational expansions. These operational expansions include hiring of more permanent labor i.e., labor with high adjustment costs. These resource adjustments have cost structure implications that vary during the initial periods versus the later periods. During the initial periods, when managers are cautious about adding resources because of the uncertainty over the persistence of the shock, the increase in revenue will outpace the increase in cost, with the result that cost elasticity decreases.[5] Subsequently during the periods when managers have a better understanding of the economic environment and firms undertake operational expansions (such as hiring permanent labor), there will be an increase in responsiveness of cost changes to revenue changes resulting in an increase in cost elasticity. The dynamic effect of managers' resource adjustment decisions should result either in firms' cost

[4] The Bureau of Labor Statistics defines temporary labor as "employees that are on the payroll of the supplying establishment but is under the direct or general supervision of the business to whom the help is furnished."
[5] Cost elasticity is the responsiveness of cost changes to changes in activity levels.

structure reverting to the level that existed prior to the arrival of positive economic shock or to reach a different level in the new steady state, which is difficult to predict *ex ante*.

The nature of such resource adjustment decisions hinges on uncertainty, and thereby on a firm's internal information environment. Therefore, I examine whether firms with better forecasting quality are able resolve the uncertainty earlier and undertake operational expansions and increase labor employee elasticity before other firms. Another operating variable that managers are likely to alter in response to a change in business environment is product mix. Product mix decision is an instrument of risk management (Carlton and Dana [2008]). Product diversity, which refers to the range of product variations offered by a firm, is an important product mix decision. Product diversity reduces risk when firms face uncertainty in their operating environment (Miller and Shamsie [1999]). Accordingly, I examine how firms change product diversity in response to an unexpected positive economic shock that also results in uncertainty. I expect firms to reduce product diversity and focus on fewer products after a positive economic shock, particularly during the later periods when the uncertainty in the operating environment has declined. The role of product diversity as an instrument to reduce risk is less important when managers have a better understanding of the operating environment.

While studying the effect of an unexpected change in the operating environment on firms' cost structure and product mix decisions, it is important to accurately identify what constitutes an "unexpected" change.[6] A limitation of industry-specific economic shocks is that these shocks affect the entire cross-section of firms, making it difficult to recognize whether the shocks are exogenous or whether they are an outcome of firm characteristics and actions and hence endogenous. I address this problem by examining a change in the operating environment

[6] If the change in operating environment is anticipated, firms would have undertaken resource adjustments in the past muting the resource adjustments after the change.

that results from positive economic shocks caused by the actions of firms *outside* the focal industry.

My setting uses the liquidity windfalls experienced by banks from oil and natural gas shale development (termed the "shale boom"), which was a positive economic shock to the banking industry in the counties where shale development occurred (Gilje [2019]; Plosser [2014]). Technological advancements that resulted in shale developments were unlikely to be anticipated or influenced by bank managers (Gilje, Loutskina, and Strahan [2016]; Reed et al. [2019]). Moreover, the viability of these technological advancements was uncertain across different geographical areas. Therefore, it was difficult for bank managers to evaluate whether the shale developments would be transitory or persistent at the onset of the shale boom. Additionally, liquidity windfalls for the banks were predominantly localized, resulting in within-state variation in exposure of banks to the positive economic shock (Gilje et al. [2016]; Plosser [2014]). Consequently, an advantage of my empirical setting is that it provides a quasi-natural experiment to investigate how firms make changes to their cost structure and product mix when they experience an unexpected change in their operating environment. This change in operating environment demands an estimation of required adjustments to long-term resource choices. In a frictionless capital market, an increase in bank deposits should not affect a bank's operations because interbank borrowings or external capital markets would find it profitable to fund all positive NPV projects (Gilje [2019]). However, the shale boom not only increased bank deposits but also mortgage lending (e.g., Gilje et al. [2016]). Thus, banks exposed to the shale boom encountered a spike in their activities, which required adjustments to their operations.

There are several factors that contributed to bank managers being blindsided by the shale boom. These include the unexpectedness of the boom, the genesis of the boom being outside the banking industry, and the contribution of engineering and technology to the boom – which was outside the expertise of bank managers. Indeed, even industry experts could not predict or project the impact of the shale boom (Lake et al. [2013]; Reed et al. [2019]). The lack of understanding of the magnitude and persistence of the boom increased uncertainty and affected banks' resource adjustment decisions. High uncertainty regarding the nature of the shale boom increases the value of the option to wait and learn about the permanence of the boom (Grenadier and Malenko [2010]).[7] Uncertainty in operating environment diminishes over time as bank managers become more confident that the shale boom is not transitory. Accordingly, managers make dynamic adjustments to operations.

Bank managers have three major avenues through which they can meet the increase in demand. First, they can adjust resources by increasing the hours per employee (utilize the fixed resources i.e., tap into fixed cost) or hiring temporary employees during the initial years of the demand increase when both the magnitude and persistence of the shale boom are uncertain.[8] Temporary employees are cheaper than permanent employees because they do not get the same level of fringe benefits or raises and promotions. Hiring temporary employees should reduce the responsiveness of labor cost changes to revenue changes because revenue increases would outpace the increase in such labor costs. Second, they can expand capacity by hiring full-time employees during the later years of the shale boom when uncertainty about the persistence of boom has declined. Hiring full-time employees should increase the responsiveness of labor cost changes to revenue changes because the magnitude of labor cost changes would keep pace with

[7] This option to learn should be most valuable immediately after the arrival of the shale boom because uncertainty about the persistence of the boom is highest at that point.
[8] Firms hire part-time employees during periods of high uncertainty such as recession (Valletta and Bengali [2013]). However, in prior studies, it is unclear whether this hiring behavior is a response to a reduction in activity or to an increase in uncertainty.

revenue. In short, banks are likely to use resources with low adjustment costs during the initial periods of the shale boom and use resources that are costly to adjust during the later periods. Finally, they could reduce product diversity particularly during the later periods of the shale boom because the need to use product mix scope to deal with demand risk is less of a concern when uncertainty regarding the persistence of shale boom has declined.

Using a difference-in-differences estimation on 14,929 bank-year observations from 2005 to 2014, I examine labor adjustments and product mix changes undertaken by banks in response to an unexpected change in operating environment. I find that banks exposed to the shale boom reduce labor cost elasticity on average. I breakdown the labor cost into labor cost per employee and number of employees to further explore whether banks change the labor mix during the shale boom. I find an increase in labor employee elasticity and a decrease in labor cost elasticity per employee for banks exposed to the shale boom.[9] Taken together, these results indicate that the number of employees become more sensitive to changes in interest income for the banks exposed to the shale boom, and the banks hire a higher proportion of low-skilled employees or increase the hours per employee.[10] Resource adjustments using less costly resources reduce labor cost elasticity for the banks exposed to the shale boom. I also find that banks reduce product diversity after the arrival of the shale boom, indicating a reduced role of product mix diversity as an instrument to reduce demand risk.

If uncertainty is the driver of operating decisions, then labor adjustments and product mix changes should systematically vary over the period of the shale boom. The earlier periods of the

[9] Labor cost elasticity (labor employee elasticity) is the responsiveness of labor cost (number of employees) to changes in interest income.
[10] It is also possible that banks hire a higher proportion of temporary labor after the arrival of the shale boom. Although it is not possible to deterministically conclude the exact nature of labor adjustments undertaken by banks, all three avenues can be categorized as resources that can be easily adjusted in the short run.

shale boom are characterized by high uncertainty because of the inability of bank managers to understand whether the change in operating environment is transitory or persistent. Accordingly, I examine the dynamic labor adjustments and product mix changes made by banks in response to the shale boom. Results suggest that bank managers adjust resources dynamically in response to the shale boom, and their response depends on the uncertainty they face with respect to the persistence of the boom. I follow Bloom [2009] and measure uncertainty as the cross-sectional spread of bank-level earnings growth. Based on this measure, I observe that uncertainty is high during the first three years of the shale boom. During this period, banks exposed to the shale boom reduce labor cost elasticity, which is a result of increasing the labor with low adjustment costs. This reduced labor cost elasticity eventually increases to the pre-shale boom level. This adjustment results from hiring full-time employees during the later periods of the shale boom when managers update the likelihood of the permanence of the shale boom and reduce their assessment of uncertainty. This evidence is consistent with the analytical predictions of Grenadier and Malenko [2010] in which Bayesian uncertainty over past shocks causes significant delay in firms' response to positive cash flow shocks. I also find that banks with a better concurrent quality of allowance for loan and lease losses make permanent labor adjustments earlier than their peers. The internal information quality plays an important role in resolving the uncertainty arising from an unexpected change to the operating environment. Taken together, these results provide evidence of dynamic adjustments to resources by banks in response to the shale boom. Further, relative to non-exposed banks, I find that banks exposed to the shale boom reduce product diversity during the later periods of the shale boom when they face relatively low uncertainty. Also, banks exposed to the shale boom do not reduce product diversity in the initial periods of the shale boom. Overall, the results indicate that bank managers adjust product mix only when they are confident that the effects of the shale boom are persistent.

I contribute to the accounting literature in several ways. First, I identify a setting in which an exogenous positive economic shock at the local level results in an unexpected change in operations requiring adjustments to resources. Prior studies have examined resource adjustment decisions when managers can forecast the increase in demand with reasonable accuracy. Therefore, my study contributes to a better understanding of how uncertainty drives operational decisions of managers when there is a sudden and unexpected change in the business environment. Second, I contribute to the literature on cost management by providing evidence that adjustments to cost structure are dynamic in nature i.e., managerial resource choices are contingent on the operating environment. Third, I provide empirical evidence that managers prefer to wait even during positive economic shocks to learn about the permanence of the shock, which results in operational expansions that occur only during the later periods of the boom. Thus, managers not only delay hiring during periods of negative economic shocks but also during periods of unexpected positive economic shocks because of high uncertainty. Finally, I contribute to the literature on the effects of uncertainty on managerial decisions. While a robust literature has examined negative economic shocks (e.g., Bloom [2009], [2014]; Bloom, Bond, and Van Reenen [2007]; Jurado, Ludvigson, and Ng [2015]), positive economic shocks have been sparsely studied. The effects of positive and negative shocks are unlikely to be symmetrical. When firms face uncertainty from negative economic shocks, it is difficult to disentangle the portion of the response that arises from a reduction in activity with that arising from the effect of uncertainty. Further, it is unclear whether uncertainty is the cause or effect of a negative economic shock (Bloom [2014]). Firms' responses may be muted even in the presence of a positive economic shock if there is uncertainty about the permanence of such shock.

Section 2 reviews the relevant literature and develops the hypotheses. Section 3 describes the research design and empirical model specification. Section 4 describes the data and reports the findings of the study, while Section 5 discusses several robustness tests. Section 6 provides concluding comments.

RELATED LITERATURE AND HYPOTHESES

Theoretical background

A cost structure in which a higher proportion of costs arise from committed resources with high adjustment costs exposes firms to higher operating risk (e.g., Chen, Kacperczyk, and Ortiz-Molina [2011]; Holzhacker et al. [2015]b; Irvine, Park, and Yıldızhan [2016]; Mandelker and Rhee [1984]; Noreen, Brewer, and Garrison [2014]). When faced with demand uncertainty, firms with a higher proportion of fixed costs (i.e., a less flexible cost structure) are exposed to more variability in cash flows and earnings. Earnings volatility and the attendant unpredictability in earnings impose challenges to managers in planning for operations (Graham, Harvey, and Rajgopal [2005]).[11] A higher proportion of fixed costs increases the break-even point, and when such a cost structure is accompanied by demand uncertainty, the number of actual demand realizations at which the firm will incur a loss increases. In short, in the presence of demand uncertainty, revenues of firms with less flexible cost structures can fall below the break-even point if demand realization is lower than expectation. Therefore, demand uncertainty interacts with rigid cost structures to increase overall risk.

Prior research in accounting analytically models the tradeoff between investing in fixed inputs ex ante and procuring variable inputs ex post when actual demand is realized. The corresponding cost tradeoff is the cost of carrying committed resources versus bearing the higher resource price and congestion costs (Banker and Hughes [1994]; Göx [2002]). An unexpectedly high demand realization relative to available capacity results in congestion costs because demand has to be met using higher priced variable inputs (Banker, Byzalov, and Plehn-Dujowich [2014];

[11] Earnings volatility can also be an outcome of poor accounting estimates or accounting choices that reduce the accuracy of the mapping between income and expenses (Dechow and Dichev [2002]; Dichev and Tang [2009]; Sloan [1996])

Banker, Datar, and Kekre [1988]). As the likelihood of high demand realizations increases, ex ante resource commitments become attractive because expected congestion costs exceed the expected cost of unused capacity from low demand realizations. In short, considerations of congestion costs and higher resource prices may result in managers committing to ex ante fixed inputs and the attendant less elastic cost structures, even if such a choice yields lower earnings when demand realizations are lower than expectations. Therefore, demand uncertainty can result in a higher proportion of fixed costs in the cost structure (Banker, Byzalov, and Plehn-Dujowich [2014]).

A large body of accounting literature examines the drivers of asymmetric managerial resource adjustment decisions in response to demand increases versus demand decreases (e.g., Anderson et al. [2003]; Chen et al. [2012]; Hall [2016]; Kama and Weiss [2013]; Weiss [2010]). These studies focus on how managers adjust resources in response to a reduction in demand. However, sparse research examines managerial resource adjustment decisions in response to an increase in demand. A few notable exceptions include Banker, Byzalov, Ciftci, et al. [2014] and Chen, Kama, and Lehavy [2019], which examine the effect of consecutive demand increases on managerial resource adjustment decisions. In both studies a future increase in demand can be forecasted with reasonable accuracy because the managerial optimism about an increase in demand stems from an expected increase in activity during the ordinary course of business. Hence, managerial resource adjustment decisions in these studies are not responding to an *unexpected* element with respect to the uncertainty in the future operating environment. Therefore, managers prefer fixed cost structures to capitalize on favorable demand realizations from variations that arise from the normal course of business. However in my setting, when faced with a positive economic shock, managers find it difficult to forecast the magnitude and persistence of the positive shock because they are *unfamiliar* with the shock (Bloom [2014]). Firms that experience such shocks move from one steady state before the arrival of a shock to another but face uncertainty during the intermediate period because managers are unsure whether the change in the operating environment is transitory or persistent. Consequently, resource adjustments in response to positive economic shocks are likely to differ from resource adjustments in response to demand increases during normal business activities because of the uncertainty over the permanence of the shock.

Empirical research also shows that when faced with increased uncertainty in the operating environment, firms respond by adjusting their operations, with corresponding effects on their cost structures. For example, hospitals have increased the elasticity of their cost structures in response to the risk imposed by fixed price regulation (Holzhacker, Krishnan, and Mahlendorf [2015]a; Kallapur and Eldenburg [2005]).[12] Managers are likely to adjust their operations *ex ante* in anticipation of an *ex post* change in activity level arising from uncertainty. A change in activity level does not result in an automatic change to resources unless managers *decide* to adjust the resources (Cooper and Kaplan [1992]; Holzhacker et al. [2015]b). For example, in response to a change in the operating environment, airline companies have used outsourcing to reduce their fixed costs (Sedatole, Vrettos, and Widener [2012]). Holzhacker et al. [2015]b find that hospitals use outsourcing, equipment leasing, and temporary labor to increase cost elasticity in the presence of demand uncertainty and increased risk. These studies highlight that cost elasticity is a choice variable influenced by managers in response to the uncertainty in

[12] Fixed price regulation increases the risk of loss because the reduced contribution margin caused by a reduction in selling price increases the quantity required to break-even. To manage this risk, firms explore using variable inputs to meet production requirements. Thus, contribution margin volatility arising from a change in the reimbursement method for hospitals from cost plus to fixed price increases the value of having a flexible cost function.

firm's economic environment. In service industries, labor costs are the largest category of costs, which require strategic cost management decisions with respect to the management of labor cost.

