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INFLATION DYNAMICS WITH NON LINEAR LOCAL PROJECTIONS: GLOBAL SUPPLY CHAINS AND CONSUMER DEBT IN THE US

TESINA

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LICENCIADO EN ECONOMÍA

PRESENTA

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*A*bstract

This dissertation researches the dynamics of US inflation using a novel non-linear local projections framework. We highlight the roles of the global supply chain and consumer debt levels in monetary policy efficacy. In order to do this, we establish four regimes, constructed on transition probabilities based on the interaction of the aforementioned variables, which are known as trigger variables. This means that we asses monetary policy effectiveness on whether there's stress in the global supply chain and simultaneously, high consumer debt levels. Hence, whilst focusing on implementing two trigger variables instead of the literature's use of one, we find that monetary policy is limited under high supply chain stress, irrespective of consumer debt levels. Conversely, in low-stress environments, monetary policy consistently proves more successful when consumer debt is high. Utilising the Global Supply Chain Pressure Index and Total Consumer Credit as proxies for our trigger variables, the results call attention to the interplay between supply-side exogenous constraints and demand-side transmission mechanisms in shaping inflation dynamics in the US.

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1 Introduction

With the high level of financial integration in the 21st century, economies worldwide are extremely prone to foreign shocks. If these are negative, domestic institutions could see themselves unexpectedly limited when conducting public policy. For example, supply driven inflation is common among both developed and emerging economies, given the fact that diverse foreign shocks accelerate the rate of inflation of intermediate and final goods. Moreover, central banks cannot directly address these inflation drivers, further prolonging the persistence of inflation. Political uncertainty, oil price shocks, war and even agricultural disruptions can create inflationary cycles that are out of reach for a given central bank. The most recent worldwide example was the COVID Pandemic: for instance, inflation levels in the United States reached levels not seen since the late 1970s. These pressures were exacerbated by fiscal policies implemented during the COVID-19 pandemic to maintain consumer spending in 2020–2021, further driving prices upward. Hence, in the 2021-2023 inflation surge, worldwide inflation averaged at 8%. Therefore, its intuitive to think that inflation becomes more persistent when its driver is exogenous. In the pandemic case, the global disruption of supply chains limited the global market, such that supply could not meet demand, resulting in an increase in the price level.

Nonetheless, rather than attributing all inflationary pressures to the fact that domestic monetary policies were constrained (given the foreign nature of the shock), one could argue that transmission mechanisms could have counter acted the pressure. In monetary policy, these are the tools that central banks use to propagate their stance, either through inflation expectations, interest rates, or in our case, debt service payments.

Thus, the aim of this dissertation is to identify and understand monetary policy effectiveness under two simultaneous scenarios: exogenous supply shocks and transmission mechanisms. If the supply shock is expected to be persistent, perhaps there's an inherent attribute or policy of a given economy that could alleviate the pressure, or even dissipate it completely. To test this, we assess how US inflation responds to foreign stress given an eased/constrained domestic mechanism of transmission. The interaction between the domestic mechanism and the foreign stress can facilitate or complicate the central bank's policy. Concisely, we choose to analyse the global supply chains and consumer debt in the US, given that their interaction provides a comprehensive understanding of inflation dynamics. Supply chain disruptions affect the supply side by causing shortages and increasing production costs, whilst consumer debt dictates spending once there´s a monetary tightening policy. We choose the US due to its highly developed credit market and integration in the global supply chain.

To assess this research question, we use a novel identification strategy based on non-linear local projections, that accounts two state (or trigger) variables instead of the literature´s main use of one. Traditionally, one would estimate heterogeneous treatment effects on inflation, based on a monetary shock, that differs given a state variable. By using two state variables, we construct regimes that capture more information and dynamics of the economy that ease/stress inflation. This allows us to see inflation impulse response functions in four different regimes, based on consumer debt and supply chain stress and their resulting interaction. We measure these states with the Global Supply Chain Pressure Index and the percent change of Total Consumer Credit, both proxies for supply chain stress and consumer debt respectively.

Our results suggest that irrespective of consumer debt levels, monetary policy is limited whenever there's stress in the global supply chain. Conversely, when there's no stress, monetary policy is substantially more effective when the economy is in a high-debt regime. The results suggest that transmission mechanisms, particularly the credit channel, are not effective in easing inflationary pressures whenever there´s exogenous supply shocks. We find similar results when we focus on the service component of consumer inflation and an example of a durable good highly dependent on the global supply chains. As well, we find that the US economy, since the late 1990s, has spent 30% of the sample period in a low supply chain stress, high consumer debt regime. The eased foreign stressor and a good transmission mechanism has allowed the US to have a robust monetary policy and relatively low inflation rates. Understanding these interactions is crucial for macroeconomic research: it provides a more nuanced view of inflation dynamics, emphasising the importance of considering both supply-side and demand-side factors. Integrating a second trigger variable could yield more applied research in macroeconomics, as implementation is relatively simple and relevant for macro topics. Ultimately, this dissertation's aim is to test whether integrating a second trigger variable in the non linear local projection framework yields reliable results: although further rigorous testing is required, the results suggest that on a first instance, results are consistent.

The rest of the paper is organised as follows: Section 2 provides a review of our trigger variables and their importance in inflation dynamics, as well as a literature review of the importance of these in the economy. Section 3 provides the econometric framework of non linear local projections, detailing how we identify monetary policy shocks and the non linear aspect of the data. Section 4 and onwards detail the results.

2 On supply chain stress and consumer debt

The role of the Global Supply Chain nowadays is important for open economies, given its a main driver for producer inflationary pressures. Yilmazkuday (2024) finds that shocks to both domestic and global supply chains increase headline inflation, where these shocks alone can account for up to 51% of the volatility. Consumer and business confidence is reduced as well. Moreover, shocks in the global supply chain impact the domestic one: volatility of the domestic supply chain is explained by the global supply chain by 49%. Moreover, Albagli et al. (2022) show that companies base their expectations of overall inflation on the price changes they observe within their supply chain, and these inflation expectations fully influence their final sales prices. The recent example of the 2020 global pandemic exemplifies this, as Liu and Nguyen (2023) argue that the costs of inputs due to supply chain disruptions and cost expectations accounted close to 60% of consumer headline inflation. Analogously, once the stress on the supply chains subsided in mid-2022, inflationary pressures eased. This trend is not unique to the US economy; similar inflationary pressures have also appeared in other advanced economies, though to a lesser degree, in the pandemic context. Supply-side developments in economies tend to be highly correlated across different countries.

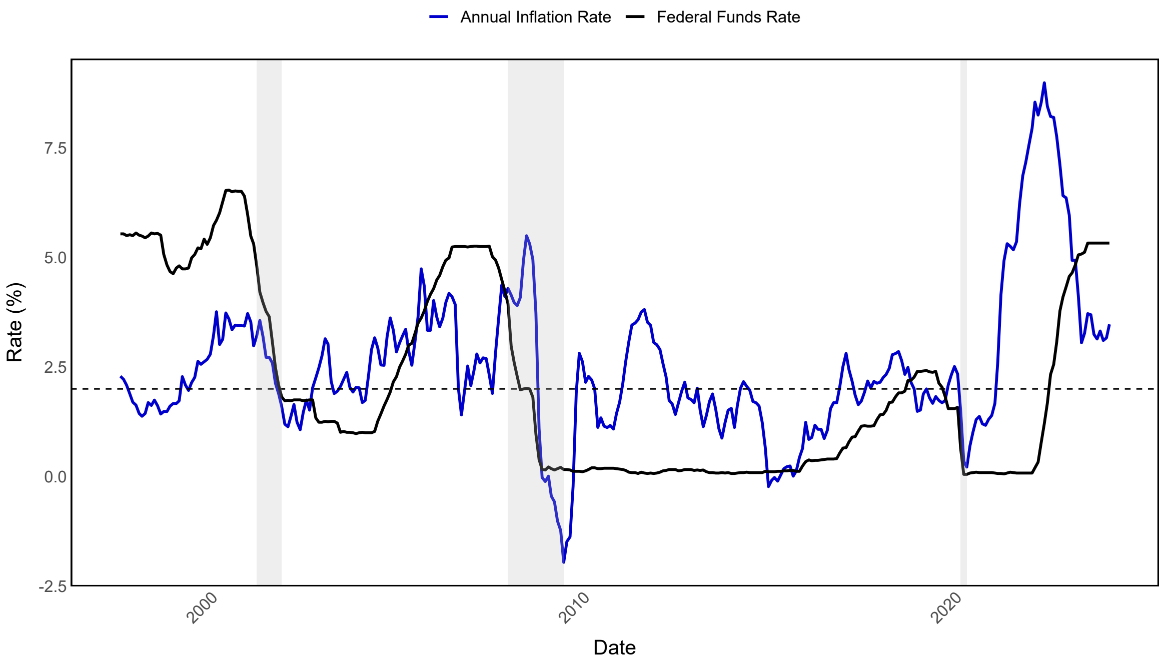
Inflation achieved a maximum rate of 9% in this episode, as the supply chains disruptions of the pandemic were then coupled with the Russian invasion of Ukraine, affecting commodity prices according to Vasquez (2023). The monetary policy response in the US was to increase the Federal Funds rate (the monetary policy rate) accordingly, as shown in Figure 1. The Federal Reserve, operating under its dual mandate of promoting maximum employment and stable prices, works within an inflation targeting system of 2%: the hawkish stance, following the supply driven inflation shock of the pandemic, marked a 22 year high on the Federal Funds Rate.

However, the response of monetary policy, given a supply shock, is limited: Fornaro and Wolf (2023) argue that when negative supply shocks disrupt investment, they can consequently lead to enduring output losses. These scarring effects can amplify and extend the inflationary consequences of supply disruptions. If monetary policy is tightened in response, it may exacerbate the scarring effects and increase inflation over the medium term.

Therefore, the high level of integration of supply chains pressures policy makers to take them into account in economic forecasting. For example, the Baltic Dry Index (BDI) was created in 1985 to address global transportation costs: Bildirici et al. (2015) argue that the BDI can be used as an indicator of a crisis in GDP growth, for the United States, fairly accurately. This relationship is highlighted by the fact that the

US relies heavily on imports for electronics and semiconductor components, with a significant portion of these components sourced from China, Taiwan, and South Korea, as detailed in Furusho (2021). As well, both the automotive industry and a large percentage of its active pharmaceutical ingredients (APIs), depend on the supply chains.

Figure 1: Consumer Inflation Rate (YoY) and Federal Funds Rate.