Labor cost management

Labor is one of the most important resources in service firms therefore managers adjust labor costs in response to changes in activity. Extant literature finds evidence that firms make adjustments to labor capacity to meet demand (Caballero, Engel, and Haltiwanger [1997]; Hamermesh [1989]). Numerous factors such as managerial incentives, industry factors, and firm characteristics can increase the frequency of labor adjustments (Hall [2016]). For example, firms that incur an accounting loss or firms that barely meet the zero earnings benchmark frequently reduce labor investments (Dierynck, Landsman, and Renders [2012]; Pinnuck and Lillis [2007]). Therefore, firm characteristics play an important role in labor adjustments. Furthermore, labor adjustments are likely to be nonlinear on average. For example, Ilut, Kehrig, and Schneider [2018] study the manufacturing industry and find a slow hiring response to a positive output shock. The response is more pronounced if the establishment employs more skilled workers or future output is subject to higher uncertainty (Ono and Sullivan [2013]). A slow hiring response to a positive output shock can be driven by a firm's propensity to adjust hours per employee or employ temporary workers, which allows the firm to be responsive to such shocks.

Firms tend to hire labor with low adjustment costs to meet an unexpected increase in demand for their products or when an economic environment is uncertain (Wander [2018]).[13] This hiring strategy allows firms to reduce labor adjustment costs if the uncertainty subsides or when an increase in demand is only temporary.[14] Firms adjust hiring in response to permanent

[13] One type of labor adjustment undertaken by firms is to hire temporary labor (Rothschild [2012]), which is a part of labor-related business strategy for many firms.
[14] Hiring of temporary employees is particularly salient in industries that are susceptible to demand shifts (Dey, Houseman, and Polivka [2017]).

shocks to output but avoid adjustments to labor in response to temporary shocks (Guiso, Pistaferri, and Schivardi [2005]). Temporary labor provides flexibility to firms especially during periods of reduced economic activity or high uncertainty and when firms are unable to decide whether a change in the operating environment is transitory or persistent. Temporary labor allows firms to respond to demand changes with lower adjustment costs that arise from recruitment and termination. Katz et al. [1999] find that firms reduce adjustment costs by hiring temporary employees during periods of changing labor demand.

Shale boom and bank operations

Technological advancements have enabled the extraction of natural gas shale through horizontal drilling combined with hydraulic fracturing (also known as "fracking"). Until the end of the 20th century, shale gas was not considered to be economically viable and contributed to less than 1 percent of U.S. natural gas production. However, the industry changed drastically in 2003 with the development of Barnett shale in Texas. The challenge in extracting natural gas from shale areas arises from the highly nonporous nature of the rock that traps the gas in the rock. Fracking breaks apart shale and allows the collection of natural gas. This technological breakthrough combined with three-dimensional seismic imaging reduced the cost of fracking (Wang and Krupnick [2015]). Additionally, higher natural gas prices meant that shale reserves became economically profitable to extract.

Shale booms have been studied to examine their effects on local economies in general (e.g., Bartik et al. [2019]) and banks in particular (Gilje [2019]; Gilje et al. [2016]; Plosser [2014]; Stuber [2019]; Wu [2017]).[15] Shale discoveries have an immediate effect on supply as well as demand for bank credit especially in counties exposed to the shale boom because of an

[15] For example, shale regions experienced a significant increase in employment in the construction industry between 2007 and 2011 (Eberhart [2014]).

overall increase in economic activities. Typically drilling companies negotiate leases and pay a large bonus upfront to the landowners, unconditional on the well's productivity, followed by a royalty as a function of gas production.[16] Landowners, such as those in the Haynesville region of North Louisiana, turned into millionaires overnight. Between 2007 and 2008, the lease rates in this region increased from $100 an acre to $10,000 to $30,000 per acre (Times-Picayune [2008]). These landowners deposit the money in local banks resulting in liquidity windfalls for the banks. Thus, an increase in wealth windfalls for the county residents from the shale boom increases bank deposits and bank lending (Gilje [2019]; Gilje et al. [2016]; Plosser [2014]). In short, a shale boom results in a spike in operations for the banks exposed to the shale boom.[17] Banks are in turn required to make resource adjustments to accommodate the spike in operations.[18]

The change in operating environment for banks exposed to shale boom was unexpected for the following reasons. First, drilling of shale wells is viable only if the demand and price of natural gas are within specific parameters. These parameters are in turn a function of national and global macroeconomic forces and independent of local economic conditions (Lake et al. [2013]). Second, even though technological breakthroughs made fracking feasible, the viability was uncertain across different geographical areas. The U.S. Energy Information Administration (EIA) doubled its estimate of total recoverable U.S. shale gas resources between 2009 and 2011, highlighting the unpredictable nature of shale discoveries (Lake et al. [2013]). It was challenging even for industry experts to forecast the number of wells required within a shale play area to develop recoverable resources (Gilje et al. [2016]). Therefore, it is unlikely that the banks in

[16] Royalty payments for 1.8 million lease contracts from six major shale plays were approximately $39 billion in 2014 (Brown, Fitzgerald, and Weber [2016]).
[17] In Table 1.1, I replicate the result that the shale boom increased the deposits for the banks exposed to the shale boom. Additionally, I also examine whether there was an increase in interest income for the exposed banks to ensure that there was indeed a spike in my proxy measure for activity.
[18] For example, First International Bank in North Dakota added 65 employees to its workforce of nearly 300 existing employees across 21 branches in 2012 in response to increased customer demand (Eberhart [2014]).

shale areas strategically adjusted their resources and product mix in anticipation of a change in operating environment. Further, banks not only experienced an unexpected change in their operating environment, but also faced uncertainty regarding the persistent effects of the shale boom especially during the initial periods of the boom.

Labor cost management in banks in response to a positive economic shock

Efficient cost management is particularly important for commercial banks because the banking industry is highly competitive and faces regulatory constraints. Banks must maintain adequate capital as a proportion of assets adjusted for risk to ensure that they do not undertake excess leverage. Government agencies such as Federal Deposit Insurance Corporation (FDIC) and Federal Reserve Board (FRB) monitor this capital adequacy requirement. Capital requirements incentivize banks to focus their efforts on cost management because low regulatory capital makes it difficult for banks to add labor when required (Hall [2016]). I particularly focus on labor cost management decisions of banks because labor is the largest cost item relative to non-interest expense. Further, managers have discretion with respect to labor cost. For example, in my sample labor cost is 54 percent of non-interest expense and 37 percent of total expense on average.[19] Additionally, labor is the most important capacity resource for the service industry.

Banks have discretion over their labor mix decisions. For example, banks can increase the proportion of variable-pay employees or delay hiring fixed-pay employees when faced with uncertainty. Because labor costs are committed in advance, banks maintain slack labor resources to meet unexpected demand. In the service industry, demand typically follows a Poisson distribution. As a result, capacity is not a hard number, but exhibits some flexibility to make adjustments. Banks maintain a mix of labor during the normal course of business and adjust their

[19] The average ratio of labor cost as a percentage of non-interest expense for all banks from 1997 to 2018 is also approximately 54 percent.

labor cost in response to a change in activity to maintain this mix. However, when there is a change in operating environment the demand distribution also shifts warranting labor adjustments to accommodate such a change. During such periods, the labor mix can be expected to change at least temporarily, which in turn affects cost elasticity. Therefore, labor cost elasticity is likely to change particularly when operations fall outside the relevant range of planned capacity (Balakrishnan, Petersen, and Soderstrom [2004]).

Additionally, when the change in operating environment is sudden and unexpected, as was the case with the shale boom, banks are required to change their labor adjustment strategies in response to a change in activity because of the following two conditions. First, bank managers experiencing a spike in activities from the shale boom face uncertainty regarding the nature of the shale boom, given the complexity of macroeconomic factors that contribute to the boom. Second, there is a high level of uncertainty regarding future revenue generation particularly during the initial periods of the shale development. That is, banks are unsure what a steady state will look like in the future. Although there is an increase in activity for the banks exposed to the shale boom, uncertainty around its persistence warrants a cautionary strategy with respect to labor adjustments (Grenadier and Malenko [2010]). Hiring of employees is a real option because if the spike in operations is temporary, the banks must incur the cost of layoffs. It is also possible that the increase in operations exceeds the effect of uncertainty and signals a need to hire employees in response to the spike in demand (Grenadier and Malenko [2010]). Accordingly, I expect banks to make labor adjustments differently in response to a change in activity during the shale boom compared to the pre-shale boom period. During the initial periods of the boom, banks can benefit from untapped economies of scale and temporarily adjust operations by increasing hours per employee, hire temporary workers, or hire employees with low adjustment costs which changes the labor mix.[20] In short, demand driven increases in output during the initial periods can be accommodated by increasing capacity utilization as permitted by the relevant range (Balakrishnan et al. [2004]). Consequently, the increase in revenue for banks exposed to the shale boom will outpace the increase in labor costs and reduce labor cost elasticity as stated in my first hypothesis:

> **H1:** Relative to banks operating in counties that did not experience the shale development, banks operating in counties where the shale development occurred will reduce the elasticity of labor cost during the post shale development period.

Uncertainty, dynamic resource adjustments, and real options

The decision about how much capacity to build is one of the most fundamental operating decisions made by firms. When faced with uncertain demand, the capacity decision involves a tradeoff between excess capacity cost and the opportunity cost of lost sales or premium price to be paid for on demand inputs ordered on a flexible basis arising from high demand realizations relative to planned capacity (Banker, Byzalov, and Plehn-Dujowich [2014]; Petruzzi and Dada [1999]). Firms operating in less competitive markets can make capacity decisions disregarding demand uncertainty because market power allows these firms to utilize the capacity (Van Mieghem and Dada [1999]). Firms with market power can use inventories to manage sales fluctuations by smoothing out production. When service industries face uncertainty, capacity choice decision becomes even more important because the output cannot be inventoried. Accordingly, service firms operating in competitive industries will prefer operational flexibility under uncertainty, i.e., invest in resources with low adjustment costs because they lack market power and output cannot be inventoried.

[20] Another possibility is that banks can outsource some of the activities such as loan processing (Hall [2016]).

During times of reduced economic activity, firms layoff temporary workers before laying off permanent employees and delay the hiring of permanent employees during the recovery (Heinrich and Houseman [2019]). Delays in hiring can occur from a mismatch between the supply of skills available in the labor market and the demand for skills by firms. Such delays can also result from heightened uncertainty during periods of recovery (Baker, Bloom, and Davis [2016]; Kocherlakota [2010]). For example, aggregate employment growth for long-term labor was weak during the recovery period after the financial crisis of 2008-2009 because firms were uncertain whether the recovery would sustain (International Monetary Fund [2012]).

During periods of small positive demand shocks, firms adjust resources by hiring labor (e.g., Bloom [2009]). However, resource adjustments in response to a substantive positive economic shock is not well-documented. Grenadier and Malenko [2010] model the investment behavior of firms in response to past economic shocks. They argue that when firms observe a positive shock to their cash flows but are unable to identify its true properties, there is an option value to wait and learn whether the cash flow shock is temporary or persistent. This option to wait allows Bayesian updating of the likelihood that the change in the operating environment is temporary. In a nutshell, uncertainty about the permanence of economic shocks increases the option value of waiting to observe if the change reverts.

The resource adjustments are likely to be dynamic in response to an unexpected positive shock. During the initial periods of the shock, firms have positive demand expectations but also face uncertainty regarding the persistence of the shock. In the later periods, there is less uncertainty surrounding positive demand expectations because managers are familiar with the new operating environment and update their perceptions about the permanence of the shock. In short, the resource adjustments can be expected to systematically vary during the initial and later periods of the unexpected positive economic shock. Based on real options theory and the analytical predictions of Grenadier and Malenko [2010], I expect that managerial resource adjustments will systematically vary during the initial periods versus later periods of the shock. During the initial periods when future uncertainty about the effects of the shock is high, managers will prefer to invest in resources with relatively low adjustment costs.[21] Additionally, managers can utilize the slack available to meet the increase in demand as permitted by the relevant range (Balakrishnan et al. 2004). During the later periods when uncertainty is lower or managers are better able to estimate the magnitude of the shock, banks will undertake operational expansions. These operational expansions are likely to include hiring of more permanent labor. Overall, banks are likely to either adjust hours per employee or hire workers with low adjustment costs, or both, and delay hiring workers with high adjustment costs during periods of higher uncertainty.

These resource adjustments have cost structure implications that vary during the initial periods versus the later periods. During the initial periods, when a larger proportion of additional resources with low adjustment costs are deployed, the increase in revenue will outpace the increase in cost, with the result that cost elasticity decreases. Subsequently during the periods when managers have a better understanding of the economic environment, the firm will undertake operational expansions (such as hiring permanent labor). Consequently, there will be an increase in responsiveness of cost changes to revenue changes resulting in an increase in cost elasticity. Accordingly, I state the following hypothesis:

H2: Banks operating in counties where the shale development occurred decrease (increase) the labor cost elasticity during the initial periods (later periods) of the post

[21] Temporary labor is an example of a resource with low adjustment costs because they are not on the payroll of the firm, are hired on a contract or fee basis (such as per diem) and can be hired and terminated as required.

shale development period relative to banks that did not experience the shale development.

Labor cost adjustments and banks' forecasting abilities

In the presence of uncertainty, decisions related to labor procurement and resource adjustments are influenced by the forecasting ability of the bank. Banks with better forecasting ability are likely to have greater confidence in their ability to make labor employee elasticity decisions. The quality of forecasting is a latent variable; however, it can be proxied with other strategic variables that reflect a bank's ability to manage its operations. One such strategic variable in the banking industry is the allowance for loan and lease losses. This allowance is based on the estimate of the amount of loans that are projected to incur losses. The loss period extends beyond the balance sheet date. If the bank expects the loss to occur in future periods, then a loss is deemed to have accrued in the current period and accordingly a provision is made.[22] Allowance for loan and lease losses provide forward-looking information about the bank, particularly the expected credit losses (e.g., Beatty and Liao [2011]; Harris, Khan, and Nissim [2018]). Additionally, bank characteristics and incentives affect the quality of loan loss provisioning (Nichols, Wahlen, and Wieland [2009]). Khan and Ozel [2016] find that estimated credit losses of banks aggregated to the state level provide information about local conditions that is incremental to other leading indicators of economic activity. Therefore, the quality of the loan loss provision not only provides information about banks' abilities to forecast but also their knowledge of local economic conditions.[23] The banks' knowledge base provides them with

[22] Regulatory guidance requires banks to forecast the loan losses that are expected to occur over the next one year from the date of balance sheet and maintain an allowance for loan losses (OCC) [1998]).
[23] Consistent with prior literature, I use the ratio of charge offs in the following year to allowance for loan losses in the current year to evaluate the forecasting quality (Beatty, Liao, and Zhang [2019]; Cantrell, McInnis, and Yust [2014]; Stuber [2019]).

greater ability to estimate the magnitude and persistence of the shale boom. Such a better information base can reduce the error in the estimate of the uncertainty regarding the persistence of the shale boom and accordingly diminish the option value of waiting (Grenadier and Malenko [2010]). Therefore, I expect banks with high forecasting quality, proxied by the quality of their allowance for loan and lease losses, to increase their labor employee elasticity earlier than other banks as stated in the following hypothesis:

> **H3:** Among the banks exposed to the shale development, banks with high forecasting ability increase labor employee elasticity earlier than other banks.

Product diversity

Decisions related to labor procurement and resource adjustments are likely to influence a bank's product mix choices. Product diversity, which refers to the range of product variations offered by a firm, is an important product mix decision. A full range of products allows firms to cater to different market segments and obtain economies of scope (Tallman and Li [1996]). Additionally, product diversity is a risk management tool, especially during periods of unexpected changes in the operating environment (Miller and Shamsie [1999]). Carlton and Dana [2008] argue that product diversity reduces the risk arising from demand uncertainty because it reduces the expected costs of sunk capacity. However, a firm's inability to assess the impact of uncertainty on its outcomes could result in the firm choosing to narrow its focus on more profitable product lines (Miller and Shamsie [1999]).

Banking is a multi-product industry. Most banks offer a variety of loan products to their customers such as home mortgage loans, car loans, education loans, credit cards, and so on. There is often some degree of overlap of borrowers across products. When faced with a change in the operating environment, banks are likely to alter their product mix to increase their focus on more profitable products. Although reducing product diversity could reduce their economies of scope, it allows them to benefit from economies of scale.[24] However, the timing of when banks will make changes to the product mix is an empirical question. It is unlikely that banks will make changes to their product mix immediately after the shale boom, but likely that they will respond later when the uncertainty surrounding the persistence of the shale boom is lower. I predict that banks will reduce their product diversity in response to the shale boom, but this reduction will only occur during the later periods of the boom as stated in the following hypotheses:

H4a: Banks operating in counties where the shale development occurred reduce product diversity during the post shale development period relative to banks that did not experience the shale development.

H4b: There is a significant difference in product diversity between the initial and later periods of the post shale development for banks operating in counties where the shale development occurred.

[24] Bernard, Redding, and Schott [2010] use census data to provide evidence that manufacturing firms exposed to positive productivity shocks add products to their portfolio. I study how banks reallocate their loan portfolio, which is different from adding or dropping a product altogether.

RESEARCH DESIGN AND METHODOLOGY

Banks exposed to the shale boom

To determine that a change in bank's operating environment was *unexpected*, there must be adequate reasons to assume that the growth in extraction of oil and natural gas in shale counties was unanticipated. As discussed above, the unexpected nature of development in shale counties was a surprise even for the experts in the field (Gilje et al. [2016]; Lake et al. [2013]; Reed et al. [2019]). Thus, when even oil and gas scientists were taken by surprise by the extent of production possibilities, it is unlikely that bank managers could have anticipated such a change and *ex ante* adjusted their resources to accommodate the increase in future operations.

The exposed counties (shale counties) are those within a "play" state with shale formation based on the classification of U.S. Energy Information Administration (EIA).[25] The counties within a play state without shale formation are non-exposed or non-shale counties. According to EIA, there are eight major U.S. shale regions.[26] Figure 1 shows a U.S. map that highlights each shale region. Significant fracking activity began in the Permian region in 2005, and my sample period begins in 2005, this region is therefore excluded from my sample. Additionally, I follow Stuber [2019] and exclude the state of New York and Texas from my analyses.[27] These exclusions result in six U.S. shale regions, which I include in my analyses. Figure 2 depicts the exposed and non-exposed counties in the shale play states and the year when

[25] EIA defines a shale "play" as shale formations containing significant accumulations of natural gas and which have similar geologic and geographic properties. The data on shale counties can be obtained from https://www.eia.gov/tools/faqs/faq.php?id=807&t=8

[26] The Appalachia region consists of Marcellus and Utica. I treat them as two separate basins for the purpose of my analyses because significant fracking began in Marcellus region in 2007 and in Utica region in 2011.

[27] The state of New York within the Marcellus shale play is excluded because drilling activity was halted https://www.cnn.com/2010/US/12/13/new.york.fracking.moratorium/index.html. The state of Texas is excluded because conventional oil drilling before shale boom makes it difficult to determine the pre and post periods. Consequently, the entire Eagle Ford region and parts of Haynesville region covering the state of Texas are excluded from analyses.

significant fracking began within each shale region. As shown in Figure 2, I study the operating decisions of banks from 11 play states: ND, MT, PA, WV, OK, LA, AR, CO, WY, NE, and OH.

I identify exposed banks as those with the majority of branches in shale counties. Banks that operate within the shale play state but do not have the majority of their branches in shale counties are identified as non-exposed banks. *Exposed Bank* is determined based on the number of branches of a bank in the first year when significant fracking activity began within the shale play state. Information for bank branch locations is obtained from Federal Deposit Insurance Corporation (FDIC) Summary of Deposits (SOD) data. I restrict the analyses to banks operating within the shale play states, which allows me to compare the operating decisions of exposed banks with non-exposed banks that operate within the geographical proximity.

Research design

Examining the effect of change in operating environment on resource adjustment and product mix decisions requires an event that was unanticipated by managers. If managers adjust operations in anticipation of a change in operating environment, the changes in resource adjustments and product mix will be measured with error because it is difficult to determine the post-event period accurately.[28] The unexpected nature of the shale development alleviate concerns of *ex ante* correlation between a bank's exposure to the shale boom and operational changes. However, local economic trends can confound the analysis of resource adjustments and product mix. I address this concern by comparing the exposed banks with banks that have little or no exposure to the shale boom operating within the same play state using a difference-in-differences analysis. Difference-in-differences estimation addresses the concerns that confounding factors affect the exposed and non-exposed banks during the post-shale

[28] For example, if the shale boom occurs in 2007 and managers anticipate this development and add resources in 2006, the appropriate post-treatment period to be considered is 2006.

development period or that time trends unrelated to the shale development could affect the exposed banks (Imbens and Wooldridge [2009]).

Hypothesis 1-3: Effect of change in operating environment on labor elasticity

Consistent with prior literature, I infer resource adjustments from the observed cost elasticities (Banker, Byzalov, and Plehn-Dujowich [2014]; Hall [2016]). Similar to Hall [2016], I also use labor cost elasticity and labor employee elasticity to make inferences about resource adjustments. Labor cost constitutes approximately 54 percent of total non-interest expense on average and is therefore the largest category of resource costs for banks. Labor cost elasticity is the slope coefficient obtained by regressing the log change in labor cost on log change in revenue (Banker, Byzalov, and Plehn-Dujowich [2014]; Dierynck et al. [2012]; Hall [2016]; Holzhacker et al. [2015]b)**.** I choose the log-changes model over log-levels for three reasons. First, a log-level model measures elasticity in the long run (Noreen and Soderstrom [1994]) and it is likely that banks maintain a certain level of labor cost elasticity in the long-run and adjust their elasticities accordingly to this level over the period of the shale boom. Thus, there may be no difference in long-run elasticities in labor costs before and after the shale boom. Second, with bank fixed effects, the levels model removes the average interest income and labor cost *across the entire sample* whereas a changes model differences out the interest income and labor cost of a bank *from the previous year*. A changes model is particularly relevant because earlier sample years (2005 to 2007) are likely to exhibit a different trend than later sample years (2008 to 2014) because of financial crisis (Gilje et. al [2016]). The log-changes model with bank fixed effects accounts for bank-specific trends alleviating this concern (Wooldridge [2010]). Finally, I am interested in examining how banks make dynamic labor adjustments during the initial and later periods of the shale boom, which requires an estimation of short-run elasticity.[29] I use interest income as a proxy for revenue, which is consistent with prior literature that uses sales as an activity-driver in elasticity studies (Banker, Byzalov, and Plehn-Dujowich [2014]; Kallapur and Eldenburg [2005]).[30]

H1 examines the effect of the shale development on labor cost elasticity for exposed banks relative to non-exposed banks using the following model:

$$\begin{aligned}
&\Delta \log \textit{labor cost def}_{it} \textit{ or } \Delta \log \textit{employees}_{it} = \beta_0 + \beta_1 \Delta \log \textit{interest income}_{it} + \\
&\quad \beta_2 \textit{Exposed Bank}_i + \beta_3 \textit{Post}_t + \beta_4 \Delta \log \textit{ interest income}_{it} \times \textit{Exposed Bank}_i + \\
&\quad \beta_5 \Delta \log \textit{interest income}_{it} \times \textit{Post}_t + \beta_6 \textit{Exposed Bank}_i \times \textit{Post}_t + \\
&\quad \boldsymbol{\beta_7 \Delta \log \textit{interest income}_{it} \times \textit{Exposed Bank}_i \times \textit{Post}_t} + \beta_8 \textit{ASINT}_{it} + \\
&\quad \beta_9 \Delta \log \textit{interest income}_{it} \times \textit{ASINT}_{it} + \beta_{10} \textit{EMPINT}_{it} + \beta_{11} \Delta \log \textit{interest income}_{it} \times \\
&\quad \textit{EMPINT}_{it} + \beta_{12} \Delta \textit{FFRLNS}_{it} + \beta_{13} \log \textit{assets}_{i,t-1} + \beta_{14} \Delta \log \textit{deposits}_{it} + \delta_i + \gamma_t + \\
&\quad e_{it} \qquad (1)
\end{aligned}$$

where subscripts i and t refer to bank and year respectively.

Labor cost and Employees: The dependent variable $\Delta\, log\ labor\ cost\ def_{it}$ is the natural log of labor costs in the current year divided by labor costs of the prior year. Consistent with the literature on cost behavior, the labor costs are deflated by the average consumer price index (Banker, Byzalov, and Plehn-Dujowich [2014]; Holzhacker et al. [2015]b).

I separate the labor cost into labor cost per employee and number of employees for a nuanced understanding of labor adjustments by banks in response to the shale boom. Accordingly, to examine labor employee elasticity, the dependent variable is $\Delta \log \textit{employees}_{it}$

[29] In additional analyses, I examine long-run elasticities and discuss them in Section 5.
[30] An alternative cost driver to interest income is total revenue (Hall [2016]). However, Hall [2016] uses data at the bank holding company level, where a significant portion of revenue is non-interest revenue. My analysis uses bank-level data and interest income constitutes a major portion of total revenue (85% on average) for the banks in my sample. Additionally, the economic magnitude of labor cost elasticity when non-interest income is used as an activity measure is close to 0 (untabulated). In additional tests (untabulated), I use the sum of interest and non-interest revenue as a cost driver and the results are qualitatively similar.

defined as the natural log of number of full-time equivalent employees in the current year divided by number of full-time equivalent employees in the previous year. Similarly, to examine labor cost elasticity per employee, the dependent variable is $\Delta \log labor\ cost\ per\ emp_{it}$ defined as the natural log of labor cost per full-time equivalent employee of current year divided by labor cost per full-time equivalent employee of the previous year. The labor cost per full-time equivalent employee is also deflated by the average consumer price index.

Revenue: I use interest income as the activity measure. $\Delta\ log\ interest\ income_{it}$ is the natural log of interest income in the current year divided by interest income in the prior year.

Exposed Bank: $Exposed\ Bank_i$ is an indicator variable equal to 1 if majority of branches of bank i are in counties identified as exposed to the shale boom within a shale play state, and 0 otherwise. The number of branches in the year in which significant fracking activity began in each of the play states is used to determine this variable.

Shale development period: The shale development period is determined as the period from the year when significant fracking activity began in the shale play state (Bartik et al. [2019]; Gilje [2019]; Stuber [2019]). $Post_t$ is an indicator variable equal to 1 if significant fracking activity has commenced in a state where bank i has branch locations, and 0 in prior years.

Asset Intensity and Employee Intensity: I follow prior literature and include $Asset\ intensity_{it}$ which is defined as the ratio of nonfinancial assets (property, plant, and equipment [PP&E]) to interest income and $Employee\ intensity_{it}$ defined as the ratio of number of employees to interest income multiplied by 1,000. These variables proxy for capacity adjustment costs (Hall [2016]; Holzhacker et al. [2015]b).

Federal Funds Rate: The interest income of a bank can change due to changes in interest rate. Therefore, I follow (Hall [2016]) and include $\Delta\ FFRLNS_{it}$ measured as the percentage change in the average federal funds rate multiplied by the total dollar amount of loans at the beginning of the year, where the average rate is calculated using the federal funds rate in January plus the federal funds rate in December of year *t* divided by 2. This variable also controls for the effects of macroeconomic conditions on a firm's activity (e.g., Holzhacker et al. [2015]a).

Size: Bank size can affect the labor cost elasticities because of economies of scale (Balakrishnan, Labro, and Soderstrom [2014]) and accordingly I include $log\ assets_{i,t-1}$ defined as log of total assets of bank *i* at the beginning of the year.

Capacity utilization: A bank's capacity utilization can influence the labor cost elasticities (Balakrishnan et al. [2004]; Cannon [2014]) and accordingly I include $\Delta\ log\ deposits_{it}$ defined as log change in total deposits of bank *i* from year *t-1* to year *t* (Banker, Byzalov, and Plehn-Dujowich [2014]).

I include year fixed effects (γ_t) and bank fixed effects (δ_i). The year indicators are relative to the year of the shale development in a shale play state. Consequently, the main effect of $Post_t$ is absorbed by year fixed effects. Similarly, the main effect of $Exposed\ Bank_i$ is absorbed by bank fixed effects. All the continuous variables are demeaned in the interactions so that the main effects can be interpreted as the slope at the mean levels of all variables.

To study the effect of the shale boom on bank's labor elasticities, I adopt a difference-in-differences approach. The first difference β_4 measures the difference in labor cost elasticity for exposed and non-exposed banks prior to the shale boom. β_7 is the coefficient of primary interest, which measures the difference-in-differences estimate of labor cost elasticity for the exposed banks during the post shale development period vis-à-vis non-exposed banks in the entire period and exposed banks in the pre shale development period. In short, β_7 captures the change in labor cost elasticity from a change in operating environment resulting from the shale boom. A negative coefficient on β_7 would indicate that labor cost elasticity decreased in the post shale development period for exposed banks.

For a better understanding of labor adjustments undertaken by banks in response to the shale boom, I replace the dependent variable $\Delta\, log\ labor\ cost\ def_{it}$ with $\Delta\, log\ employees_{it}$ and $\Delta\, log\ labor\ cost\ per\ emp_{it}$ and estimate equation (1). A negative coefficient on β_7 when the dependent variable is $\Delta\, log\ labor\ cost\ per\ emp_{it}$ would indicate that labor cost elasticity per employee decreased in the post shale development period for exposed banks.

To test H2, I replace the $Post_t$ indicator variable in equation (1) with three separate indicator variables $Post_j$, which takes the value 1 in the first two years of the post-shale development and 0 otherwise, $Post_k$, which takes the value 1 in the third and fourth year of the post-shale development and 0 otherwise, $Post_l$, which takes the value 1 for all years after four years of the post-shale development and 0 otherwise. Breaking the post shale development period allows me to examine the labor elasticity changes by exposed banks during the initial and later periods of the shale boom.

To test H3 i.e., whether banks with better forecasting ability adjust labor employee elasticity earlier than other banks, I split the full sample used to test H2 into banks with *high forecasting ability* and *low forecasting ability*. Bank-years with *high forecasting ability* are defined as 1 if the ratio of charge offs in year *t+1* to allowance in year *t* for a bank falls in the highest quartile.[31]

[31] A ratio of charge offs to allowance for loan and lease losses greater than 1 indicates an inadequate reserve. Since the ideal measure for this ratio is 1, I treat bank-years with ratio greater than 1.68 to be of low forecasting quality. The results are consistent if all bank-years with ratio greater than 1 are excluded from the high forecasting ability subsample and included in the low forecasting ability subsample (untabulated).