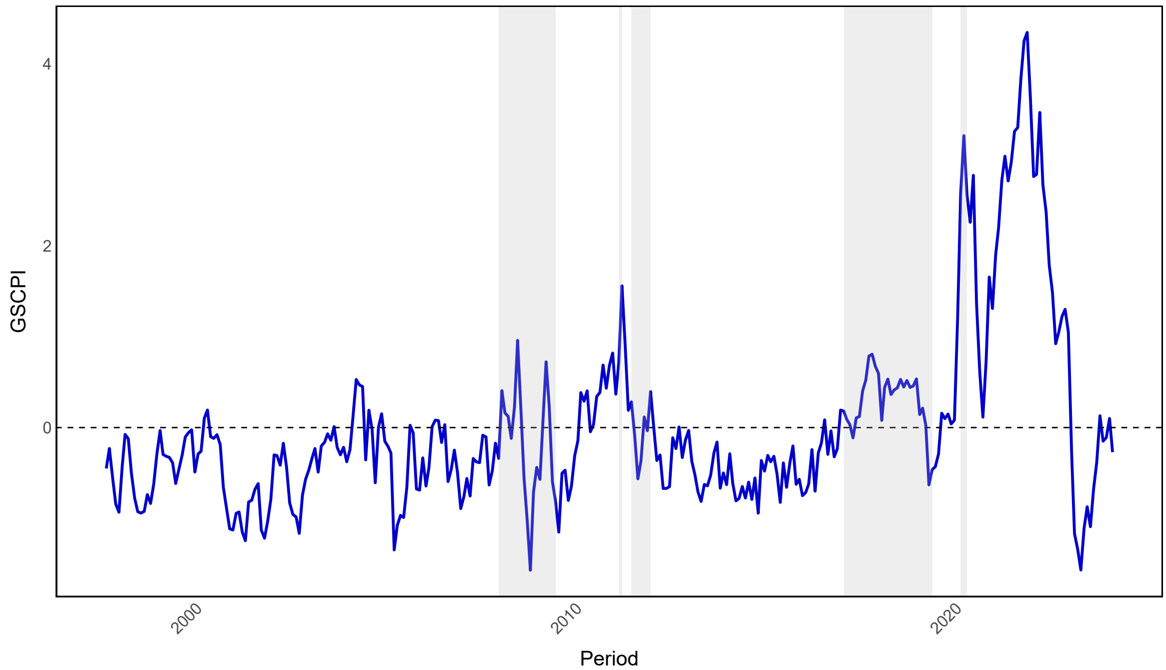


Shaded areas are the Dot-com bubble, GFC and the COVID Pandemic. Inflation target of 2% shown. Own making with U.S. Bureau of Labor Statistics (2024) data.

In response, the Federal Reserve Bank of New York developed the Global Supply Chain Pressure Index (GSCPI), as shown in Figure 2, in order to parsimoniously capture pressure in the supply chains and effectively use it as proxy variable for worldwide stress. The GSCPI consolidates various widely-used indicators to offer a detailed overview of potential supply chain disruptions. It evaluates global transportation costs using data from the BDI, the Harpex index and airfreight cost indices provided by the U.S. Bureau of Labour Statistics. Additionally, the GSCPI incorporates several supply chain-related metrics from Purchasing Managers' Index (PMI) surveys, targeting manufacturing firms in seven major interconnected economies: China, the Eurozone, Japan, South Korea, Taiwan, the United Kingdom, and the United States. To address data availability, the index (whenever there's discrepancies or missing data) estimated a common component for the sample. This is done with *principal component analysis* (PCA), a technique that identifies patterns in data by transforming it into a set of orthogonal components. PCA helps in reducing the dimensionality of the data while retaining most of the variability, thereby ensuring a robust and comprehensive measure of global supply chain pressures despite inconsistencies in the underlying data .

Moreover, several studies have used the GSCPI as regime indicator: Benigno et al. (2022) proposed it as proxied measure of stress in the supply chains, and research like Alper et al. (2017) show that global supply chain pressures have a sizeable, significant, and persistent impact on domestic inflation in sub-Saharan Africa. Hernández et al. (2024) found similar results for Mexico, highlighting the slow response of inflation expectations to a monetary policy tightening in a high-stress regime.

Figure 2: Global Supply Chain Pressure Index



Shaded areas include the Great Financial Crisis, Japan´s Tsunami, Thailand Floods, US-China Trade Wars and the COVID Pandemic. Own making with Federal Reserve Bank of New York (2024) data.

We are also interested in domestic conditions, particularly the role of consumer debt on inflation as monetary policy transmission channel. Monetary policy effectiveness hinges on the channel's ability to propagate the Federal Reserve stance throughout the economy. These channels vary from expectations, asset prices and interest rates. However, we are interested in the credit channel and its relationship with consumer and household debt, alongside consumption. When the Federal Reserve lowers interest rates, borrowing becomes cheaper. This stimulates investment and consumption. Conversely, raising rates makes borrowing more expensive, cooling down economic activity. The credit channel extends the impact of interest rate changes by altering the availability and cost of credit. Lower interest rates can increase bank lending by making it more profitable for banks to extend credit, and on the contrary, higher rates can restrict credit supply.

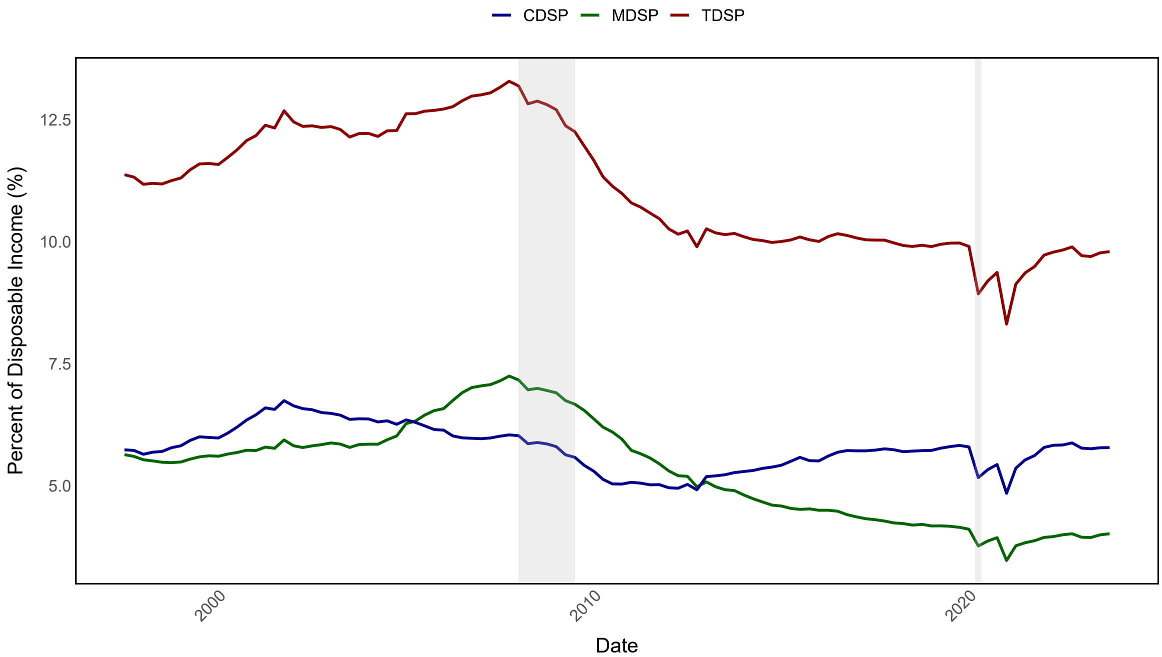
The US consistently ranks amongst the countries with highest household debt, which is defined by the Organisation for Economic Cooperation and Development (OECD) as all liabilities of households (including non-profit institutions serving households) that require payments of interest or principal by households to the creditors at a fixed dates in the future. This relatively high debt is influenced by other factors: Historically low interest rates have made borrowing more attractive, allowing consumers to take on more debt, particularly in the form of mortgages and student loans. Debt enables households to mitigate financial shocks and invest in high-return opportunities, thereby increasing their overall lifetime consumption. Nevertheless, excessive household debt can heighten the economy's susceptibility to economic crisis, potentially hindering economic growth: slowed economic growth in the medium term, possibly increasing the likelihood of systemic distress.

The Federal Reserve's policies following the 2008 Global Financial Crisis (GFC) kept interest rates low in order to mitigate the adverse shock, as seen in Figure 1. This helped maintain manageable debt service costs but also encouraged higher borrowing levels. Albagli et al. (2022) show that in Australia, a developed open market economy, the way households react to changes in monetary policy is heavily influenced by their levels of debt relative to income. Households with higher debt levels are more likely to cut back on their current consumption and spending on durable goods when faced with contractionary monetary policy. Conversely, households with lower debt levels might not alter their spending habits in response to monetary policy changes, as they tend to possess more interest-earning assets. The heterogeneous nature of consumer debt suggest that stable and relatively high debt enhances monetary policy transmission, as debt service payments increase whilst spending decreases.

After the GFC, Zabai (2017) categorised the US as an economy with high, yet stable, household debt levels. Note that the majority of household debt service payment comes from Mortgage Debt, as shown in Figure 3. However, it fell after the GFC, where Non-Mortgage Debt is now predominantly the biggest component of household debt: Figure 3 shows the Household Debt Service Payments as a Percent of Disposable Personal Income (TDSP), which is conformed by Mortgage Debt (MDSP) and Non-Mortgage Debt (CDSP).

This is important, given a household's debt level influences its capacity to manage unexpected adverse changes in its situation, such as reductions in income, declines in asset values, or increases in interest rates. Zabai (2017) shows that after the GFC, households with higher leverage reduced their spending significantly more than those with lower ratios. As well, the liquidity of wealth financed through debt determines the cut in consumption, where mortgage-leveraged households would

Figure 3: Debt Service Payments as percent of Disposable Income



Shaded areas are the GFC and the COVID Pandemic. Own making with Board of Governors of the Federal Reserve System (2024a) data.

cut consumption the most. This is also studied by Hiilamo (2018): during economic downturns, over leveraged households are more likely to cut back on spending, leading to prolonged recessions. Auclert (2019) details three mechanisms in which monetary policy and consumer debt interact.

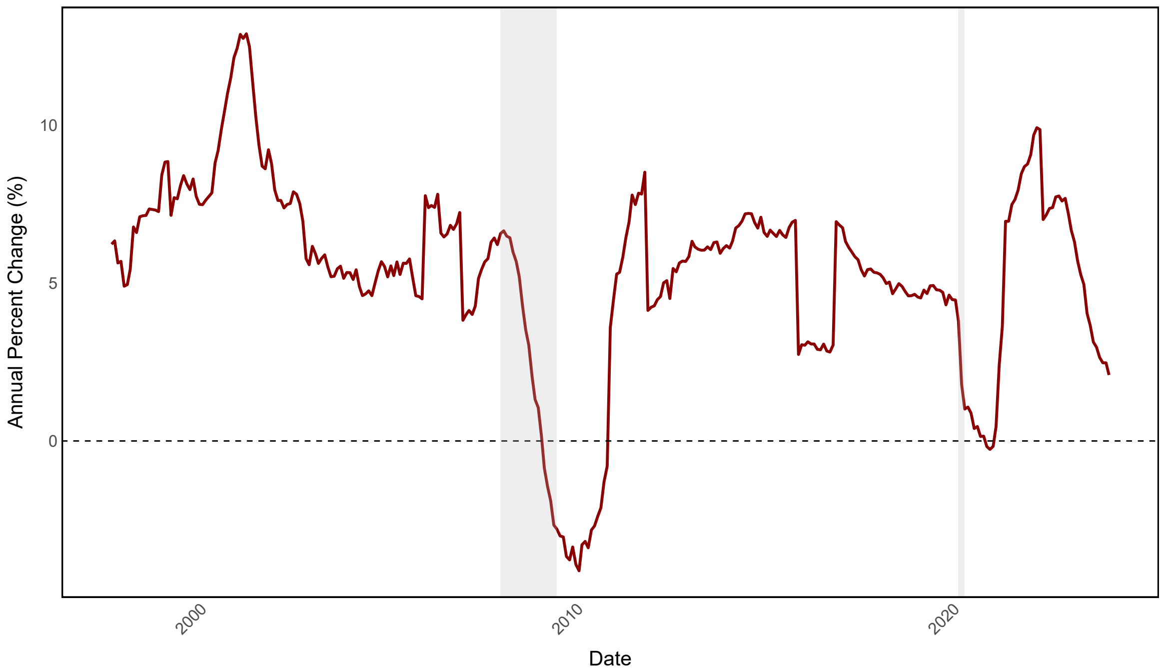
First, the *Earnings Heterogeneity* Channel operates through the unequal distribution of income gains from monetary expansions. When monetary policy is accommodative, it tends to increase labour and profit earnings, but these increases are not evenly distributed across the population. This means that some households earn more than others. Essentially, households that gain more income tend to have higher marginal propensities to consume, leading to a greater increase in aggregate spending and therefore debt.