Hypothesis 4: Effect of change in operating environment on product diversity

To test H4a and H4b, I estimate the effect of the shale development on product diversity using the following model:

$$\text{Product diversity}_{\text{it}} = \beta_0 + \beta_1 \log interest\ income_{it} + \beta_2 Exposed\ Bank_i + \beta_3 Post_t + \boldsymbol{\beta_4 Exposed\ Bank_i} \times \boldsymbol{Post_t} + \beta_5 Exposed\ Bank_i \times Large\ bank_i + \beta_6 Large\ bank_i \times Post_t + \boldsymbol{\beta_7 Exposed\ Bank_i} \times \boldsymbol{Post_t} \times \boldsymbol{Large\ bank_i} + \beta_8 ASINT_{it} + \beta_9 EMPINT_{it} + \beta_{10} \Delta FFRLNS_{it} + \beta_{11} \log assets_{i,t-1} + \beta_{12} \Delta \log deposits_{it} + \delta_i + \gamma_t + e_{it} \quad (2)$$

Product diversity: $Product\ diversity_{it}$ is measured as the natural log of the sum of the squares of consumer loans, real estate loans, and commercial and industrial loans as a proportion of gross loans for bank *i* in year *t*. This measure is multiplied by -1 so that the index is positive, and a higher number reflects a more diversified portfolio of a bank. For example, if a bank only provides real estate loans, its product diversity measure will be 0.

Large Bank: Large banks have a greater ability to adjust the product mix in response to change in operating environment by expanding into otherwise unexplored business or geographical segments. Therefore, I include an indicator variable $Large\ Bank_i$ if a bank's total assets at the beginning of the year in which significant fracking activity began in a shale play state is greater than 500 million USD and 0 otherwise (Gilje [2019]).

The variables in equation (2), which are also a part of equation (1) are defined above and the discussion related to the main effect of $Exposed\ Bank_i$ and $Post_t$ is also relevant here. The main variable of interest is the interaction between $Exposed\ Bank_i$ and $Post_t$. The coefficient on this variable measures the change in bank's product diversity during the post-shale development period. A negative coefficient on β_4 indicates that banks exposed to the shale boom reduced product diversity. The coefficient on $Exposed\ Bank_i \times Post_t \times Large\ bank_i$ measures whether large banks responded to the shale development and adjusted product diversity differently than small banks. The main effect of $Large\ Bank_i$ and $Exposed\ Bank_i \times Large\ Bank_i$ will be absorbed by bank fixed effects.

To test the dynamic effect of change in operating environment on product diversity (H4b), I apply the procedure mentioned above to test H2 and replace $Post_t$ with three indicator variables and interact them with $Exposed\ Bank_i$ to examine the difference in product diversity changes during the initial and later periods of the shale development.

DATA AND RESULTS

Sample

Table 1.2 provides the sample selection details. I begin with the year-end *Consolidated Report of Condition and Income* (Call Reports) filed by all banks in U.S. during 2004- 2015. The lagged variables for 2005 required in the analyses are computed using 2004 data and the charge offs required to construct the forecasting quality variable for 2014 are computed using 2015 data. The sample period begins in 2005 to avoid a long time-series because resource adjustments are likely to be affected by the structural changes in banking industry in the long-run. I discard banks in the top 1 percent of assets and banks outside the play state because these banks are not comparable to the banks in the sample. Consistent with prior literature, I discard bank-year observations if salaries exceed interest income in the current or prior year or if salaries and interest income are in the top and bottom 1 percentile to ensure that the estimates are not affected by outliers (e.g., Banker et al. [2014]). The final sample includes 14,929 bank-year observations.

Descriptive statistics

Table 2.1 presents the descriptive statistics for the sample of bank-years used in my analyses. All continuous variables except labor cost and interest income are winsorized at 1 and 99 percentiles. The mean labor cost is 4 million dollars, and an average bank employs approximately 68 full-time equivalent employees. The median number of employees is 36, which indicates that this number is right skewed due to the existence of few large banks in the sample. The mean growth in labor cost (employees) is 3 (2) percent.[32] The median change in employees is 0 which is consistent with the evidence that firms do not adjust labor regularly but often adjust labor cost. The mean growth in interest income (deposits) is 2.8 (5.9) percent. The standard

[32] The log changes in labor cost approximates a percentage change in labor cost. It measures a continuously compounded growth in labor cost.

deviation for growth in interest income is larger than the standard deviation for growth in labor cost. The distribution for product diversity is positively skewed, which indicates that some banks have a highly diversified loan portfolio.

Table 2.2 presents the correlations among the variables used in my analyses. As expected, the growth in labor cost is highly correlated with the growth in interest income. Only a moderate correlation can be observed between the growth in labor cost and growth in employees. A high positive correlation exists among the number of branches, log assets, and number of employees. A negative and significant correlation exists between product diversity and log assets, which suggests that large banks in my sample have a relatively less diversified loan portfolio.

Table 2.3 shows the univariate analyses for exposed and non-exposed banks before and after the shale boom. The difference in average labor cost scaled by number of branches is positive and significant at the 5 percent level only during the later periods of the shale development which suggests that banks exposed to the shale boom hired costly labor resources in the later periods of the shale boom. Similarly, the difference in interest income scaled by number of employees is positive and significant during the post shale development period. The difference in log deposits is positive and significant for exposed banks during the pre and post shale development period.

Hypothesis 1-3: Effect of a change in operating environment on bank's labor elasticity

The results of estimating labor cost elasticity changes in response to the shale boom are tabulated in Table 3.1. In all the columns, year fixed effects are included, which are relative to the onset of boom and absorb the main effect of $Post_t$. Standard errors are clustered by bank to account for serial correlation. Columns (1) to (4) estimate the labor cost elasticity changes without the control variables but includes different types of fixed effects. Column (2) includes state fixed effects to account for time invariant state factors that can affect the labor cost elasticity of banks in the sample. Column (3) includes county fixed effects to account for time invariant county factors that can affect the labor cost elasticity of the banks in the sample. Column (4) includes bank fixed effects to account for bank specific factors that do not change over time. Therefore, in Column (4) the main effect of $Exposed\ Bank_i$ is absorbed by bank fixed effects. The labor cost elasticities in Columns (1) to (4) are consistent and show a statistically significant decrease in labor cost elasticity for the banks exposed to the shale boom relative to non-exposed banks providing support for H1. In the remainder of this paper, I perform all my analyses by including bank fixed effects. Table 3.1, Column (5) provides the results of estimating equation (1). The labor cost elasticity for the exposed as well as the non-exposed banks in the pre-shale development period is 0.681 (p-value<0.01). The labor cost elasticity for exposed banks in the post-shale development period falls to 0.501 whereas the labor cost elasticity for non-exposed banks does not change in the post-shale development period. The results indicate that exposed banks' responsiveness to a change in interest income is lower after the shale boom. The revenue increases for the banks exposed to the shale boom outpaced the increase in labor cost with the attendant effect that labor cost elasticity reduced in the post-shale period. Although the exposed banks obtained an increase in revenues, they did not make corresponding changes to labor cost and instead benefited from economies of scale and slack resources that they had at their disposal. Thus, H1 is supported i.e., banks exposed to the shale boom reduce labor cost elasticity in the post-shale development period.

To examine whether exposed banks changed the composition of their labor resources after the shale boom, in Table 4.1, I analyze labor cost elasticity per employee and labor employee elasticity. In all the columns, year indicators relative to the onset of the boom absorb the main effect of $Post_t$, and standard errors are clustered by bank. Columns (1) and (2) estimate the labor cost elasticity per employee whereas Columns (3) and (4) estimate the labor employee elasticity. Columns (1) and (3) are estimated with county fixed effects while Columns (2) and (4) are estimated with bank fixed effects. The negative coefficient on $\log interest\ income_{it} \times Exposed\ Bank_i \times Post_t$ in Columns (1) and (2) show that labor cost elasticity per employee decreased for the banks exposed to the shale boom. Exposed banks did not match the changes to their labor cost on a per-employee basis relative to the increase in their revenues from the boom. Thus, the total labor budget on a per-employee basis did not increase to correspond to their revenue increase. However, exposed banks increased the number of employees as can be observed from the positive coefficient on $\log interest\ income_{it} \times Exposed\ Bank_i \times Post_t$ as seen in Columns (3) and (4). The shale boom resulted in windfall gains for the banks and required labor to service the increase in operations. However, the labor that banks hired to account for the increase in operations was of lower cost, which maintained the total labor cost budget to be below the corresponding increase in revenues (Table 4.1, negative coefficient $\log interest\ income_{it} \times Exposed\ Bank_i \times Post_t$). Thus, banks were cautious about resource adjustments in the boom period and did not increase their labor budget to even budget neutral levels, which would have maintained the level of labor employee elasticity and labor cost per employee at pre-boom levels. Taken together, the results of Table 3.1 and 4.1 suggest that exposed banks hired less costly labor during the post-shale development period. Thus, in response to a change in interest income, banks made adjustments to labor with low average cost. Consequently, the elasticity of the number of employees increased but the total labor cost elasticity and the labor cost elasticity per employee decreased for banks exposed to the shale boom.

An alternative explanation for the reduction in cost elasticity observed in Table 3.1 could be that banks exposed to the shale boom prefer rigid cost structures in the post-shale development period. A rigid cost structure, i.e., a reduction in cost elasticity, helps firms to earn higher profits from favorable demand realizations. To gain better insights for the results from Table 3.1 and 4.1 and rule out this potential alternative explanation, I next examine dynamic labor adjustments undertaken by exposed banks during the post-shale development period. If banks exposed to the shale boom prefer rigid cost structures to capitalize on favorable demand outcomes, I should observe an increase in labor cost elasticity during the initial periods when banks add resources followed by a reduction in elasticity during the later periods when firms utilize the added resources. On the other hand, if managers were cautious during the initial periods of the shale boom, the labor cost elasticity should decrease during the initial periods and increase during the later periods when the banks face less uncertainty in the operating environment. Dynamic labor adjustments help to examine which of the abovementioned two explanations is appropriate. Table 5.1 presents the results for dynamic changes in labor cost and labor employee elasticity during the initial and later periods of the shale boom. I estimate the elasticities using equation (1) but replace the $Post_t$ indicator variable with 3 indicator variables to examine dynamic changes in elasticities. Columns (1) and (2) report the labor cost elasticities for exposed banks and non-exposed banks respectively while column (3) reports the difference. The results show that labor cost elasticities fall significantly ($p<0.05$) during the initial periods of the shale boom for exposed banks, as observed earlier in Table 3.1, whereas the difference in labor cost elasticity is insignificant for non-exposed banks. Therefore, exposed banks did not increase their labor cost in proportion to their increase in revenues. However, the difference in labor cost elasticity for exposed and non-exposed banks during the later periods of the shale boom is not significant. Additionally, the labor cost elasticity for the exposed banks is not significantly different from its labor cost elasticity during the pre-shale boom period. In short, the exposed banks' labor cost elasticity eventually reverts to the pre-shale boom level. Columns (4) and (5) report the labor employee elasticity for exposed banks and non-exposed banks respectively while column (6) reports the difference. The results show that the differences in labor employee elasticities are not significant during the initial periods of the shale boom and only become positive and significant during the later periods of the shale boom. The results suggest that exposed banks made adjustments to employee count in response to an increase in interest income only during the later periods of the shale boom. Further, the labor cost elasticity for exposed banks shows an increasing trend during the post-shale boom period, which also coincides with an increasing trend in labor employee elasticity for the exposed banks. Overall, the results indicate that exposed banks added more employees during the later periods of the shale boom, which also made labor cost more responsive to change in interest income.

I next examine the reasons for the differences in elasticities during the initial and later periods of the shale boom. As mentioned earlier, a reduction in labor cost elasticity during the initial periods of the shale boom is likely caused by an increase in interest income outpacing the increase in labor cost. A possible explanation is that banks increased the hours per employee or hired temporary employees rather than hiring more expensive full-time employees to meet the increase in operations. This choice of resource adjustment could be driven by managers' inability to determine whether the shale boom is transitory or persistent. To examine whether this is a possible explanation, I follow Bloom [2009] and compute the cross-sectional standard deviation of banks' pretax profit growth scaled by average interest income of current and previous year as a measure of uncertainty.[33] I find that the first three years after the shale boom are represented in the top quartile of the uncertainty measure.[34] Therefore, there is suggestive evidence that exposed banks increased labor adjustments during the post-shale boom period but only in the later periods when they were confident that the boom was persistent. Overall, results are consistent with the theoretical predictions of Grenadier and Malenko [2010] that uncertainty with respect to determining whether the past economic shock is transitory or persistent results in a delay in investment in response to a positive cash flow shock. Hence, I find support for H2.

Next, I examine the effect of the exposed bank's forecasting ability on its labor adjustments. Banks with greater forecasting ability are in a better position to gauge whether the shale boom is persistent or transitory and make speedier responses. I estimate equation (1) by including three $Post$ indicators which were included to test H2 and split the sample into banks with high forecasting ability and low forecasting ability. I use the ratio of charge offs in year $t+1$ to the allowance for loan and lease losses as a measure of bank's forecasting ability. Table 6.1 presents the labor employee elasticities for banks with high and low forecasting ability. Columns (1) to (3) provide the labor employee elasticity for banks with high forecasting ability and Columns (4) to (6) provide the labor employee elasticity for banks with low forecasting ability. Column (1) indicates that labor adjustments for exposed banks in response to change in interest income are significantly higher during years 3 and 4 on average after the shale boom than the pre-shale boom period. Additionally, Column (4) shows that labor adjustments for exposed banks in response to change in interest income are significantly higher only after 4 years after the shale boom than the pre-shale boom period. The results show that banks with high forecasting

[33] Pretax profit growth scaled by average interest income is winsorized at the 1% level.

[34] I recompute this measure by excluding years 2009 and 2010 to ensure that the measure does not capture the uncertainty around the financial crisis. Results continue to indicate that uncertainty was high during the first three years of the shale boom.

ability can better estimate the effect and magnitude of the shale boom and undertake labor adjustments during the post-shale development period earlier than banks with low forecasting ability. Overall, the results provide support for H3.

One concern with the above results is that banks could have faced competition from other industries or skilled employees were difficult to find in the short run. Therefore, delay in labor adjustments could be unrelated with uncertainty around the persistence of shale boom. In additional analyses, I use the Bureau of Labor Statistics (BLS) data on labor force and unemployed at the county-year level and aggregate them for all counties in which a bank has branches. I control for the unemployment rate computed using the aggregated labor force and unemployed in my analyses. The results are qualitatively similar and close to the estimates in Tables 3 to 6. Additionally, if labor supply was driving the results, then banks with better forecasting ability would not be able to undertake labor adjustments earlier than peer banks. Overall, the results indicate that labor adjustments made by bank managers are influenced by uncertainty in the operating environment.

Hypothesis 4: Effect of change in operating environment on bank's product diversity

In this section, I examine the product diversity changes. I estimate equation (2) and tabulate the results in Table 7.1. The models include bank and year fixed effects and cluster standard errors by bank. Columns (1) and (2) show that there is a significant reduction in product diversity for the exposed banks relative to non-exposed banks. However, the coefficient on $Exposed\ Bank_i \times Post_t \times Large\ Bank_i$ is not significant in Column (2) which means that there is no difference in product diversity changes between small and large banks exposed to shale boom. Overall, the results provide support for H4a and suggests that banks became less concerned about the downside risk and hence concentrate their focus on fewer loan products after the shale boom.

I examine at what period exposed banks reduce product diversity. If the banks were less concerned about downside risk, then the product diversity reduction should be higher during the later periods of the shale boom when uncertainty is relatively lower. I adopt a similar approach followed to test H2 i.e., I replace the indicator variable $Post_t$ with three indicator variables and estimate equation (2) with bank and year fixed effects, and cluster standard errors by bank. The results tabulated in Table 8.1 show that there is no significant difference in product diversity between exposed and non-exposed banks during the initial periods of the shale boom. However, the difference in product diversity is negative and significant ($p<0.01$) during the later periods of the shale boom. Additionally, I find that product diversity for the exposed banks during the later periods of the shale boom is lower than the product diversity during the initial two years of the shale boom. Thus, exposed banks reduce product diversity during the later periods of the shale boom when bank managers are more confident that the effects of the shale boom are likely to be persistent.

ROBUSTNESS TESTS

Parallel trends assumption

A necessary condition in difference-in-differences estimation is that in the absence of treatment, the difference between the treatment and control group is constant over time. This assumption implies that in the absence of the shale boom, the difference in labor cost, labor employee elasticity, and product diversity between exposed and non-exposed banks is constant over time (Cerulli and Ventura [2019]). This assumption cannot be directly tested and therefore I adopt multiple approaches to mitigate the concerns that the results are not confounded by difference in trends. First, estimating equation (1) and (2) by including bank fixed effects prevents any time invariant factors from affecting the labor cost, labor employee elasticity, or product diversity. Second, I graph the difference in labor cost elasticity, labor employee elasticity, and product diversity for exposed and non-exposed banks. Figure 3 shows that there is no significant difference in labor cost elasticity for exposed and non-exposed banks during the pre-shale boom period except for one year when the difference is marginally significant at the 5% level. The combined effect of all years in the pre-shale boom period is insignificant. Similarly, figures 4 and 5 reveal that there is no significant difference in labor employee elasticity or product diversity for exposed and non-exposed banks during the pre-shale boom period. Third, I estimate equation (1) by replacing the $Post_t$ indicator variable with year indicators and test whether the differences in labor cost elasticity, labor employee elasticity, and product diversity for exposed and non-exposed banks during the pre-shale boom period are jointly significant (Granger [1969]). The results (untabulated) indicate that differences in labor cost, labor employee elasticity, and product diversity are not jointly significant ($\chi^2(6) = 5.31, \mathrm{p} = 0.5042$ for labor cost elasticity; $\chi^2(6) = 3.09, \mathrm{p} = 0.7973$ for labor employee elasticity; and $\chi^2(6) = 7.74, p = 0.2575$ [35] Therefore, there is no indication of differences in trends for the variables of interest between the exposed and non-exposed banks prior to the shale boom.

Comparing short run and long run labor elasticity

The baseline results for labor cost elasticity and labor employee elasticity in Table 3.1, Column 5 and Table 4.1, Column 4 show that labor cost elasticity is significantly higher compared to labor employee elasticity (0.681 in the pre-shale boom period for labor cost and 0.204 for employees), which is consistent with the results in prior literature (e.g., Banker et al. [2014]).[36] The labor cost and labor employee elasticity imply that labor is a quasi-fixed resource in the banking industry in the short run. I examine the long-run elasticity using a log-level model and estimate equation (1) (Noreen and Soderstrom [1994]). I find that long-run elasticity for labor costs or employees are almost identical (0.83 for labor cost and 0.86 for employees) (Untabulated). Further, the results show that labor cost elasticity does not decrease for the exposed banks relative to non-exposed banks after the shale development, but labor employee elasticity does increase. These results are consistent with the overall hypothesis that in the post-shale development period, the exposed banks hired more employees to accommodate the increase in operations. Increasing the hours per employee and hiring temporary labor to adjust for an increase in operations is not sustainable and likely to be reversed in the long run. Therefore, it is important to study the short-run elasticity to gain insights on resource adjustments of firms from one steady state before the change in operating environment to another steady state after such a change.

[35] The results are similar if the analysis is restricted to only three years before the shale boom.
[36] The difference between labor cost elasticity and labor employee elasticity in my analyses is larger compared to the results in Banker et al. [2014]. This difference is possibly driven by large variation in the skill of employees in a banking industry compared to a manufacturing industry.

Additional tests

The exposed and non-exposed banks were identified based on the location of majority of branches in a shale county. It is possible that some exposed banks are not significantly affected by the shale boom whereas some non-exposed banks are significantly affected by the shale boom. To address this concern, I undertake two additional analyses. First, I estimate equations (1) and (2) by replacing the exposed bank variable with a continuous measure based on the proportion of total bank branches that are in counties exposed to the shale boom. The *exposure* variable is 0 for all banks before the onset of shale boom and takes the value between 0 to 1 depending on the proportion of branches in shale counties. The advantage of using this measure is that it is less restrictive and allows heterogeneous effects based on a bank's exposure to the shale boom. The results are qualitatively similar for all dependent variables (untabulated). Second, I estimate equation (1) by splitting the sample and analyze labor adjustments of exposed banks in single county and multiple counties. I include bank and year fixed effects and cluster the standard errors by bank. The results for labor cost and labor employee elasticity for banks operating in multiple counties and single counties are shown in Table 9.1. Columns (1) and (2) show the labor cost elasticity for banks operating in multiple counties and a single county respectively whereas Columns (3) and (4) show the labor employee elasticity for banks operating in multiple counties and a single county respectively. The results indicate that single county banks exposed to the shale boom reduced labor cost elasticity but did not change labor employee elasticity compared to single county banks not exposed to the shale boom.[37] A possible explanation is that single county banks can adjust labor by increasing the hours per employee to

[37] In the analyses related to single county banks one could argue that standard errors should be clustered at the county level (Abadie et al. [2017]). Accordingly, I also estimate equation (1) for the sub-sample of single county banks in Table 9.1 and 10.1 by clustering the standard errors at the county level and find consistent results (untabulated).

accommodate the spike in operations. On the other hand, exposed banks operating in multiple counties do not have a reduction in labor cost elasticity relative to non-exposed banks but have an increase in labor employee elasticity. Exposed banks operating in multiple counties are likely to hire more employees, which makes the labor employee elasticity more responsive to interest changes in the post-shale boom period. As a result, their labor cost elasticity keeps pace with the increase in interest income and does not show a decline in the post-shale boom period.

I further analyze banks operating in a single county by splitting them into banks with high market share and banks with low market share. I determine high market share based on a median split of proportion of deposits of bank in the county in which the bank is operating. The results tabulated in Table 10.1 indicate that exposed banks with low market share reduce labor cost elasticity relative to non-exposed banks whereas banks with high market share increase labor employee elasticity relative to non-exposed banks. Taken together, the results suggest that exposed banks with high market share adjust labor to accommodate the increase in revenues from the shale boom. On the other hand, exposed banks located in a single county with a low market share do not adjust labor in response to the shale boom. Thus, these banks are likely adjusting hours per employee or hiring temporary labor to accommodate the increase in operations.

CONCLUSION

In this study, I examine the effect of an unexpected positive change in operating environment on firm's operating decisions. I use the banks exposed to the shale boom as a setting to study firms' responses to such changes. Specifically, I investigate labor adjustment and product mix decisions in response to an unexpected change in operating environment that increases firms' revenues. Decisions surrounding an unexpected economic boom are challenging because of the difficulty in forecasting whether the change in operating environment is transitory or persistent. Conversely, managers can forecast the demand with reasonable accuracy during the ordinary course of business. Therefore, unfamiliarity with the operating environment is likely to cause managerial responses to differ from their responses to sales increases during normal business cycles.

I find that relative to the pre-shale boom period, banks exposed to the shale boom adjust employee cost. However, these adjustments occur during the later periods of the boom when there is less uncertainty about the persistence of the boom. In the initial periods, banks make adjustments to hours per employee or hire temporary labor. As a result, the increase in interest income outpaces the increase in labor cost, which reduces labor cost elasticity but does not impact labor employee elasticity. I further examine whether banks with superior forecasting ability are able to resolve the uncertainty around the persistence of the shale boom and undertake labor adjustment decisions earlier than other banks. The results provide evidence for earlier adjustment by banks with high forecasting ability. I also examine product mix changes by exposed banks in response to the shale boom and find that banks reduce product diversity. A reduced downside risk allows banks to focus on fewer products and maintain their profitability. The results show that exposed banks reduce product diversity, and this reduction happens during the later periods of the shale boom when bank managers are likely to be more confident that the change in operating environment is persistent. Overall, resource adjustment and product mix decisions are dynamic in nature contingent on the operating environment.

I contribute by showing that a change in operating environment has a differential response during the initial and later periods of such change. In the initial periods, firms are likely to adjust resources with low adjustment costs, whereas in the long-term firms alter resources with higher adjustment costs. These responses are driven by uncertainty arising from difficulty to assess whether the change is transitory or persistent. The internal information environment also plays an important role in an early resolution of uncertainty and enables managers to stabilize their cost structures earlier rather than later.

APPENDICES

APPENDIX A

Variable Definitions

Variable Definitions

Dependent Variables	
$\Delta \log labor\ cost\ def_{it}$	Log-change in labor cost deflated by average consumer price index of bank i from year $t-1$ to year t
$\Delta \log labor\ cost\ per\ emp_{it}$	Log-change in labor cost per full-time equivalent employee deflated by average consumer price index of bank i from year $t-1$ to year t
$\Delta \log employees_{it}$	Log-change in number of full-time equivalent employees of bank i from year $t-1$ to year t
$Product\ diversity_{it}$	Logarithm of sum of the squares of consumer loans, real estate loans, and commercial and industrial loans as a proportion of gross loans for bank i in year t. This measure is multiplied by -1 to convert the index into a positive number.
Explanatory Variables	
$\Delta \log interest\ income_{it}$	Log-change in the total interest income of bank i from year $t-1$ to year t
$Branches_{it}$	Number of branches of bank i as on June 30 of year t (SOD)
$Exposed\ Bank_i$	Indicator variable equal to 1 for bank i with majority of branches in counties identified as exposed to the shale boom within a play state and 0 otherwise. This variable is computed based on the number of branches in the first year when significant fracking activity began in each of the play state. Branch location is identified from FDIC Summary of Deposits database
$Post_t$	Indicator variable equal to 1 for all years once significant fracking activity began in state s. The year when significant fracking activity began is established based on (Bartik et al. [2019]; Gilje et al. [2016]; Stuber [2019]) as follows: Marcellus (2007), Bakken (2007), Andarko (2008), Haynesville (2008), Niobrara (2010), and Utica (2011).
$Large\ Bank_i$	Indicator variable equal to 1 if a bank has total assets greater than 500 million and 0 otherwise. This criterion is applied for a bank i one year before significant fracking activity began in a shale play state.
Controls	
$Asset\ intensity_{it}$	The ratio of non-financial assets (Property, equipment, furniture and fixtures) to interest income for bank i in year t
$Employee\ intensity_{it}$	The ratio of number of employees to interest income for bank i in year t
$\log assets_{i,t-1}$	Log of total assets of bank i at the beginning of year t
$\Delta\ FFRLNS_{it}$	Following Hall (2016), $FFRLNS_{it}$ is computed as average federal funds rate multiplied by total loans at the beginning of year t, where the average federal funds rate is computed as the federal funds rate in January and federal funds rate in December of year t divided by 2. $\Delta\ FFRLNS_{it}$ is computed as the change in FFRLNS of bank i from year $t-1$ to year t
$\Delta \log deposits_{it}$	Log-change in total deposits of bank i from year $t-1$ to year t

$Liquidity_{i,t-1}$	Total cash and cash equivalents scaled by total assets of bank i at the beginning of year t
High Forecasting Quality	Indicator variable equal to 1 if the ratio of charge offs in *t+1* to allowance for loan and lease losses in year *t* for bank *i* is greater than or equal to 0.32 and less than 1.68 and 0 otherwise. 0.32 is the 75^{th} percentile for the ratio in the sample
Single County Bank	An indicator equal to 1 if the bank branches are in a single county
High Market Share	An indicator equal to 1 if the market share for single county bank is above the median market share. Market share is computed as the ratio of total deposits of a bank i located in county j in year t to the total deposits of county j in year t

APPENDIX B

Tables

TABLE 1.1: SHALE-BOOM EXPOSED BANKS AND GROWTH IN DEPOSITS AND INCOME

This table reports the estimation from OLS regressions on the growth in deposits and interest income for the period 2005-2014. The dependent variable is log of deposits for bank i in year t in column (1) and log of interest income for bank i in year t in column (2). Column (1) estimates the growth in deposits while column (2) estimates the growth is in interest income for banks exposed to the shale boom. The constant is not reported because it does not have an economic interpretation. Year and bank fixed effects are included, and standard errors are clustered by bank and reported in parenthesis. $Exposed\ Bank_i$ is measured at the bank level and is time invariant, its coefficient is absorbed by bank fixed effects. Year indicators are relative to the onset of boom and therefore the coefficient on $Post_t$ is absorbed by year fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Variables	(1) log $deposits_{it}$	(2) log $interest\ income_{it}$
$\boldsymbol{Exposed\ Bank_i \times Post_t}$	**0.040*** **	**0.031*** **
	(0.007)	**(0.009)**
$log\ assets_{i,t-1}$	0.781***	0.918***
	(0.013)	(0.013)
$Liquidity_{i,t-1}$	−0.131***	−0.824***
	(0.037)	(0.040)
$Product\ diversity_{i,t-1}$	−0.002	0.001
	(0.010)	(0.012)
Observations	14,929	14,929
Within R−squared	0.800	0.649
Bank Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
SE clustered by	Bank	Bank

TABLE 1.2: SAMPLE CONSTRUCTION

This table presents the details of sample construction. The primary sample is constructed by merging the bank regulatory Call Report database with Federal Deposit Insurance Corporation (FDIC) Summary of Deposits (SOD) database to identify the branch locations. The 79,072 Regulatory Filings for 2005-2014 represent all banks identified as main office in SOD database.

Regulatory Filings 2005-2014 for banks identified as main office in SOD database	79,072
Less: Drop banks in top 1% of assets	(791)
Less: Bank-years with missing data for salaries or interest income either in current or previous year	(17,797)
Less: Bank-years with salaries greater than interest income either in current or previous year	(2,571)
Less: Eliminate banks outside the play-state	(41,964)
Less: Eliminate bank-years with salaries and interest income in top and bottom 1 percentile	(430)
Less: Eliminate observations with missing data	(581)
Less: Eliminate bank-years that had a mismatch between change in salaries and change in number of employees or changes affected by merger	(9)
Total number of bank-year observations	14,929
Total number of unique banks	1,657

TABLE 2.1: DESCRIPTIVE STATISTICS

All continuous variables except labor cost and interest income are winsorized at 1 and 99 percentiles. Labor cost and interest income are trimmed at 1 and 99 percentiles before constructing this sample.