Secondly, the *Fisher* Channel involves the revaluation of nominal balance sheets due to unexpected inflation. Nominal debtors gain because their debts are devalued, while nominal creditors lose as the real value of their assets decreases. This revaluation affects consumption because households with higher propensities to consume (debtors) gain more purchasing power, which can increase aggregate consumption and ultimately debt.

Third, the *Interest Rate Exposure* Channel states that monetary policy impact depends on whether households have longer durations for their assets compared to their liabilities. Households with more short-term assets and long-term liabilities benefit from lower real interest rates. Real interest rate changes redistribute wealth between households with different interest rate exposures. US data suggest these three channels amplify monetary policy effectiveness.

Ultimately, capital gains and losses matter for understanding monetary policy transmission mechanisms. Figure 4 shows consumer credit both owned and securitized, which is the total amount of credit extended to consumers that is either owned directly by financial institutions or securitized. Note how consumer credit (spending) falls heavily in recession periods and increases right after. Securitization involves pooling various types of debt—including consumer credit—and selling the consolidated debt as bonds or other financial instruments to investors. Total consumer credit is conformed by revolving and non-revolving credit: Revolving credit allows borrowers to repeatedly access funds up to a set limit, with repayments replenishing available credit (e.g., credit cards). Non-revolving credit provides a one-time loan with fixed repayment terms, where funds cannot be reused once repaid, such as in mortgages or auto loans.

Figure 4: Total Consumer Credit Owned and Securitized



Shaded areas are the GFC and the COVID Pandemic. Own making with Board of Governors of the Federal Reserve System (2024b) data.

2.1 Inflation in the US, Global Supply Chains and Consumer Debt

Hence, the role of the global supply chain and consumer debt is clear: monetary policy effectiveness is partially determined by both the level of stress in the supply chain and household debt, particularly the household's sensibility to changes in interest rate through disposable income service payments. In this dissertation, we focus on consumer inflation dynamics in the US and how these evolve depending on the rate of change of consumer debt in the US economy and the stress in the global supply chains. We choose supply chains as exogenous shocks for supply-side disruptions, rather than climate conditions or geopolitical uncertainty, given the unique position of the US of being the advanced economy that imports the most volume of goods (both intermediate and final) as of 2024. As well, we choose household debt as our monetary policy transmission mechanism, rather than other channels, because the US consistently ranks amongst the countries with more household debt relative to Gross Domestic Product (GDP). Further research could highlight the role of additional transmission mechanisms and their effectiveness given different exogenous supply shocks.

As detailed by Albagli et al. (2022), the mechanism in which supply chain stress passes through domestic inflation is via producer prices derived from inflation expectations and increasing input costs. Periods of stress reflect input disruptions. Moreover, supply shocks are challenging for central banks: expansionary monetary policy could alleviate inflationary pressures via demand, whilst the foreign supply shock cannot be addressed by the central bank. Simultaneously, due to the US highly developed credit market and stable household debt, we should expect an increase in debt service payments as a percent of disposable income, reducing aggregate consumption and thus making monetary policy more effective.

Therefore, we propose using global supply chain stress and consumer debt as trigger variables to assess monetary policy efficiency. Essentially, we argue that an effective tightening shock in the interest rate fundamentally depends on the level of supply chain stress and debt in the US economy. If the Global Supply Chain is in stress, monetary policy should be less effective overall. If consumer debt is high, the magnitude of the effect should be deeper. To assess this, we use the previously mentioned GSCPI as a proxy for stress in the supply chains and Total Consumer Credit rate of change as a proxy for consumer debt. The total consumer credit owned and securitized, as seen in Figure 4 is an important economic indicator as it reflects the rate of change of consumer borrowing and can indicate consumer confidence and spending behaviour. We use it as a proxy for household debt.

3 Econometric Methods

Local Projections (LP), as detailed and introduced by Jordà (2005), are an appropriate method for estimating monetary policy under the said regimes. Particularly, LP estimates have certain advantages over the traditional Vector Autoregression (VAR) method. According to Jordà (2005), there are three main advantages of using LP over VAR. LP can be estimated with ordinary least squares (OLS) and standard errors robust to heteroskedasticity and autocorrelation, such as Newey and West (1987), can be also used. As well, impulse responses are more robust when a linear VAR is misspecified and implementation of non-linearities is relatively straightforward given the single equation estimation characteristic of LP. This advantage specifically will allow us to analyse the consumer debt and supply chain role in inflation dynamics. Although it could be argued that performance of impulse responses could differ significantly, Brugnolini (2018) shows that LP impulse responses perform better whenever lags are correctly specified, particularly when they are fixed in each horizon. LP are suitable for our research question.

Since their introduction, LP have been consistently used in macroeconomic research. For example, Auerbach and Gorodnichenko (2012) use state-dependent LP to show that fiscal policy is considerably more effective in recessions rather than expansions, Jordà et al. (2015) demonstrates that under loose monetary conditions there's consequently real estate lending booms and Ahmed and Cassou (2016) research the role of consumer confidence in durable goods spending under different economic condition regimes.

We are interested in studying the accumulated response of consumer inflation h periods ahead ($\pi_{t+h} - \pi_{t-1}$) in the US given a exogenous monetary shock in period t (Δr_t). LP can be estimated via OLS for every horizon h with a set of macroeconomic variables (x_t'), which also includes lags of π_t:

$$\pi_{t+h} - \pi_{t-1} = \alpha_h + \beta_h \Delta r_t + \gamma_h x_t' + u_{t+h}, \qquad h = 0, 1, ..., H \tag{1}$$

where α_h is an intercept, β_h are our parameters of interest, γ_h estimated parameters for control variables x_t' and u_{t+h} are autocorrelated/heteroskedastic disturbances. β_h can be interpreted as the impulse responses of $\pi_{t+h} - \pi_{t-1}$ to a reduced form shock in t. Its common to use Newey and West (1987) standard errors due to the serial correlation of u_{t+h}. However, identifying shocks through recursive ordering would yield invalid OLS estimates in this particular research, due to the simultaneous causality of monetary policy and inflation. As well, monetary decisions are endogenous not only to inflation, but also the macroeconomic setting of the US given the Fed's dual mandate. Therefore, we use external instruments as our identification strategy. This also allows us to estimate the shocks without previously constructing a SVAR.

3.1 Identification with external instruments: Monetary policy surprises

The instrumental variable (IV) approach has been adopted relatively recently in macroeconomics as a response of the challenge of identification in a macro setting. In the SVAR literature, examples are Caldara and Kamps (2017), Mertens and Ravn (2013), Romer and Romer (1989), Gertler and Karadi (2015) and Montiel Olea et al. (2021). IVs can be used as well in a multi step forecasting regression rather than a SVAR, as shown in Stock and Watson (2017), Jordà et al. (2015) and Ramey and Zubairy (2018).

Hence, our instrument of choice is defined as the monetary policy surprises in the US. Particularly, we follow Tenreyro and Thwaites (2016), Brandao-Marques et al. (2020) and Hernández et al. (2024), where monetary policy shocks are the estimated residuals of a regression. This is after controlling for macroeconomic conditions that determine the monetary policy stance of the Federal Reserve. Our choice of identification is also driven by data limitations, which restrict the use of alternative identification methods like high-frequency identification, that are commonly used in the literature. Nonetheless, these authors capture monetary policy shocks by an estimated residual given a Taylor-like rule. Deviations from Taylor-like rules are meant to capture the non-systematic and unexpected aspects of monetary policy actions. The Taylor rule, guides central banks in setting interest rates based on inflation and economic output. It suggests raising rates when inflation is high or output exceeds potential, and lowering rates in the opposite scenarios. However, Brandao-Marques et al. (2020) argues that this shock identification strategy only works given a monetary policy framework that uses interest rates as its main policy tool. Countries in which central banks do not actively target a short-term interest rate or do not systematically adjust their policy rate based on changes in output or inflation forecasts, the estimated residuals merely represent exogenous interest rate fluctuations.

Particularly:

$$\Delta s_t = \alpha^* + \gamma^* x_t^{*\prime} + \eta_t \tag{2}$$

where Δs_t are changes in Wu and Xia (2016) Shadow Federal Funds rate, α^* is an intercept and $x_t^{*\prime}$ are the monetary policy determinants. We use the Shadow Federal Funds, instead of the main nominal rate, given that it accounts for the effects of unconventional monetary policy tools, such as quantitative easing. This is useful, especially when the actual Federal Funds rate is at or near the zero lower bound, as shown in Figure 5. It reflects the real interest rate: its a theoretical rate that aims to capture the stance of monetary policy when traditional interest rate policy is constrained. If said determinants control for inflationary pressures and the economic setting of the US, then $\hat{\eta}_t$ is orthogonal to these and effectively an exogenous surprise in the monetary policy stance, as it captures the unexplained factor of the shadow rate given the Federal Reserve's position. Concisely, $x_t^{*\prime}$ contains the log-difference US industrial production, log-difference Consumer Price Index, 1-year ahead inflation expectations and the 10-year market yield on US treasuries (which captures global risk aversion).

However, given that monetary policy surprises are constructed with the Shadow Federal Funds rate Δs_t, we use an alternative rate to measure the monetary policy stance. Gertler and Karadi (2015) make a distinction between monetary instrument and monetary indicator.[1] In their baseline specification, they use the 1-year government bond rate as their main rate, rather than the Federal Funds rate, due to the incorporation of forward guidance in the rate's innovation. Essentially, the rate´s innovations include both the effects of monetary surprises and shifts in expectations about the Federal Funds future behaviour. The effects of monetary policy actions on the government bond yield curve translate into effects on private borrowing rates. We follow the same method in our baseline case, as it also enables us to have another rate represent the monetary conditions of the US. Figure 5 shows the close relationship between the rates.

Therefore, we argue that $\hat{\eta}_t$ is a valid instrument for Δr_t. We asses its validity with Stock and Watson (2017) criteria of instrument validity:

$$\begin{aligned} E[\hat{\eta}_t \Delta r_t] &\neq 0 \\ E[\hat{\eta}_t \pi_t] &= 0 \\ E[\hat{\eta}_t \epsilon_{t+j}] &= 0 \end{aligned} \tag{3}$$

These are instrument relevance, contemporaneous exogeneity and lead/lag exogeneity, respectively. ϵ_{t+j} are all other shocks at all leads and lags. On one hand, the surprises are relevant given that the 1-year government bond yield will adjust to unexpected changes in the Federal Funds rate. Effectively, we find that $Cor(\Delta r_t, \hat{\eta}_t) \approx 0.51$ with a t-statistic of 10.62. We do not see a stronger correlation because, in contrast with the shadow rate, yields were strictly positive during the sample period. As well, the F-statistic of the first stage, without controls,is 112.3.

[1] In said research, monetary policy surprises are measured with changes in Federal Funds Rate future prices following a Federal Open Market Committee (FOMC) meeting.