Variables	N	Mean	Std Dev	p25	p50	p75	min	max
Labor cost (000s)	14,929	4,007.012	6,484.451	954.000	2,005.000	4,090.000	213.000	67,983.000
Labor cost def	14,929	1,841.825	2,968.441	441.239	930.781	1,867.617	90.818	34,456.730
$\Delta \log labor\ cost\ def_{it}$	14,929	0.030	0.156	−0.024	0.017	0.065	−2.517	2.621
$Employees_{it}$	14,929	67.770	95.447	17.000	36.000	73.000	5.000	606.000
$\Delta \log employees_{it}$	14,929	0.020	0.130	−0.030	0.000	0.053	−1.591	2.015
$\Delta \log labor\ cost\ per\ emp_{it}$	14,929	0.010	0.147	−0.039	0.010	0.057	−2.567	2.804
Interest income (000s)	14,929	13,204.940	21,808.200	3,085.000	6,417.000	13,503.000	587.000	236,489.000
$\Delta \log interest\ income_{it}$	14,929	0.028	0.176	−0.057	0.010	0.095	−2.612	3.063
$Exposed\ Bank_i$	14,929	0.261	0.439	0.000	0.000	1.000	0.000	1.000
$Post_{st}$	14,929	0.606	0.489	0.000	1.000	1.000	0.000	1.000
$Asset\ intensity_{it}$	14,929	0.379	0.285	0.171	0.320	0.514	0.009	1.636
$Employee\ intensity_{it}$	14,929	5.867	2.044	4.470	5.670	7.002	1.820	12.526
Average fed funds rate	14,929	1.620	1.899	0.110	0.140	3.285	0.090	4.770
$FFRLNS_{it}$(000s)	14,929	239,772.200	719,321.200	8,050.035	32,222.970	183,759.600	277.725	13,900,000.000
$\Delta\ FFRLNS_{it}$	14,929	0.038	0.625	−0.191	−0.040	0.202	−0.962	11.789
Assets (000s)	14,929	275,299.400	470,866.200	63,446.000	131,068.000	277,751.000	10,152.000	5,720,415.000
$\log assets_{it}$	14,929	11.853	1.094	11.058	11.783	12.534	9.225	15.560
Deposits (000s)	14,929	215,637.900	318,452.500	53,044.000	109,455.000	229,677.000	13,240.000	2,012,555.000

TABLE 2.1 (cont'd)

$\log deposits_{it}$	14,929	11.659	1.072	10.879	11.603	12.344	9.491	14.515
$\Delta \log deposits_{it}$	14,929	0.059	0.123	0.000	0.044	0.096	−1.363	1.921
$Product\ diversity_{it}$	14,929	0.753	0.599	0.328	0.593	1.018	0.002	2.666
$Large\ bank_{i}$	14,929	0.108	0.310	0.000	0.000	0.000	0.000	1.000
$Liquidity_{i,t-1}$	14,929	0.067	0.062	0.028	0.045	0.082	0.007	0.373
$Branches_{it}$	14,929	5.470	6.941	2.000	3.000	6.000	1.000	44.000

TABLE 2.2: CORRELATIONS

This table presents the Pearson correlations among the variables used in analyses. Numbers in shaded boxes represent significant correlations at 10% level.

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1)	$\Delta \log labor\ cost\ def_{it}$	1.000														
(2)	$\Delta \log interest\ income_{it}$	0.681	1.000													
(3)	$Employees_{it}$	0.082	0.040	1.000												
(4)	$\Delta \log employees_{it}$	0.483	0.356	0.102	1.000											
(5)	$Exposed\ Bank_{i}$	−0.009	0.003	0.010	−0.006	1.000										
(6)	$Post_{st}$	−0.022	−0.296	0.035	−0.047	0.055	1.000									
(7)	$Asset\ intensity_{it}$	−0.020	−0.069	0.101	0.045	−0.013	0.124	1.000								
(8)	$Employee\ intensity_{it}$	−0.075	−0.161	−0.016	0.046	0.029	0.119	0.394	1.000							
(9)	$\Delta FFRLNS_{it}$	0.092	0.435	0.010	0.098	0.004	−0.413	−0.026	0.012	1.000						
(10)	$\log assets_{it}$	0.089	0.029	0.774	0.103	0.040	0.121	0.112	−0.224	−0.029	1.000					
(11)	$\Delta \log deposits_{it}$	0.397	0.481	0.069	0.514	0.025	−0.047	0.035	−0.053	0.092	0.107	1.000				
(12)	$Product\ diversity_{it}$	0.005	0.045	−0.197	−0.021	−0.069	−0.017	−0.237	0.034	0.030	−0.373	0.040	1.000			
(13)	$Large\ Bank_{i}$	0.040	0.029	0.732	0.049	−0.007	−0.018	−0.005	−0.134	0.024	0.620	0.044	−0.164	1.000		
(14)	$Liquidity_{it}$	−0.037	−0.106	−0.157	−0.057	−0.037	0.201	0.013	0.210	−0.068	−0.220	−0.102	0.084	−0.129	1.000	
(15)	$Branches_{it}$	0.046	0.010	0.925	0.042	0.006	0.046	0.127	0.012	−0.005	0.736	0.032	−0.197	0.688	−0.146	1.000

TABLE 2.3: DIFFERENCE IN MEANS

This table presents the differences in means for banks exposed to the shale boom and banks not exposed to the shale boom. Column (2) to (4) presents the mean and difference in mean for average deflated labor cost per branch. Column (5) to (7) computes the mean and difference in mean for interest income deflated per employee. Column (8) to (10) computes the mean and difference in mean for log deposits.

Year	Average deflated labor cost per branch			Interest Income deflated per employee			log deposits		
(1)	Exposed Banks (2)	Non−Exposed Banks (3)	Diff (4)	Exposed Banks (5)	Non−Exposed Banks (6)	Diff (7)	Exposed Banks (8)	Non−Exposed Banks (9)	Diff (10)
	Mean	Mean		Mean	Mean		Mean	Mean	
Before the shale boom	11.880	12.724	−0.843**	101.255	101.285	−0.030	11.553	11.465	0.088***
First two years	11.452	12.050	−0.598	95.809	92.069	3.740*	11.672	11.633	0.039
Next two years	11.829	11.896	−0.067	86.240	83.314	2.927	11.815	11.733	0.083*
After 4 years	11.917	11.060	0.857**	79.134	75.428	3.704***	11.975	11.881	0.093**

TABLE 3.1: DIFFERENCE IN LABOR COST ELASTICITY FOR SHALE BOOM EXPOSED BANKS

This table reports the estimation from OLS regression on the cost elasticity for the period 2005-2014. The dependent variable is log-change in deflated labor cost from year t-1 to t. All the columns estimate the change in cost elasticity for all banks in the sample. Columns (1) to (4) do not include any control variable whereas column (5) includes control variables. Column (2) includes state fixed effects, column (3) includes county fixed effects and columns (4) and (5) include bank fixed effects. Year fixed effects are included in all columns, and standard errors are clustered by bank and reported in parenthesis. $Exposed\ Bank_i$ is measured at the bank level and its coefficient is absorbed by bank fixed effects in columns (4) and (5). Year indicators are relative to the onset of boom and therefore the coefficient on $Post_t$ is absorbed by year fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Variables	$\Delta \log labor\ cost\ def_{it}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta \log interest\ income_{it}$	0.598***	0.630***	0.620***	0.614***	0.681***
	(0.046)	(0.046)	(0.051)	(0.054)	(0.048)
$Exposed\ Bank_i$	−0.011**	−0.010*	−0.004		
	(0.006)	(0.005)	(0.010)		
$\Delta \log interest\ income_{it} \times Exposed\ Bank_i$	−0.037	−0.029	−0.037	−0.055	−0.007
	(0.074)	(0.068)	(0.076)	(0.087)	(0.064)
$\Delta \log interest\ income_{it} \times Post_t$	0.162***	0.131**	0.139**	0.144**	0.062
	(0.054)	(0.054)	(0.058)	(0.063)	(0.044)
$Exposed\ Bank_i \times Post_t$	−0.003	−0.003	−0.004	−0.008	−0.009
	(0.007)	(0.006)	(0.007)	(0.008)	(0.007)
$\boldsymbol{\Delta \log interest\ income_{it} \times Exposed\ Bank_i \times Post_t}$	**−0.189****	**−0.194****	**−0.191***	**−0.200***	**−0.180****
	(0.095)	**(0.091)**	**(0.099)**	**(0.108)**	**(0.084)**
$Asset\ intensity_{it}$					−0.014
					(0.011)
$\Delta \log interest\ income_{it} \times Asset\ intensity_{it}$					0.046
					(0.036)
$Employee\ intensity_{it}$					0.023***
					(0.002)
$\Delta \log interest\ income_{it} \times Employee\ intensity_{it}$					0.013***
					(0.004)
$\Delta\ FFRLNS_{it}$					−0.056***
					(0.005)
$log\ assets_{i,t-1}$					0.053***
					(0.009)
$\Delta \log deposits_{it}$					0.042**
					(0.020)
Observations	14,929	14,929	14,929	14,929	14,929
Within R−squared	0.515	0.522	0.510	0.490	0.547
Fixed Effects	Year	Year, State	Year, County	Year, Bank	Year, Bank
SE clustered by	Bank	Bank	Bank	Bank	Bank

TABLE 4.1: DIFFERENCE IN LABOR COST ELASTICITY PER EMPLOYEE AND NUMBER OF EMPLOYEES ELASTICITY FOR SHALE BOOM EXPOSED BANKS

This table reports the estimation from OLS regression on the labor cost per employee elasticity and labor employee elasticity for the period 2005-2014. The dependent variable in column (1) and (2) is log change in labor cost per employee from year t-1 to t and the dependent variable in column (3) and (4) is log-change in number of employees from year t-1 to t. Column (1) and (2) estimate the change in labor cost per employee elasticity whereas column (3) and (4) estimate the change in labor employee elasticity after the shale boom for all banks in the sample. County and year fixed effects are included in column (1) and (3) whereas bank and year fixed effects are included in column (2) and (4). $Exposed\ Bank_i$ is measured at the bank level and its coefficient absorbed by bank fixed effects in column (2) and (4). Year indicators are relative to the onset of boom and therefore the coefficient on $Post_t$ is absorbed by year fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Variables	$\Delta \log labor\ cost\ per\ emp_{it}$		$\Delta \log employees_{it}$	
	(1)	(2)	(3)	(4)
$\Delta \log interest\ income_{it}$	0.505***	0.479***	0.142***	0.204***
	(0.054)	(0.055)	(0.026)	(0.030)
$Exposed\ Bank_i$	−0.011		0.010	
	(0.009)		(0.010)	
$\Delta \log interest\ income_{it} \times Exposed\ Bank_i$	0.045	0.031	−0.046	−0.039
	(0.070)	(0.074)	(0.046)	(0.050)
$\Delta \log interest\ income_{it} \times Post_t$	0.078	0.081	0.001	−0.021
	(0.055)	(0.059)	(0.032)	(0.039)
$Exposed\ Bank_i \times Post_t$	−0.004	−0.010	−0.003	0.002
	(0.007)	(0.007)	(0.005)	(0.009)
$\boldsymbol{\Delta \log interest\ income_{it} \times Exposed\ Bank_i \times Post_t}$	**−0.304****	**−0.326*****	**0.120****	**0.146****
	(0.083)	**(0.087)**	**(0.061)**	**(0.065)**
$Asset\ intensity_{it}$	0.008*	0.037***	−0.016***	−0.052***
	(0.005)	(0.011)	(0.005)	(0.012)
$\Delta \log interest\ income_{it} \times Asset\ intensity_{it}$	0.033	0.040	0.017	0.005
	(0.023)	(0.026)	(0.018)	(0.027)
$Employee\ intensity_{it}$	−0.007***	−0.021***	0.014***	0.045***
	(0.001)	(0.002)	(0.001)	(0.003)
$\Delta \log interest\ income_{it} \times Employee\ intensity_{it}$	0.005	0.001	0.001	0.012***
	(0.003)	(0.003)	(0.002)	(0.003)
$\Delta\ FFRLNS_{it}$	−0.038***	−0.029***	−0.008**	−0.027***
	(0.006)	(0.006)	(0.003)	(0.003)
$log\ assets_{i,t-1}$	−0.001	−0.022**	0.009***	0.076***
	(0.001)	(0.011)	(0.001)	(0.011)
$\Delta \log deposits_{it}$	−0.365***	−0.337***	0.429***	0.378***
	(0.032)	(0.030)	(0.026)	(0.024)
Observations	14,929	14,929	14,929	14,929
Within R−squared	0.336	0.350	0.288	0.331
Fixed Effects	County, Year	Bank, Year	County, Year	Bank, Year
SE clustered by	Bank	Bank	Bank	Bank

TABLE 5.1: SHALE BOOM EXPOSED BANKS AND DYNAMIC CHANGES IN LABOR COST AND LABOR EMPLOYEE ELASTICITY

This table reports the marginal effects of the dynamic changes in labor cost elasticity and labor employee elasticity estimated from OLS regression for the period 2005-2014. The dependent variable for columns (1) to (3) is log change in deflated labor cost from year t-1 to t. Column (1) and (2) estimates the labor cost elasticity before and after the shale boom for banks exposed to the shale boom and banks not exposed to the shale boom respectively whereas column (3) measures the difference in columns (1) and (2). The dependent variable for columns (4) to (6) is log-change in number of employees from year t-1 to t. Column (4) and (5) estimates the labor employee elasticity before and after the shale boom for banks exposed to the shale boom and banks not exposed to the shale boom respectively whereas column (6) measures the difference in columns (4) and (5). Bank and year fixed effects are included. All control variables from Table 3.1 are included but not reported for brevity. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	$\Delta \log labor\ cost\ def_{it}$			$\Delta \log employees_{it}$		
VARIABLES	Exposed Banks	Non−Exposed Banks	Difference	Exposed Banks	Non−Exposed Banks	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log interest\ income_{it}$						
Before the shale boom	0.658***	0.670***	−0.012	0.159***	0.197***	−0.038
	(0.063)	(0.043)	(0.065)	(0.046)	(0.029)	(0.050)
First two years in the shale boom	0.441***	0.707***	−0.266***	0.233***	0.170***	0.063
	(0.058)	(0.060)	(0.075)	(0.043)	(0.029)	(0.049)
Next two years in the shale boom	0.523***	0.730***	−0.208**	0.321***	0.229***	0.092
	(0.079)	(0.054)	(0.093)	(0.060)	(0.049)	(0.076)
After four years (Long run effect of the shale boom)	**0.688*** **	**0.797*** **	**−0.109**	**0.330*** **	**0.178*** **	**0.152** **
	(0.104)	**(0.033)**	**(0.107)**	**(0.054)**	**(0.053)**	**(0.071)**
Difference in elasticity 4 years after and before the shale boom	**0.029**	**0.126** **	**−0.097**	**0.171** **	**−0.018**	**0.190** **
	(0.118)	**(0.050)**	**(0.122)**	**(0.071)**	**(0.059)**	**(0.087)**
Controls		Yes			Yes	
Observations		14,929			14,929	
Within R−squared		0.550			0.332	
Bank Fixed Effects		Yes			Yes	
Year Fixed Effects		Yes			Yes	
SE clustered by		Bank			Bank	

TABLE 6.1: SHALE BOOM EXPOSED BANKS, FORECASTING QUALITY, AND DYNAMIC CHANGES IN LABOR EMPLOYEE ELASTICITY

This table reports the marginal effects of the dynamic changes in labor employee elasticity estimated for banks with high forecasting quality and low forecasting quality from OLS regression for the period 2005-2014. The dependent variable for columns (1) to (6) is log change in number of employees from year t-1 to t. Column (1) and (2) estimates the number of employees elasticity before and after the shale boom for banks exposed to the shale boom and banks not exposed to the shale boom respectively for banks with high forecasting quality whereas column (3) measures the difference in columns (1) and (2). Column (4) and (5) estimates the labor employee elasticity before and after the shale boom for banks exposed to the shale boom and banks not exposed to the shale boom respectively for banks with low forecasting quality whereas column (6) measures the difference in columns (4) and (5). Bank and year fixed effects are included. All control variables from Table 4.1 are included but not reported for brevity. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	$\Delta \log employees_{it}$			$\Delta \log employees_{it}$		
VARIABLES	Exposed Banks	Non−Exposed Banks	Difference	Exposed Banks	Non−Exposed Banks	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log interest\ income_{it}$						
Before the shale boom	0.225***	0.296***	−0.071	0.151**	0.192***	−0.041
	(0.062)	(0.058)	(0.076)	(0.062)	(0.035)	(0.065)
First two years in the shale boom	0.306**	0.193***	0.113	0.208***	0.138***	0.070
	(0.122)	(0.072)	(0.137)	(0.047)	(0.039)	(0.055)
Next two years in the shale boom	0.460***	0.282***	0.178	0.287***	0.197***	0.090
	(0.123)	(0.067)	(0.131)	(0.071)	(0.054)	(0.076)
After four years (Long run effect of the shale boom)	0.342***	0.196*	0.146	0.328***	0.179***	0.149*
	(0.087)	(0.106)	(0.121)	(0.062)	(0.067)	(0.084)
Difference in elasticity 4 years after and before the shale boom	0.117	−0.100	0.217	**0.177****	**−0.014**	**0.191***
	(0.095)	(0.108)	(0.138)	**(0.089)**	**(0.072)**	**(0.106)**
Difference in elasticity next two years in the shale boom and before the shale boom	**0.235***	**−0.014**	**0.249***	0.136	0.004	0.132
	(0.131)	**(0.073)**	**(0.146)**	(0.092)	(0.062)	(0.110)
Difference in elasticity first two years in the shale boom and before the shale boom	0.081	−0.103	0.184	0.057	−0.054	0.111
	(0.129)	(0.083)	(0.152)	(0.074)	(0.046)	(0.086)
Controls		Yes			Yes	
Observations		3,420			11,509	
Within R−squared		0.352			0.322	
Bank Fixed Effects		Yes			Yes	
Year Fixed Effects		Yes			Yes	
SE clustered by		Bank			Bank	