On the other hand, the surprises are contemporaneously exogenous due to the orthogonality with the macroeconomic setting of the US at time t. We argue that given that we controlled for inflationary pressures, financial conditions and economic activity, $\hat{\eta}_t$ is orthogonal by construction and is not determined by inflation dynamics. Essentially, the surprise can be interpreted as a movement of the Shadow Federal Funds rate that its not set by its endogenous macro determinants. For example, in Gertler and Karadi (2015), the changes in Federal Funds future prices are driven by the market reaction to the FOMC announcement, rather than the macroeconomic setting of the US. We find that $Cor(\pi_t, \hat{\eta}_t)$ is not statistically different from zero. As in Brandao-Marques et al. (2020), we argue that the residual $\hat{\eta}_t$ essentially captures the exogenous fluctuations in the shadow rate, independent of contemporaneous changes in output, prices, inflation expectations and market expectations. This explains the nullity of the correlation test. The authors argue that these fluctuations might be due to adjustments in other monetary policy tools, such as reserve requirements or interest on excess reserves, but could also result from other external factors.

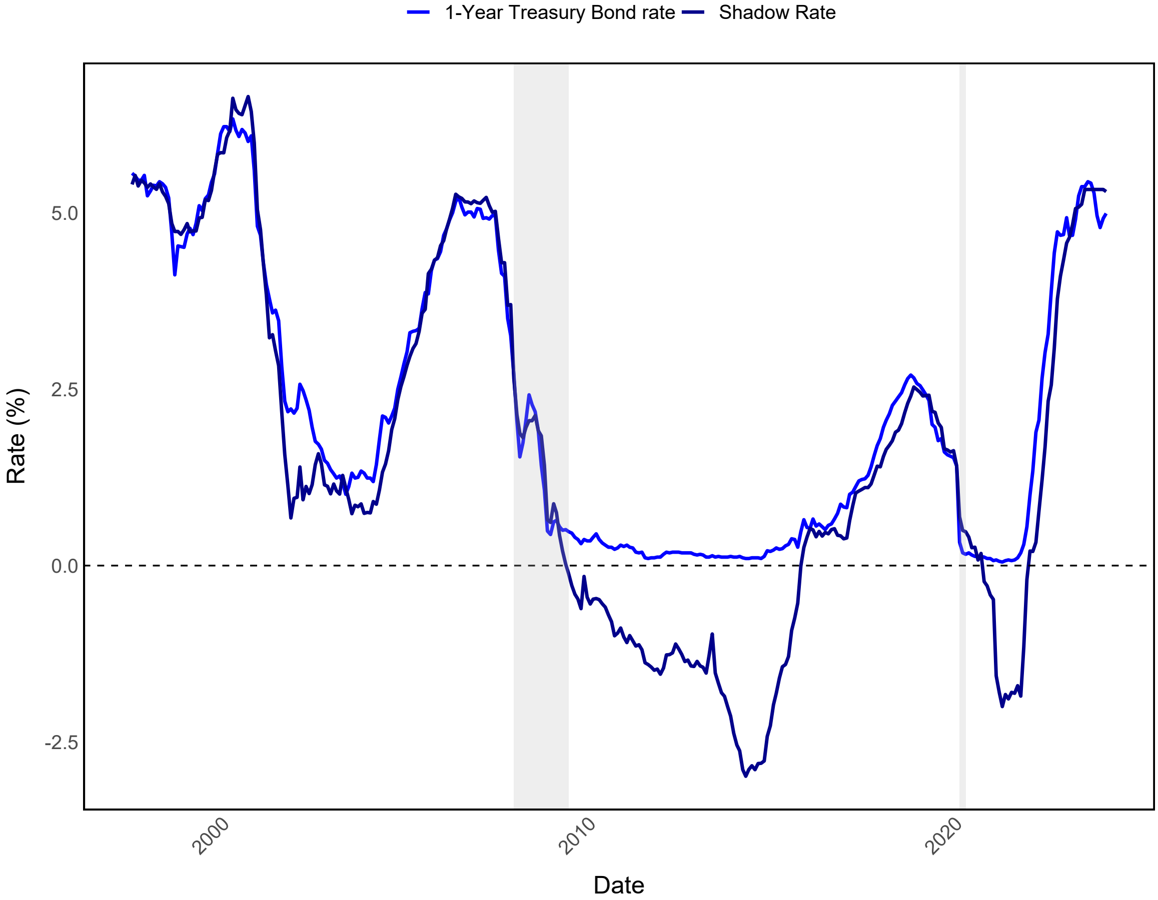
Lastly, we address lag exogeneity by including relevant macro variables that capture some of the dynamics of the instrument. Stock and Watson (2017) argue that if $\hat{\eta}_t$ is to identify only our shock of interest, it must be uncorrelated with all shocks at any lags or leads. This can be achieved by including relevant lags of macro variables, as well as lags of π_t and $\hat{\eta}_t$. We then construct the first stage as follows:

$$\Delta r_t = \tau + \psi \hat{\eta}_t + \phi m'_t + \nu_t \tag{4}$$

where τ is an intercept, ψ is the monetary policy surprise estimated parameter, ϕ are estimated control parameters and m'_t is a vector of controls used in Gertler and Karadi (2015): changes in the 5, 10 and 30 year treasury rates (Δi_t), changes in Moody's Seasoned Baa Corporate Bond Yield (ΔBAA_t) and changes in the 30-year Mortgage rate (Δi^M_t). We additionally include a lag of π_t and $\hat{\eta}_t$ to address Equation 3. By accounting for different segments of the credit market, the authors argue that they can more accurately identify the effects of monetary policy shocks and avoid attributing changes in consumer inflation to omitted variable bias. As well, $\hat{\nu}_t$ is orthogonal to $\hat{\eta}_t$. $\hat{\Delta r_t}$ is the exogenous measure of monetary condition changes in the US. Consequently, the second stage can be estimated analogous to Equation 1:

$$\pi_{t+h} - \pi_{t-1} = \alpha_h + \beta_h \hat{\Delta r_t} + \gamma_h x'_t + u_{t+h}, \qquad h = 0, 1, ..., H-1 \tag{5}$$

Figure 5: 1-year Treasury Rate and Shadow Federal Funds Rate



Shaded areas are the GFC and the COVID Pandemic. Own making with Federal Reserve Bank of Atlanta (2024) data.

3.2 Non Linearities

In essence, the LP approach does not model the entire system simultaneously. Instead, it directly estimates the impulse responses of a shock on future values of an endogenous variable using separate single-equation regressions for each horizon of interest. This approach simplifies the interpretation of shocks because it does not require specific assumptions about the contemporaneous relationships between variables. Nonetheless, the main benefit of LP in this research context is non-linearities. For example, the asymmetry of impulse response functions (IRF) behaviour, depending on the phase of the business cycle, should be addressed. Most of economic and financial variables respond to shocks in recession, while their behaviour is smoother otherwise. Although the business cycle phase is beyond the scope of this paper, the argument of non-linearities is the same: monetary policy unevenly affects consumer inflation depending the consumer debt level and the supply-chain pressure level. In contrast with a Hidden Markov Model, which constructs regimes based on the dependent variable, we can choose additional regime variables that set these conditions. As exemplified by Auerbach and Gorodnichenko (2012), we can address the non-linearity feature in local projections with a regime-switching/trigger variable in Equation 1, effectively computing regime probabilities with a logistic function:

$$F(z_{t-1}) = \frac{\exp^{-\kappa z_{t-1}}}{1 + \exp^{-\kappa z_{t-1}}} \tag{6}$$

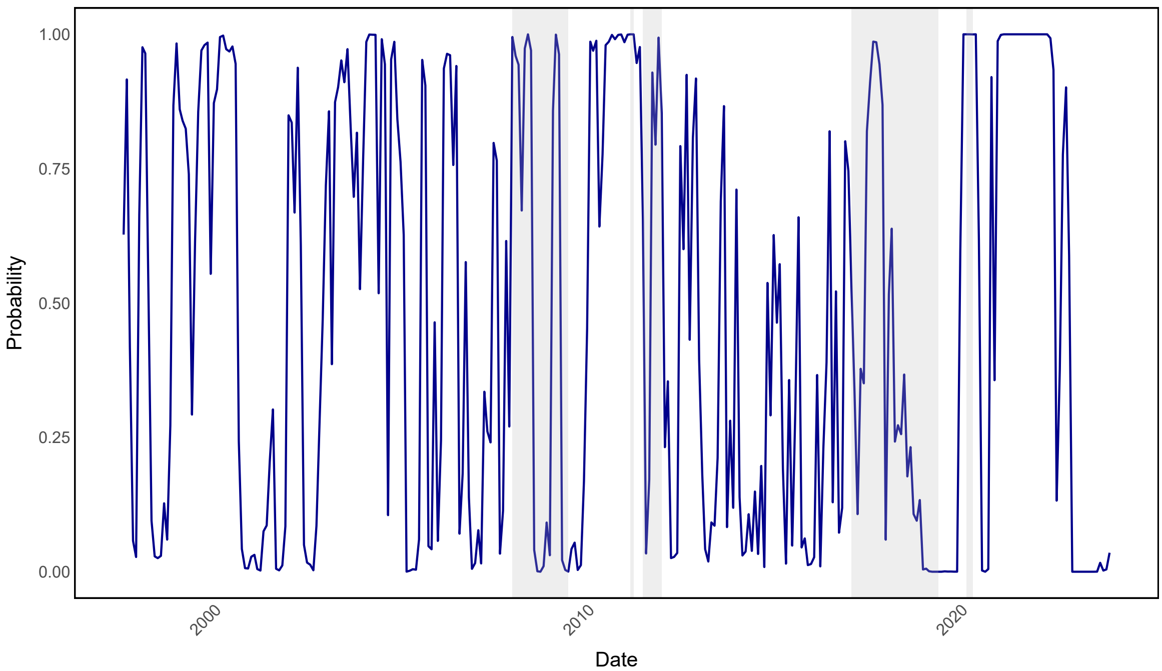
Where z_t is any given trigger variable. The logistic probability function enables us to avoid using a dummy approach, which allows the use of all observations. Although in some cases its suitable to think of a binary trigger variable, the data is separated into two independent regimes, lowering the degrees of freedom and data coverage. As well, a nice feature is that the transformed trigger variable would now have $Var(z_t) = 1$ and $E(z_t) = 0$. The logistic probability density function has curvature parameter $\kappa > 0$, which captures the regime-switching behaviour of the trigger variable. As a baseline, we use $\kappa = 6$ for both trigger variables. Moreover, $F(\cdot)$ can have the lag of the trigger variable (z_{t-1}) as its input. This is done to avoid feedback. Lastly, we use the Hodrick-Prescott (HP) filter, as recommended by Auerbach and Gorodnichenko (2012), to remove the cyclical component of the trigger variable. For the decomposition parameter λ of the HP filter, we use $\lambda = 129,600$ for monthly data as suggested by Ravn and Uhlig (2002). This allows us to obtain a smoothed-curve representation of the trigger, which becomes more sensible to long-term fluctuations. Thus, we capture the dynamics with our respective triggers with non-linear local projections (NLLP).

Figure 6 and Figure 7 display the regime probabilities under the logistic function. For example, in Figure 6, the probability of being in a high stress regime in the global supply chain was high for 19 months following the supply chain disruptions of the COVID pandemic. No other event severely stressed as long the global supply chain during the sample period. Note that the GFC had a delayed effect on the supply chain. Conversely, in Figure 7, the probability of being in a high consumer credit regime fell following the financial crisis of 2008, accordingly as in Figure 4. In the COVID pandemic, we do not see such behaviour. Nonetheless, the probability of being in a high debt regime tends to be relatively constant over the sample, confirming our previous argument that the US has consistently high consumer debt levels.