TABLE 7.1: SHALE BOOM EXPOSED BANKS AND PRODUCT DIVERSITY

This table reports the estimation results on product diversity for the period 2005-2014. The estimation for product diversity is obtained from OLS regression. The dependent variable in column (1) and (2) is the product diversity of bank in year t. Column (1) and (2) estimate the difference in product diversity for exposed and non-exposed banks. Column (2) estimates the heterogenous effect of the shale boom on product diversity for large and small banks. Year and bank fixed effects are included, and standard errors are clustered by bank and reported in parenthesis. $Exposed\ Bank_i$, $Large\ bank_i$, and $Exposed\ Bank_i \times Large\ bank_i$ are measured at the bank level and are time invariant, their coefficient is absorbed by bank fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) $Product\ diversity_{it}$	(2) $Product\ diversity_{it}$
$\log interest\ income_{it}$	−0.023	−0.023
	(0.031)	(0.031)
$\boldsymbol{Exposed\ Bank_i \times Post_t}$	**−0.023****	**−0.025****
	(0.011)	**(0.012)**
$Large\ bank_i \times Post_t$		0.029**
		(0.011)
$\boldsymbol{Exposed\ Bank_i \times Post_t \times Large\ bank_i}$		**0.022**
		(0.023)
$Asset\ intensity_{it}$	−0.055***	−0.056***
	(0.017)	(0.017)
$Employee\ intensity_{it}$	0.001	0.001
	(0.004)	(0.004)
$\Delta\ FFRLNS_{it}$	0.009***	0.009***
	(0.003)	(0.003)
$log\ assets_{i,t-1}$	−0.058**	−0.059**
	(0.026)	(0.026)
$\Delta \log deposits_{it}$	−0.013	−0.011
	(0.025)	(0.025)
$Liquidity_{i,t-1}$	0.025	0.029
	(0.076)	(0.076)
Observations	14,929	14,929
Within R−squared	0.090	0.091
Bank Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
SE clustered by	Bank	Bank

TABLE 8.1: SHALE BOOM EXPOSED BANKS AND DYNAMIC CHANGES IN PRODUCT DIVERSITY

This table reports the marginal effects of the dynamic changes in product diversity estimated from OLS regression for the period 2005-2014. The dependent variable for columns (1) to (3) is Product diversity for bank i in year t. Column (1) and (2) estimates the product diversity before and after the shale boom for banks exposed to the shale boom and banks not exposed to the shale boom respectively whereas column (3) measures the difference in columns (1) and (2). Bank and year fixed effects are included. The marginal effect for product diversity before the shale boom is absorbed by bank fixed effects. All control variables from Table 5.1 are included but not reported for brevity. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	Product diversity$_{it}$		
VARIABLES	Exposed Banks	Non−Exposed Banks	Difference
	(1)	(2)	(3)
Before the shale boom	Absorbed by Bank fixed effects		
First two years in the shale boom (a)	0.752***	0.755***	−0.003
	(0.008)	(0.002)	(0.010)
Next two years in the shale boom	0.738***	0.751***	−0.013
	(0.011)	(0.004)	(0.013)
After four years (b) (Long run effect of the shale boom)	0.681***	0.738***	−0.057***
	(0.014)	(0.008)	(0.015)
(b) – (a)	**−0.071*** **	**−0.017**	**−0.054*** **
	(0.015)	**(0.010)**	**(0.015)**
Controls	Yes		
Observations	14,929		
Within R−squared	0.093		
Bank Fixed Effects	Yes		
Year Fixed Effects	Yes		
SE clustered by	Bank		

TABLE 9.1: SHALE BOOM EXPOSED BANKS, GEOGRAPHICAL MARKETS, AND DIFFERENCE IN COST AND LABOR EMPLOYEE ELASTICITY

This table reports the estimation from OLS regression on the cost elasticity and labor employee elasticity for the period 2005-2014. For Columns (1) and (2), the dependent variable is log-change in deflated labor cost from year t-1 to t. Columns (3) and (4), the dependent variable is log-change in employees from year t-1 to t. Column (1) and (3) estimate the change in cost elasticity and labor employee elasticity for banks operating in multiple counties. Column (2) and (4) estimate the change in cost elasticity and labor employee elasticity for banks operating in single county. Bank and year fixed effects are included, and standard errors are clustered by bank and reported in parenthesis. $Exposed\ Bank_i$ is measured at the bank level and its coefficient is absorbed by bank fixed effects. Year indicators are relative to the onset of the boom and therefore the coefficient on $Post_t$ is absorbed by year fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Variables	$\Delta \log labor\ cost\ def_{it}$		$\Delta \log employees_{it}$	
	(1)	(2)	(3)	(4)
	Multiple Counties	Single County	Multiple Counties	Single County
$\Delta \log interest\ income_{it}$	0.683***	0.662***	0.243***	0.222***
	(0.053)	(0.073)	(0.046)	(0.034)
$\Delta \log interest\ income_{it} \times Exposed\ Bank_i$	−0.040	0.057	−0.076	−0.017
	(0.058)	(0.114)	(0.065)	(0.058)
$\Delta \log interest\ income_{it} \times Post_t$	0.045	0.077	−0.003	−0.080*
	(0.056)	(0.092)	(0.060)	(0.048)
$Exposed\ Bank_i \times Post_t$	−0.012	−0.003	−0.001	0.008
	(0.008)	(0.010)	(0.008)	(0.009)
$\boldsymbol{\Delta \log interest\ income_{it} \times Exposed\ Bank_i \times Post_t}$	**−0.032**	**−0.374****	**0.214****	**0.112**
	(0.084)	**(0.146)**	**(0.089)**	**(0.075)**
$Asset\ intensity_{it}$	−0.049***	0.002	−0.094***	−0.010
	(0.016)	(0.012)	(0.019)	(0.015)
$\Delta \log interest\ income_{it} \times Asset\ intensity_{it}$	0.051	0.054	−0.034	0.052*
	(0.054)	(0.045)	(0.052)	(0.032)
$Employee\ intensity_{it}$	0.029***	0.019***	0.050***	0.045***
	(0.002)	(0.003)	(0.004)	(0.004)
$\Delta \log interest\ income_{it} \times Employee\ intensity_{it}$	0.012	0.011**	0.014**	0.012***
	(0.008)	(0.004)	(0.006)	(0.004)
$\Delta\ FFRLNS_{it}$	−0.059***	−0.051***	−0.035***	−0.025***
	(0.006)	(0.007)	(0.005)	(0.004)
$log\ assets_{i,t-1}$	0.043***	0.077***	0.070***	0.147***
	(0.012)	(0.020)	(0.014)	(0.020)
$\Delta \log deposits_{it}$	0.074***	0.006	0.423***	0.293***
	(0.028)	(0.020)	(0.033)	(0.035)
Observations	7,707	7,222	7,707	7,222
Within R−squared	0.536	0.548	0.389	0.293
Fixed Effects	Year, Bank	Year, Bank	Year, Bank	Year, Bank
SE clustered by	Bank	Bank	Bank	Bank

TABLE 10.1: SHALE BOOM EXPOSED BANKS, MARKET SHARE, AND DIFFERENCE IN COST AND LABOR EMPLOYEE ELASTICITY

This table reports the estimation from OLS regression on the cost elasticity and labor employee elasticity for the period 2005-2014 for the sub-sample of banks operating in a single county. For Columns (1) and (2), the dependent variable is log-change in deflated labor cost from year t-1 to t. Columns (3) and (4), the dependent variable is log-change in employees from year t-1 to t. Column (1) and (3) estimate the change in labor cost elasticity and labor employee elasticity for single county banks with low market share. Column (2) and (4) estimate the change in labor cost elasticity and labor employee elasticity for single county banks with high market share. Bank and year fixed effects are included, and standard errors are clustered by bank and reported in parenthesis. $Exposed\ Bank_i$ is measured at the bank level and its coefficient is absorbed by bank fixed effects. Year indicators are relative to the onset of the boom and therefore the coefficient on $Post_t$ is absorbed by year fixed effects. All variables are defined in Appendix A. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Variables	$\Delta \log labor\ cost\ def_{it}$		$\Delta \log employees_{it}$	
	(1)	(2)	(3)	(4)
	Low market share	High market share	Low market share	High market share
$\Delta \log interest\ income_{it}$	0.509***	0.791***	0.205***	0.226***
	(0.057)	(0.073)	(0.046)	(0.047)
$\Delta \log interest\ income_{it} \times Exposed\ Bank_i$	0.261**	−0.188	0.056	−0.162*
	(0.113)	(0.194)	(0.065)	(0.094)
$\Delta \log interest\ income_{it} \times Post_t$	0.278***	−0.112	−0.038	−0.122*
	(0.084)	(0.108)	(0.075)	(0.066)
$Exposed\ Bank_i \times Post_t$	0.023*	−0.037**	0.020	−0.006
	(0.013)	(0.016)	(0.014)	(0.011)
$\Delta \log interest\ income_{it} \times Exposed\ Bank_i \times Post_t$	**−0.521*** **	**−0.219**	**0.058**	**0.270*** **
	(0.149)	**(0.218)**	**(0.099)**	**(0.123)**
$Asset\ intensity_{it}$	−0.009	0.027	−0.023	0.024
	(0.016)	(0.022)	(0.021)	(0.023)
$\Delta \log interest\ income_{it} \times Asset\ intensity_{it}$	0.024	0.091	0.050	0.081**
	(0.052)	(0.056)	(0.043)	(0.040)
$Employee\ intensity_{it}$	0.021***	0.019***	0.052***	0.039***
	(0.003)	(0.005)	(0.007)	(0.003)
$\Delta \log interest\ income_{it} \times Employee\ intensity_{it}$	0.011**	0.013*	0.013***	0.008**
	(0.005)	(0.007)	(0.005)	(0.004)
$\Delta\ FFRLNS_{it}$	−0.049***	−0.055***	−0.023***	−0.026***
	(0.007)	(0.012)	(0.006)	(0.005)
$log\ assets_{i,t-1}$	0.062***	0.115***	0.139***	0.153***
	(0.024)	(0.025)	(0.024)	(0.023)
$\Delta \log deposits_{it}$	0.011	0.002	0.287***	0.306***
	(0.033)	(0.042)	(0.051)	(0.039)
Observations	3,611	3,611	3,611	3,611
Within R−squared	0.544	0.594	0.274	0.355
Fixed Effects	Year, Bank	Year, Bank	Year, Bank	Year, Bank
SE clustered by	Bank	Bank	Bank	Bank

APPENDIX C

Figures

FIGURE 1: MAJOR U.S. SHALE PLAY REGIONS

This figure shows the seven major U.S. Shale play regions with fracking activities during 2005-2014. Appalachia basin is subdivided into two regions- Marcellus and Utica because significant fracking in Utica region (Ohio) began only in 2011 whereas significant fracking activity in Marcellus region (New York, Pennsylvania, and West Virginia) began in 2007. Counties exposed to the shale boom are identified by Energy of Information Administration (EIA). Commencement of significant fracking activity is recognized based on prior research (Bartik et al. [2019]; Gilje et al. [2016]). Following Stuber (2019), Texas, New Mexico and New York states are excluded from the analyses. Therefore, Permian (New Mexico and Texas) and Eagle Ford region (Texas) are completely excluded whereas only a part of Haynesville and Anadarko region is excluded from analyses to the extent the counties are in Texas. Similarly, a part of Marcellus region is excluded from analyses to the extent the counties are in New York.

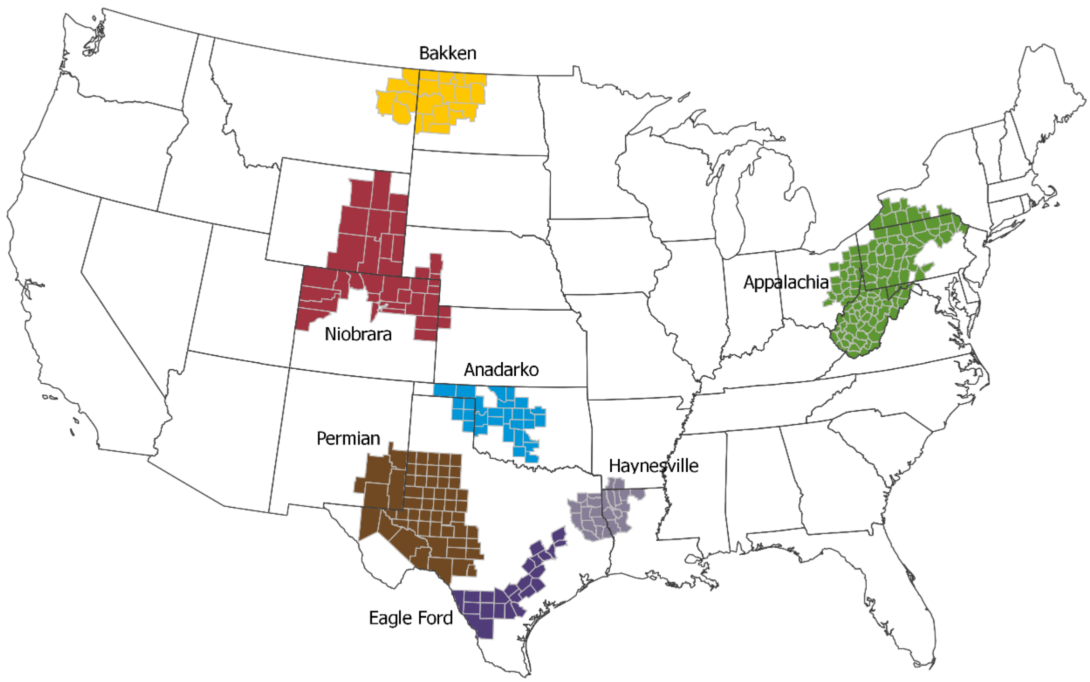


FIGURE 2: TREATMENT AND CONTROL COUNTIES WITHIN THE SHALE PLAY STATES

This figure shows the treatment and control counties used to identify the banks exposed to the shale boom within a shale play state. Counties shaded in green are identified by U.S. Energy Information Administration (EIA) as counties with shale formation. Banks with more than 50 per cent of branches in counties shaded in green are identified as exposed to the shale boom while other banks within the play state are considered as control banks. Therefore, control banks may also have a minority share of branches in the counties shaded in green.

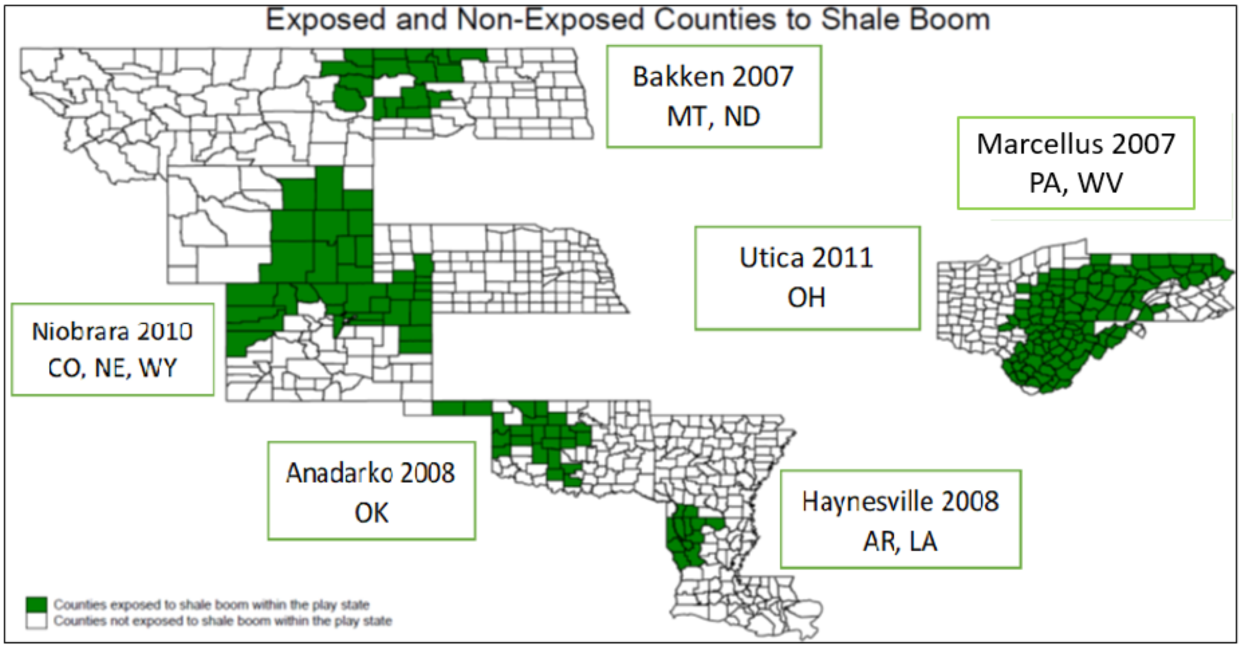


FIGURE 3: TIME SERIES ANALYSIS FOR DIFFERENCE IN LABOR COST ELASTICITY

The figure shows the coefficients on $\Delta \log interest\ income_{it} \times\ Exposed\ Bank_i \times Year$ obtained by regressing $\Delta \log labor\ cost\ def_{it}$ on $\Delta \log interest\ income_{it}$, year indicator variables relative to the onset of the shale boom and the interaction of $\Delta \log interest\ income$, year indicators, and $Exposed\ Bank$. All control variables used in estimating equation (1) are also included. The points on the bars represent the difference in labor cost elasticity for exposed and non-exposed banks during the sample period while the bars show the 95% confidence intervals. Year on the horizontal axis is relative to the onset of the shale boom. The marginal effects 4 years after and before the onset of the shale boom are combined and shown under year 5 and -5 respectively.

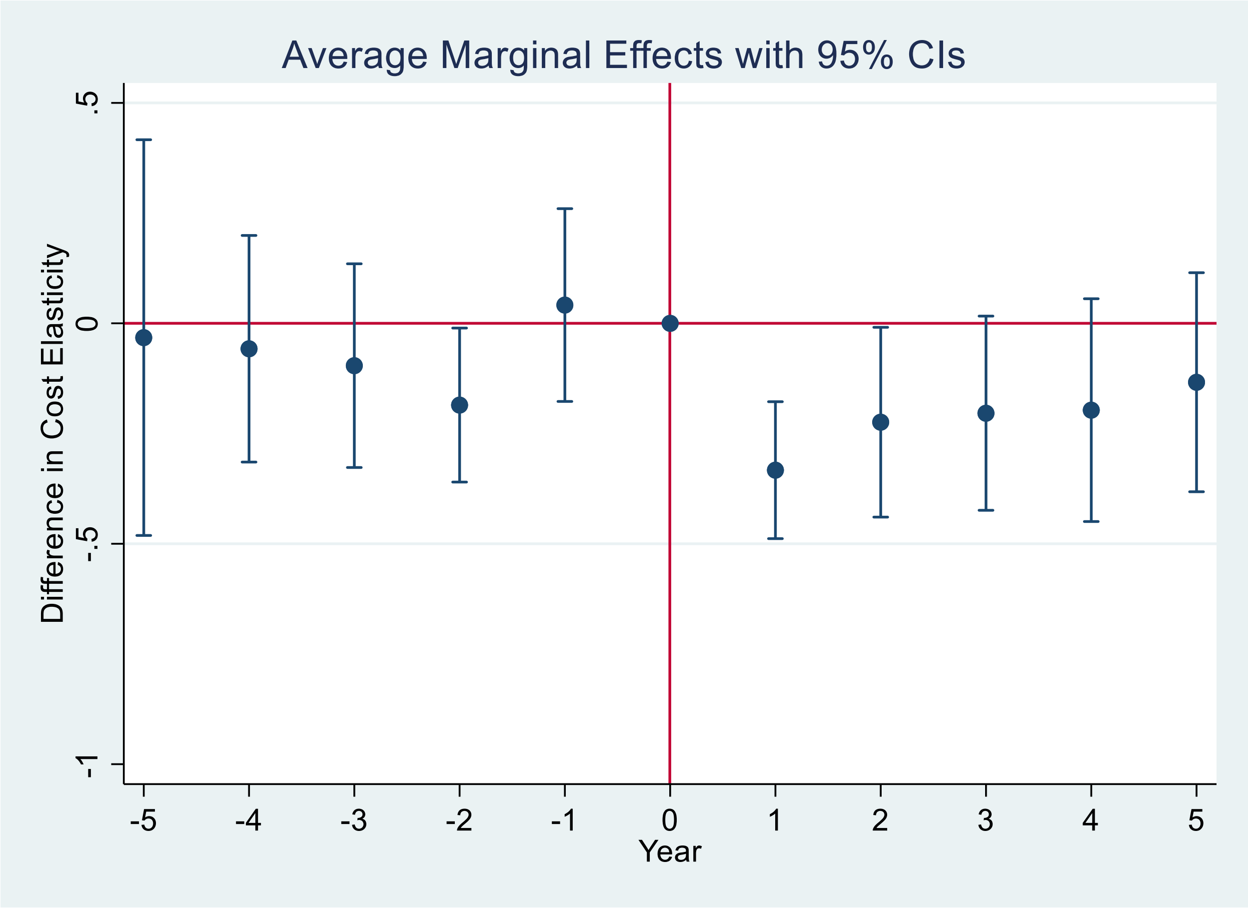


FIGURE 4: TIME SERIES ANALYSIS FOR DIFFERENCE IN LABOR EMPLOYEE ELASTICITY

The figure shows the coefficients on $\Delta \log interest\ income_{it} \times\ Exposed\ Bank_i \times Year$ obtained by regressing $\Delta \log employees_{it}$ on $\Delta \log interest\ income_{it}$, year indicator variables relative to the onset of the shale boom and the interaction of $\Delta \log interest\ income$, year indicators, and $Exposed\ Bank$. All control variables used in estimating equation (1) are also included. The points on the bars represent the difference in labor cost elasticity for exposed and non-exposed banks during the sample period while the bars show the 95% confidence intervals. Year on the horizontal axis is relative to the onset of the shale boom. The marginal effects 4 years after and before the onset of the shale boom are combined and shown under year 5 and -5 respectively.

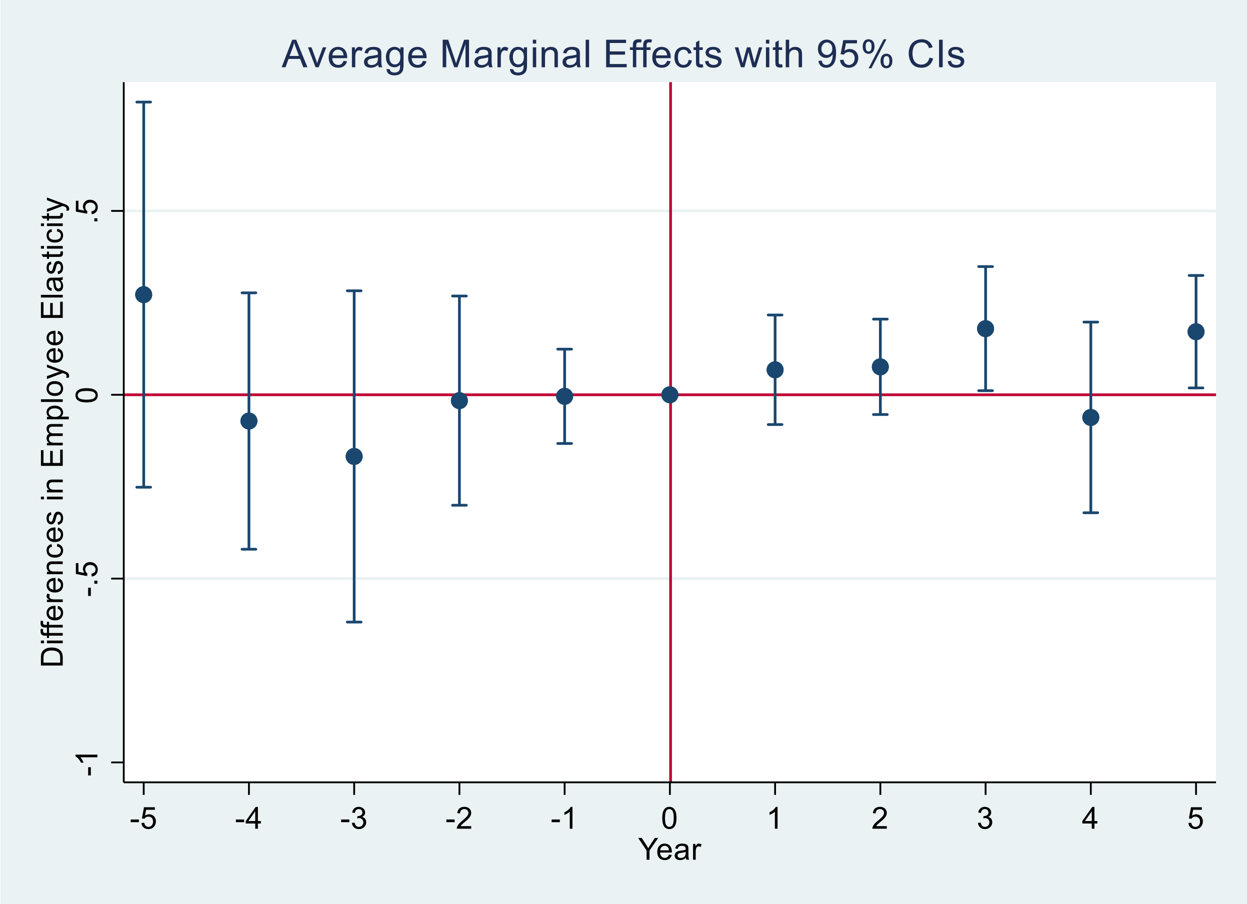
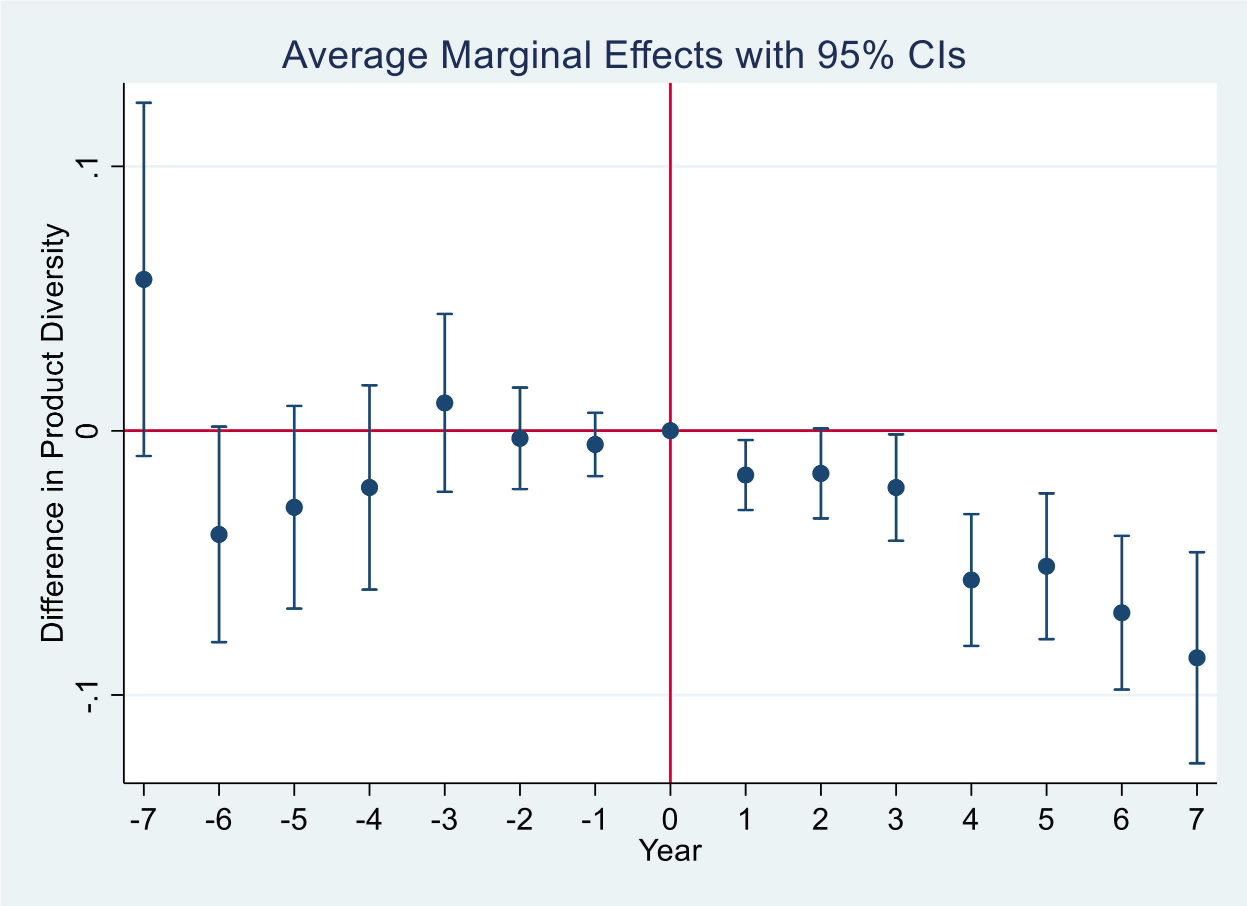


FIGURE 5: TIME SERIES ANALYSIS FOR DIFFERENCE IN PRODUCT DIVERSITY

The figure shows the coefficients on $Exposed\ Bank_i \times Year$ obtained by regressing $Product\ diversity_{it}$ on Exposed Bank, year indicator variables relative to the onset of the shale boom and the interaction of year indicators, and $Exposed\ Bank$. All control variables used in estimating equation (2) are also included. The points on the bars represent the difference in labor cost elasticity for exposed and non-exposed banks during the sample period while the bars show the 95% confidence intervals. Year on the horizontal axis is relative to the onset of the shale boom.



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