We now have all the necessary concepts to construct consumer inflation impulse responses based on a monetary policy shock under different regimes. However, our aim is to extend the literature's main use of one trigger variable. We now define our trigger variables as follows: z_t and w_t are the GSCPI and Consumer Credit (CDSP) respectively. Traditionally, when there's one trigger in place, the trigger variable would separate the data into a high (H) and low (L) regime in the following form:

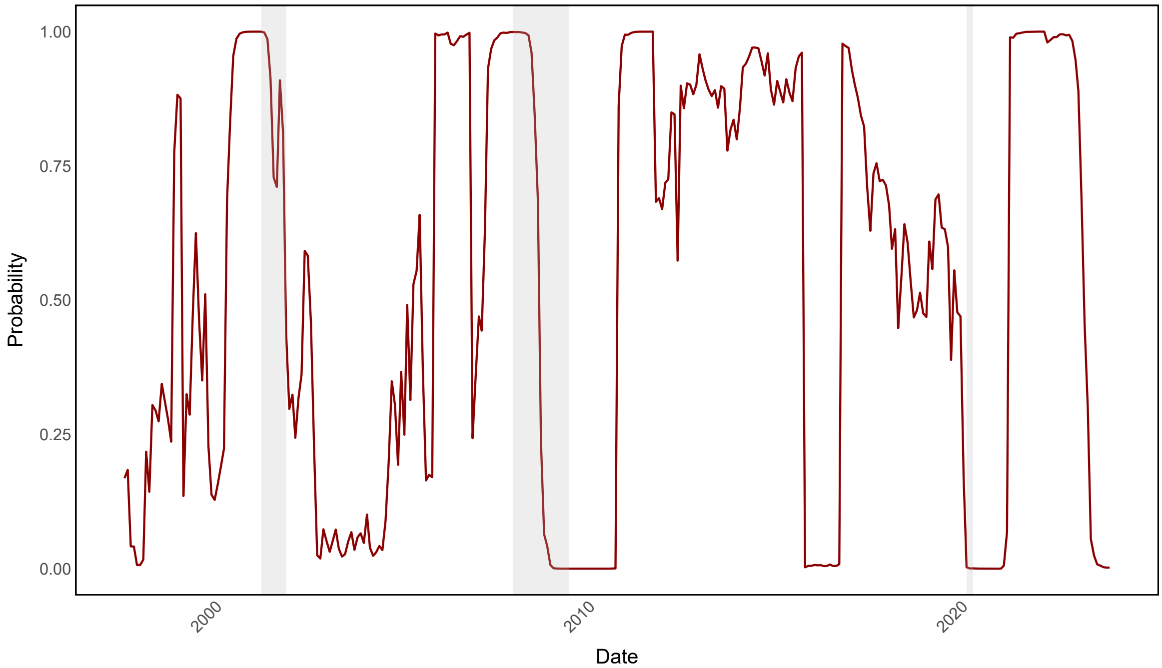
$$\pi_{t+h} - \pi_{t-1} = [1 - F(z_{t-1})](\alpha_h^L + \beta_h^L \Delta\hat{r}_t + \gamma_h^L x_t') + [F(z_{t-1})](\alpha_h^H + \beta_h^H \Delta\hat{r}_t + \gamma_h^H x_t') + \epsilon_{t+h} \tag{7}$$

Figure 6: Probability of High stress Regime in the global supply chain



Shaded areas include the Great Financial Crisis, Japan´s Tsunami, Thailand Floods, US-China Trade Wars and the COVID Pandemic. Own making.

Figure 7: Probability of High Consumer Credit Regime



Shaded areas are the Dot-com bubble, GFC and the COVID Pandemic. Own making.

There are now four regimes, where GSCPI and CDSP probabilities interact with each other. The basis of the regime extension is that its intuitive to think that different trigger variable scenarios can happen simultaneously, yet independently so, in order for regime dependent IRFs to be unassociated.

Assumption 1 *Trigger (regime-indicating) variables are orthogonal:* $z_t \perp w_t$

Orthogonality ensures that IRF are computed accurately. We argue that global supply chain pressures are orthogonal to US consumer credit levels. A simple correlation test between the GSCPI and CDSP yields $Cor(z_t, w_t) = -0.073$ with a t-statistic of -1.314, suggesting no correlation between the variables in our sample period. Domestic determinants like unemployment or consumer sentiment are not directly tied to supply chain disruptions. Moreover, we don´t consider foreign supply chain stress as a traditional determinant of household debt; if we did, other exogenous shocks that pass through supply shocks to the US economy could be considered in the normative system. Rather, we define the supply shocks consequent of global supply chain disruptions as atypical to the US.

To provider further evidence of this, we construct a VAR in order to do a multivariate Granger Causality test to see whether past values of the GSCPI are useful in forecasting Consumer Debt. We include the GSCPI, log-differenced Industrial Production, log-differenced Consumer Price Index, changes in the shadow rate, differences in the unemployment rate, consumer sentiment and the CDSP. The multivariate Granger test, essentially, allows us to see (given a set of domestic controls) if the GSCPI is granger causal to CDSP. We reject the null hypothesis of Granger Causality.[2]

We formally define the regimes as:

- Regime 1 (R_1): Low GSCPI and Low CDSP. $[1 - F(z_{t-1})][1 - G(w_{t-1})]$
- Regime 2 (R_2): Low GSCPI and High CDSP. $[1 - F(z_{t-1})][G(w_{t-1})]$
- Regime 3 (R_3): High GSCPI and Low CDSP. $[F(z_{t-1})][1 - G(w_{t-1})]$
- Regime 4 (R_4): High GSCPI and High CDSP. $[F(z_{t-1})][G(w_{t-1})]$

where $F(\cdot)$ and $G(\cdot)$ are logistic functions as in Equation 6. Our time period consists of monthly data from September 1997 to March 2024.[3] The starting point of the sample is due to data availability, as the GSCPI is publicly available since September 1997. Data is publicly available at the Federal Reserve Economic Data (FRED) website and undergoes seasonal adjustment from said database. The constructed regimes are relatively well balanced: given the sample period, the US spent 30% of the time predominantly in a low supply chain stress, high consumer debt regime. This means that for 30% of the time, the most likely regime probability out of the 4 states, is low stress and high debt. This is logical, given the temporary nature of the supply chain disruptions and increasing debt levels. The high stress and high debt regime accounted for 25% of the time, high stress and low debt for 23%, and low stress and low debt for 22%.

To highlight regime composition, we plot the probabilities. Figure 8 plots the dominant regime probability for a given month along the sample.[4] Regimes are empirically accurate: note how high debt regimes (green and yellow colours) generally correspond to either zero or lower bound interest rate periods. As well, whenever the probability of stress in the supply chains and consumer debt is high (yellow colour), consumer inflation tends to rapidly accelerate.

Consequently, the NLLP to estimate has the following form:

$$\begin{aligned}\pi_{t+h} - \pi_{t-1} = [1 - F(z_{t-1})][1 - G(w_{t-1})](\alpha_h^{R1} + \beta_h^{R1}\Delta\hat{r}_t + \gamma_h^{R1}x_t') \\ +[1 - F(z_{t-1})][G(w_{t-1})](\alpha_h^{R2} + \beta_h^{R2}\Delta\hat{r}_t + \gamma_h^{R2}x_t') \\ +[F(z_{t-1})][1 - G(w_{t-1})](\alpha_h^{R3} + \beta_h^{R3}\Delta\hat{r}_t + \gamma_h^{R3}x_t') \\ +[F(z_{t-1})][G(w_{t-1})](\alpha_h^{R4} + \beta_h^{R4}\Delta\hat{r}_t + \gamma_h^{R4}x_t') \\ +\epsilon_{t+h}\end{aligned} \tag{8}$$

[2] See Annex

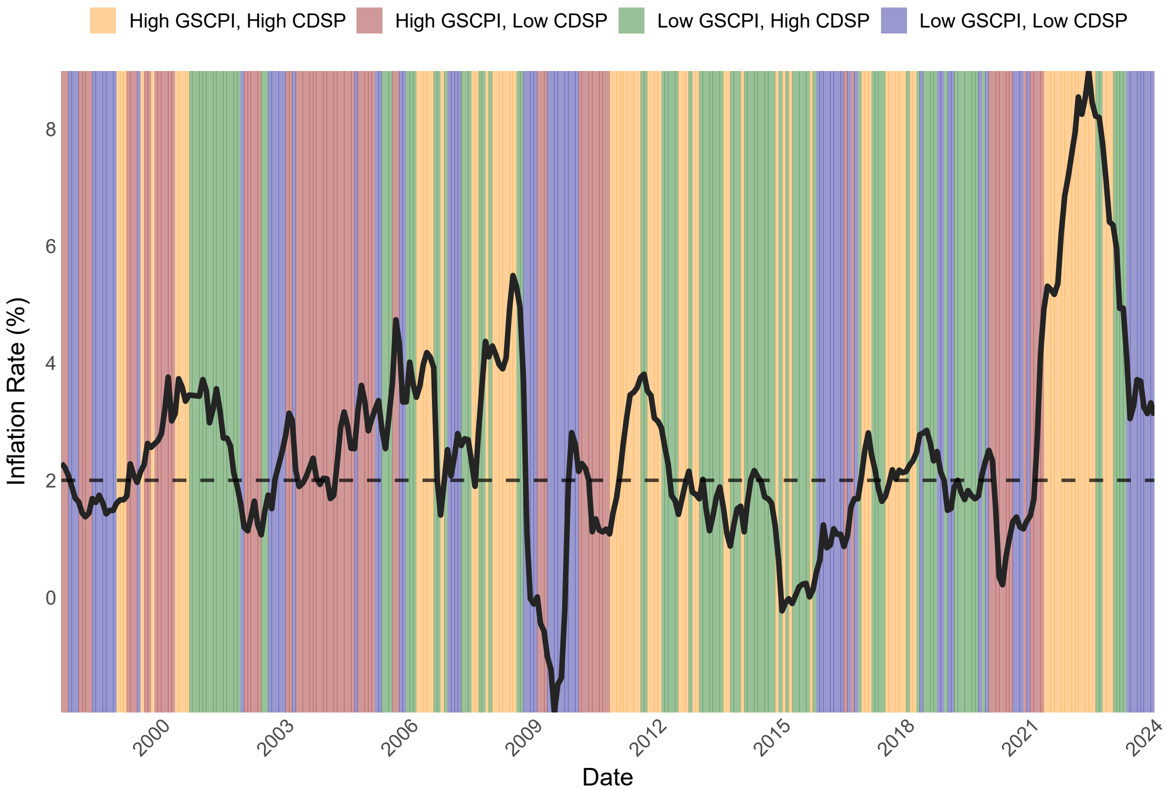
[3] We use an average for higher frequency data

[4] We maintain the regime colour scheme throughout the dissertation.

Estimating Equation 8 yields the following IRF for all regimes for $h = 1, ..., H$:

$$\begin{aligned} I\hat{R}F_{R1}(h) &= \hat{\beta}_h^{R1} \\ I\hat{R}F_{R2}(h) &= \hat{\beta}_h^{R2} \\ I\hat{R}F_{R3}(h) &= \hat{\beta}_h^{R3} \\ I\hat{R}F_{R4}(h) &= \hat{\beta}_h^{R4} \end{aligned} \tag{9}$$

Figure 8: Consumer Inflation Rate (YoY) and predominant regime probability



Inflation 2% target shown. Own making.

3.3 Data

Our baseline estimation has the same form as Equation 8, where x_t' includes the log-difference of US economic activity index ($econacti_t$) and the log-difference industrial production index (y_t) to account for economic conditions in the US. The economic activity index includes nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries changes.

Changes in 1-year inflation expectations ($\Delta E(\pi_t)$) and the log difference of producer prices (π_t^p) are used to control for changes in the expectations of the monetary stance of the FED and domestic inflationary pressures resultant from supply chain stress, respectively. The log-differenced financial volatility index (VIX_t) measures market expectations of near-term volatility conveyed by S&P 500 stock index option prices: higher VIX values indicate higher expected volatility and market uncertainty. Essentially, serves as a gauge of investor sentiment and market stress.

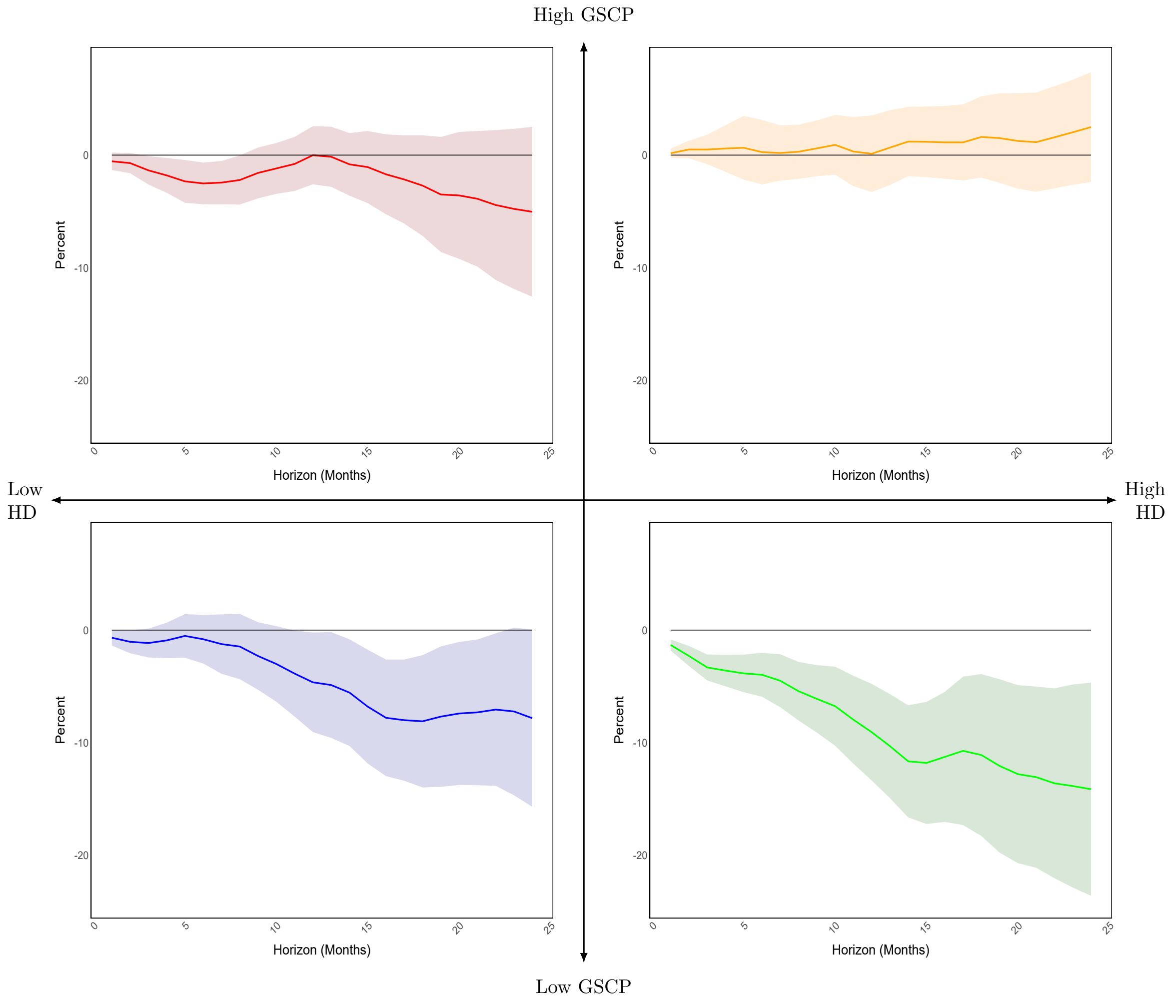
We also use regime-invariant variables such as the log-differenced oil prices (WTI_t) and changes in Moody's Seasoned Baa Corporate Bond Yield (ΔBAA_t), as well as changes in long term Treasury rates (Δi). Changes in oil prices can be directly passed through to consumer prices and indirectly through higher production and transportation costs, whilst changes in BAA yields indicate shifts in credit market conditions. Higher yields suggest higher borrowing costs for firms, which can reduce investment and spending, potentially dampening inflation. As well, long-term rates affect borrowing costs for mortgages, business loans, and other long-term investments.

4 Results

We compute the cumulative IRFs of consumer inflation π_t based on an exogenous shock of 100 basis points to the 1-year government Treasury rate $\Delta\hat{r}_t$. This is $\Delta\hat{r}_t = 1$. $\pi_t - \pi_{t-1}$ is in "long-differences", as suggested by Jordà (2023) $\pi_{t+h} - \pi_{t-1} = 100[log(CPI_{t+h}) - log(CPI_{t-1})]$. This facilitates interpretation, as $\beta_h^{R_i}$ can now be read as cumulative changes in inflation with respect to the start of the IRF for regimes $i = 1,2,3,4$. We focus on the month horizon $H = 24$, due to the response lag of at least a year as outlined by Batini and Nelson (2001).

Moreover, we account for 12 lags of Consumer Price Inflation. Inflation dynamics are inherently persistent, and past values of inflation are strong predictors of future inflation. Including lags helps capture this persistence and any delayed effects of past shocks. Lag choice is based on the Akaike Information Criterion. All other variables are used contemporaneously in order to keep the estimation of Equation 8 as parsimoniously as possible.

Figure 9: Accumulated response of the (long-difference) Consumer Price Index to a shock in monetary policy interest rate



90% confidence intervals shown. Own making.

Table 5 and Figure 9 exhibits the IRFs of consumer inflation on an exogenous monetary shock. Figure 9 is divided into 4 panels, each showcasing each regime. Vertically, we address the regime of being in either high or low supply chain pressure environments, whereas in the horizontal axis we have the same for household debt (HD) regimes.

Thus, we find that that depending on the regime of stress in the global supply chains, consumer inflation behaves differently: in a low stress environment, we have significant negative responses at least 10 months after the shock, whereas in a high stress regime, the response dissipates after the 10 month mark. This suggests that supply driven stress limits monetary policy effectiveness. The role of consumer debt amplifies the magnitude of the effect. We now address each regime separately.

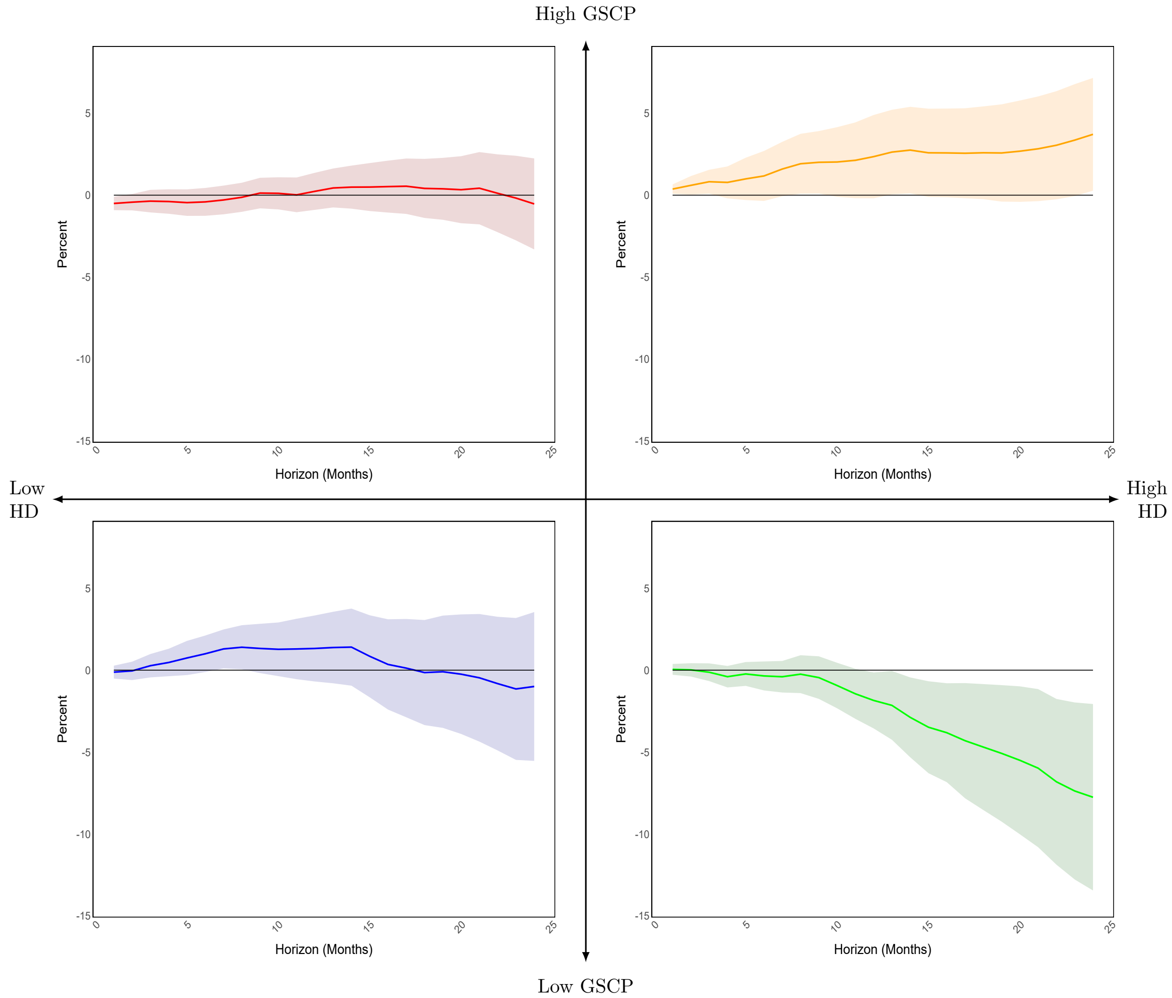
On hand hand, we have low stress in the supply chains. In a low stress, low debt regime (blue line), the accumulated decrease of inflation 12 months after the shock is -4.65%, suggesting an average response per month of 0.39%. The largest effect corresponds to the 18th month, of -8.1%. Results are significant after the 12th month. The behaviour is similar to the low stress, high debt regime (green line): however, magnitude differs considerably, given that 12 months after the shock we find a decrease of -9% in inflation. In 24 months, -14.1%.

On the other hand, negative effects dissipate in a high stress regime: in a high stress, low debt regime (red line), we find that the maximum accumulated decrease of consumer inflation is at the 6th month mark with -2.5%. The effect is not statistically significant after the 8th month. In a high stress, high debt regime (yellow line), we find no statistically significant effects.

These results suggest that whenever there's high supply chain stress, monetary policy tends to have a lesser effect on consumer inflation, if not at all, regardless of consumer debt. However, its counter intuitive that there's no clear statistical significance on the IRF. On closer inspection, this is the case because of no discernible behaviour of inflation given the sample and regime interaction. Essentially, Figure 8 shows that periods of high stress in the supply chain showcase mixed behaviour across the sample. On one hand, periods of high supply chain stress and low consumer debt (red regime) both have accelerating inflation rates (as in 2003-2006) and decelerating rates (2020). The high supply chain stress, high consumer debt (yellow regime) regime has the same dynamic, particularly when the Federal Funds was at the zero lower bound.

Moreover, we differentiate the effect on additional measures of inflation, namely services. We also focus on a durable good, such as new vehicles inflation, to showcase the sensitivity of manufactured goods that are highly dependant on global supply chain stress.

Figure 10: Accumulated response of the (long-difference) Services Consumer Price Index to a shock in monetary policy interest rate

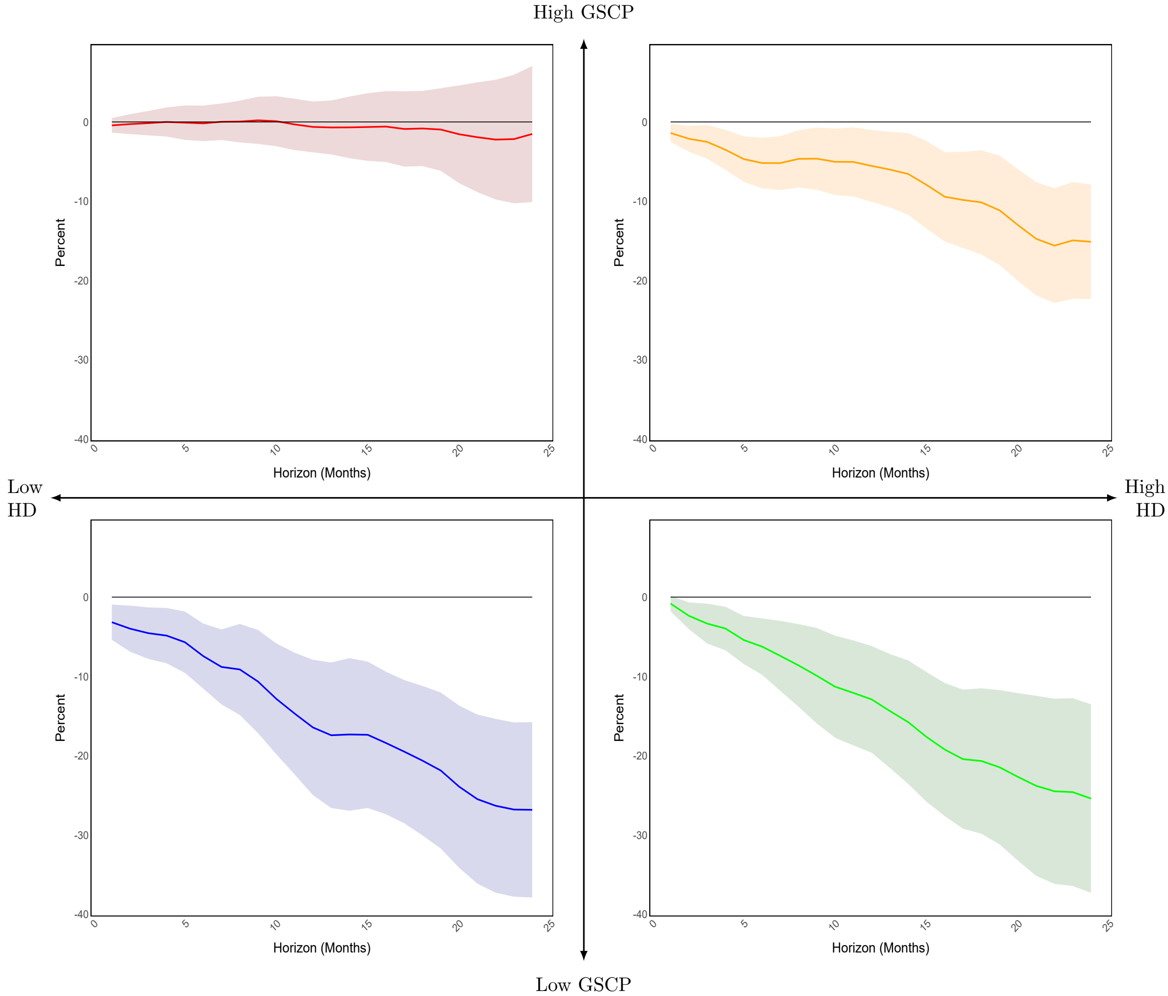


90% confidence intervals shown. Own making.

Services consumer inflation regression results are displayed in Figure 10 and Table 7. The response of services inflation, under supply chain stress, is statistically insignificant. Nonetheless, results show that whenever there´s low stress, the effect on leveraged households is statistically significant, whilst non-leveraged households is not: at the 12 month mark, we find an accumulated response of -1.8%, whereas at the 24th month, its -7.8%. This suggests that the services component of consumer inflation decreases (with a lag of 12 months) only when the credit channel is sufficiently high. Services inflation is infamously persistent.

Indebted households may face liquidity constraints: households might be forced to cut back on discretionary spending more sharply than less-indebted households, leading to a quicker and more pronounced reduction in overall demand and inflationary pressures: Cloyne et al. (2020) argues that this is particularly the case via mortgage service payment in the US. The authors also discuss how come disruptions increased the costs of various inputs and labour, contributing to higher services inflation overall.

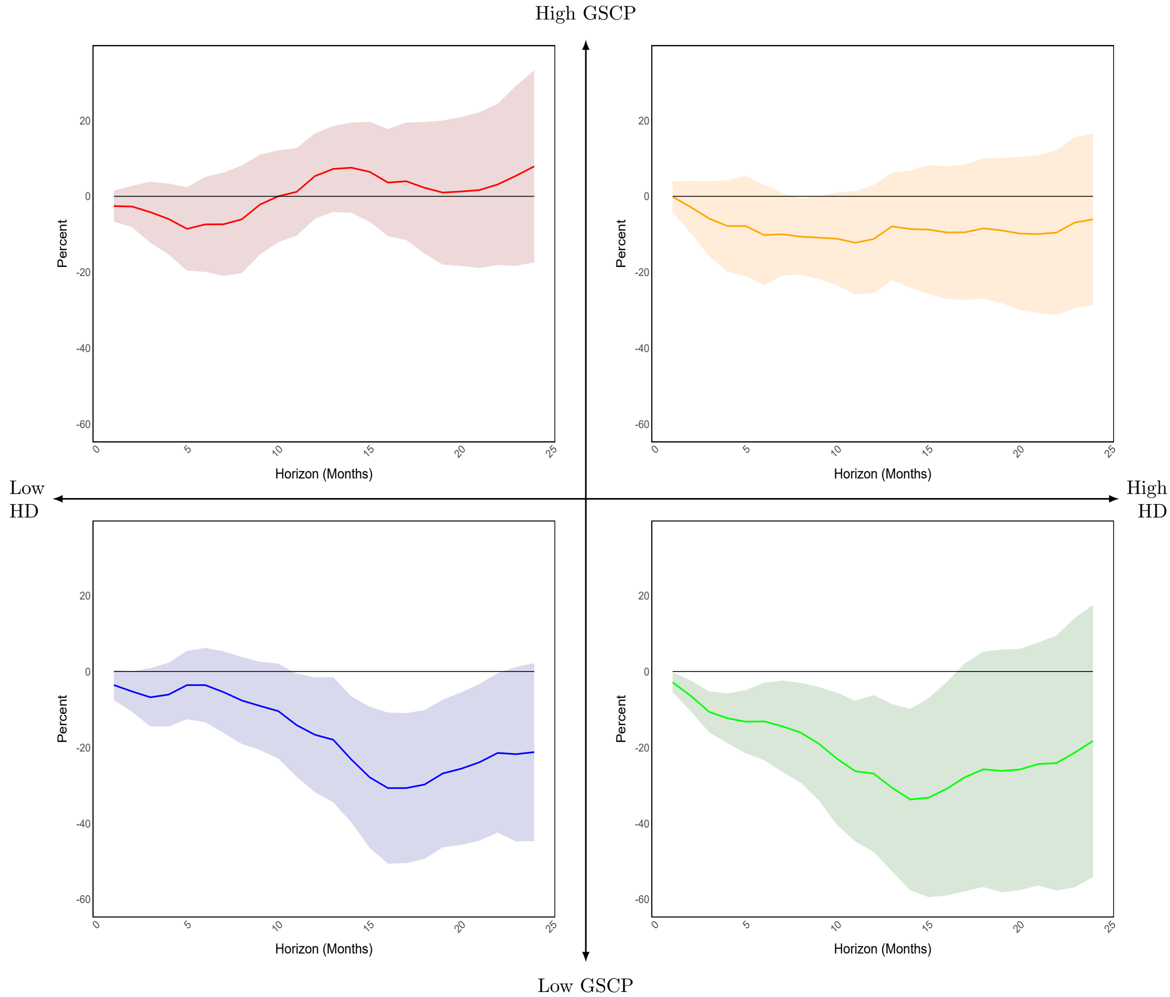
Figure 11: Accumulated response of the (long-difference) New Vehicles Consumer Price Index to a shock in monetary policy interest rate



90% confidence intervals shown. Own making.

Additionally, we use new vehicle inflation as an example of how goods that are highly dependent on global supply chains respond under different stress regimes. New vehicles are relevant, given that assembly lines are international and the car loan industry plays a critical role in the automotive and credit market. Mullin (2022) argues that in the post-pandemic inflation episode, vehicle prices increased 50% percent between January 2020 and December 2021, essentially due to chip supply shortages. Figure 11 and Table 8 display the results: we find no distinguishable difference between the IRFs of low stress regimes. This suggests that new vehicles inflation decreases following a monetary tightening irrespective of consumer debt levels whenever there's no foreign stress, with an accumulated response of -25.414% at the 24th month. This could be because durable goods income elasticity is relatively high, given the cost of car loans. On the other hand, household debt does matter in a high stress regime: we find an average accumulated response of 5.5% in the first year following the monetary shock.

Figure 12: Accumulated response of the (long-difference) Producer Price Index to a shock in monetary policy interest rate



90% confidence intervals shown. Own making.

Moreover, Figure 12 shows the IRF to a monetary policy shock to Producer Inflation: we substitute in Equation 8 the long difference Consumer Price Index by the Producer Price Index, as well as incorporating the same lag structure as in the baseline case. The rationale is that additionally to the negative relationship between stress in the supply chains and producer inflation, varying levels of consumer debt does affect producer inflation. When consumers are heavily indebted, they have less access to additional credit. Tighter credit conditions after a monetary tightening shock can limit consumer ability to finance purchases, reducing overall demand for goods. This reduced demand can pressure producers to lower prices or restrain price increases, affecting producer inflation dynamics. We find that, as in Figure 9, producer inflation responds quicker to a monetary policy shock in a low stress, high debt regime. In the low stress, low debt regime, we find an accumulated response of -15.6% at the 12 month mark, whereas in the low stress, high debt regime (green line), -25% in the 12th month. Nonetheless, the effects dissipate after the 16th month. However, in a high supply chain stress regime, we find no statistical evidence of a reduction in producer inflation, regardless of consumer debt levels. Although we find an accumulated reduction of 12% at the 8th month in the high stress, high debt regime (yellow line), effects dissipate.

4.1 Robustness exercises

We conduct different robustness exercises in order to test result consistency of estimating Equation 8. These include changing non-linearity parameter specifications, instrument specification and trigger variable w_t. Results shown in Section 7.

First, according to Hanson and Stein (2015), the two-year government bond rate is the preferred monetary policy indicator. The Federal Reserve's forward guidance strategy operates with a horizon of about two years, meaning that the central bank aims to manage expectations regarding the short-term interest rate path over this period. We therefore change Δr_t from the 1-year treasury bond rate to the 2-year. Results are qualitatively similar and shown in Table 10. Moreover, we estimate Δs_t in 2 with the Federal Funds Rate, rather than the Shadow Rate: dynamics are similar, with the difference that in the high stress, high debt regime, there´s a statistically significant reduction in inflation at the 3 month mark. We provide results in Table 11, as well as the first stage F-statistic.

Regarding the econometric specification, we change κ in the logistic transition function 6 from $\kappa = 6$ to $\kappa = 5, 8, 10$. Results are relatively similar as well, provided that κ captures regime switching behaviour. As well, 6 is estimated with either z_{t-1} or w_{t-1} to avoid feedback: whenever we use both trigger variables contemporaneously, results are similar. Finally, we change parameter $\lambda = 129,600$ in the Hodrick-Prescott filter to $\lambda = 64800, 32400$: IRF dynamics are qualitatively similar to the baseline case of $\lambda = 129,600$.

Finally, regarding the consumer debt trigger variable w_t, we use the Consumer Debt Service Payment variable as an alternative trigger, in order to not use the proxy of consumer credit. To do so, we interpolate the quarterly data into monthly frequency with the Chow-Lin method, as proposed by Chow and Lin (1971), with consumer credit as the higher frequency indicator variable. Results are similar to baseline.

In sum, the NLLP estimated in the robustness checks is, generally, qualitatively the same. This suggests that the relative effectiveness of monetary policy, strengthened when consumers are more indebted, is similar among specifications. This has two main implications. Firstly, robustness checks support baseline results: the credit transmission mechanism does not ease inflationary pressures whenever there´s supply chain stress. Secondly, robustness check results indicate that the effect of an increase in the monetary policy rate on inflation, in the first 12 months, differs given consumer debt when there´s no supply chain stress.

5 Policy Implications and Concluding Remarks

The findings of this dissertation highlight the limitations in monetary policy. Recall that exogenous supply shocks create persistent inflationary pressures: given increased stress due to the US economy size and exposure to global supply chains, consumers reducing consumption to payoff debt does not prove to be of substantial difference in deterring the adverse effects of the supply shock. This is to be expected, as inflation drivers are out of reach of the Federal Reserve and a reduction on spending would not ease imported goods inflation.

However, this does not mean that consumer debt is not a reliable transmission mechanism for monetary policy. We find that one year after a contractionary monetary policy, the accumulated reduction of headline inflation is almost twice as effective whenever consumers are indebted. The relationship stands for 24 months. This is important, given that the low supply chain stress regime accounts for more than 50% of the time in the data sample.

The results underline the critical need for policymakers to consider the interaction between global supply chain stress and consumer debt when formulating monetary policy, and more broadly, how to brace for an exogenous shock given the contemporaneous characteristics of the economy. Rather than being wary of exogenous supply shocks, exposure to the global markets intrinsically involves an increased risk of inflation. The 1973 oil crisis, 1997 Asian financial crisis and the 2011 European debt crisis all ignited periods of inflationary pressures. Such risk should be mitigated domestically, and although the consumer debt channel proves to be a weak deterrent of supply chain disruptions, further research could show its effectiveness given other shocks. Supply chain disruptions, generally, are difficult to forecast. The ensuing scarcity in inputs is unexpected: shocks like weather conditions could have a seasonal component that may enable the transmission channel to be effective, given the consumer's knowledge of the adverse weather.

Overall, our analysis emphasises that with the growing financial integration, the Federal Reserve should be aware of the increasing obstacle supply chain disruptions are for monetary policy. However, results are subject to caveats, which of course are potential research developments: first, a formal evaluation of the transmission mechanisms should be done to objectively select which one (or ones) could offset the exogenous supply shocks the most. Further research could contrast these results with arguable the most effective mechanism: inflation expectations. Moreover, we do not delve into the effect of money/credit on prices and fiscal policy, both of which do set a response to the foreign shocks. Secondly, access to high frequency data could improve the instrument´s validity as its commonly done in the literature. Thirdly, a formal and empirical statement on Assumption 1: assessing the pass-through of supply chain pressures into the US, particularly in setting consumption, spending and indebtedness behaviour, would be useful.

Overall, the present dissertation innovated the non linear local projection estimation method in order to incorporate more information in inflation dynamics. Although subject to extensions and further work, the proposed framework tentatively works. This opens up research possibilities in the lines of regime switching analysis.

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7 Annex

Table 1: Variables utilised

Variable	Source
Global Supply Chain Pressure Index	Federal Reserve Bank of New York
Total Consumer Credit (SA)	FRED
Consumer Debt Service Payment (SA)	FRED
Shadow Federal Funds Rate	Federal Reserve Bank of Atlanta
Federal Funds Effective Rate	FRED
Consumer Price Index (SA)	FRED
Services Consumer Price Index (SA)	FRED
New Vehicles Consumer Price Index (SA)	FRED
Producer Price Index (SA)	FRED
Economic Activity Index (SA)	FRED
Industrial Production Index (SA)	FRED
1-year Inflation Expectations	FRED
Financial Volatility Index (VIX)	FRED
Crude Oil Prices: West Texas Intermediate (WTI)	FRED
Moody's Seasoned Baa Corporate Bond Yield	FRED
1-year yield on US Treasuries	FRED
2-year yield on US Treasuries	FRED
5-year yield on US Treasuries	FRED
10-year yield on US Treasuries	FRED
30-year yield on US Treasuries	FRED
30-Year Fixed Rate Mortgage	FRED

The Federal Reserve Bank of Atlanta stopped updating the series in February 2022. We extended it using the observed Federal Funds Rate values thereafter. FRED stands for Federal Reserve Economic Data. SA stands for seasonally adjusted.

Table 2: Phillips–Perron unit root test for variables used in baseline results

Variable	Constant	Constant + Trend
π_t	-10.4906***	-10.5357***
π_t^p	-11.8116***	-11.7952***
$\Delta E(\pi_t)$	-23.1595***	-23.1344***
y_t	-14.2985***	-14.2944***
$econacti_t$	-17.5712***	-17.5485***
VIX_t	-18.4049***	-18.3696***
WTI_t	-13.3987***	-13.3805***
Δi_t^5	-13.2954***	-13.3707***
Δi_t^{10}	-13.8241***	-13.8748***
Δi_t^{30}	-14.0179***	-14.0581***
ΔBAA_t	-11.8604***	-11.8605***
Δi_t^M	-12.8293***	-12.8946***

The null hypothesis indicates the presence of a unit root.

Table 3: Instrumental variable 1st regression results

Dep. variable: Δr_t	Inflation (2nd stage)				
	Consumer	Services	New Vehicles	Producer	(Δr_t 2 year yield)
Estimate: ψ	0.263764	0.263599	0.268036	0.263764	0.142568
Standard Error	0.023685	0.023739	0.023997	0.023685	0.016800
t stat p-value	$< 2e-16$	$< 2e-16$	$< 2e-16$	$< 2e-16$	$9.31e-16$
F stat p-value	$< 2.2e-16$	$< 2.2e-16$	$< 2.2e-16$	$< 2.2e-16$	$< 2.2e-16$

Table 4: Multivariate Granger Causality Test results

	F	df1	df2	p	χ^2	df	p
CDSP $\Leftarrow$ GSCPI	0.54	3	291	0.657	1.61	3	0.656

F test and Wald χ^2 test based on VAR(3) model

VAR models describe the simultaneous evolution of multiple variables over time, making them useful for examining interdependencies among these variables. Granger causality, introduced by Granger (1969), is a method for detecting weak causal relationships between time series. The essence of Granger causality is that if the forecast of one time series improves when information from a second time series is included, the second time series is said to Granger-cause the first.

We therefore construct a VAR with the following stationary variables: GSCPI, log-differenced Industrial Production, log-differenced Consumer Price Index, changes in the shadow rate, differences in the unemployment rate, consumer sentiment and the CDSP. We fit a VAR(3) as suggested by the Akaike Information Criterion.

The null hypothesis for Granger causality is that the inclusion of lagged values of variable x_t does not improve the prediction of variable y_t. Mathematically, this is expressed as:

$$H_0 : \gamma_1 = \gamma_2 = \cdots = \gamma_p = 0$$

If the null hypothesis is rejected, it implies that the coefficients of the lagged values of x_t (γ_i) are significantly different from zero, indicating that x_t Granger-causes y_t. Results shown in Table 4 provide evidence that we cannot reject H_0. Although results do not formally test orthogonality, we show evidence that global supply chain disruptions, when controlling for domestic debt determinants, do not improve consumer debt forecasts.

Table 5: Accumulated response of Consumer Inflation to a shock in monetary policy interest rate under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	-0.686	-0.551	-1.331***	0.17
2	-1.055*	-0.704	-2.307***	0.50
3	-1.167	-1.355*	-3.322***	0.51
4	-0.929	-1.813*	-3.601***	0.60
5	-0.528	-2.357**	-3.854***	0.67
6	-0.827	-2.543**	-3.984***	0.29
7	-1.263	-2.462**	-4.512***	0.21
8	-1.485	-2.238*	-5.442***	0.32
9	-2.321	-1.59	-6.113***	0.62
10	-3.019	-1.186	-6.763***	0.93
11	-3.873*	-0.787	-7.963***	0.34
12	-4.647*	-0.018	-9.073***	0.14
13	-4.879*	-0.155	-10.314***	0.69
14	-5.551*	-0.827	-11.662***	1.22
15	-6.799**	-1.072	-11.801***	1.19
16	-7.793**	-1.714	-11.27***	1.14
17	-8.017**	-2.168	-10.732***	1.14
18	-8.118**	-2.718	-11.097**	1.62
19	-7.694**	-3.497	-12.058***	1.52
20	-7.414*	-3.587	-12.783***	1.27
21	-7.289*	-3.905	-13.047***	1.16
22	-7.032*	-4.475	-13.591***	1.59
23	-7.192	-4.825	-13.83**	2.04
24	-7.777*	-5.073	-14.106**	2.50

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 6: Accumulated response of Core Consumer Inflation to a shock in monetary policy interest rate under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	0.338	-0.1	-0.045	0.155
2	0.332	-0.147	-0.232	0.34
3	0.236	-0.083	-0.482	0.466*
4	0.333	-0.173	-0.876**	0.347
5	0.617	-0.31	-1.065**	0.362
6	0.93	-0.469	-1.334***	0.314
7	1.257*	-0.562	-1.672***	0.454
8	1.68**	-0.507	-1.883***	0.647
9	1.631*	-0.539	-2.254***	0.75
10	1.526	-0.498	-2.61***	0.815*
11	1.539	-0.661	-2.965***	0.918*
12	1.49	-0.63	-3.49***	0.869
13	1.456	-0.819	-4.061***	0.802
14	1.401	-1.134*	-4.713***	0.63
15	1.229	-1.415*	-5.368***	0.44
16	1.226	-1.446*	-5.63***	0.494
17	1.204	-1.544*	-6***	0.48
18	0.948	-1.58*	-6.173***	0.523
19	0.811	-1.703**	-6.501***	0.412
20	0.42	-1.829**	-6.92***	0.295
21	0.094	-1.791*	-7.343***	0.238
22	0.091	-1.953*	-7.768***	0.323
23	0.044	-2.091*	-7.967***	0.472
24	0.152	-2.197*	-8.053***	0.714

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 7: Accumulated response of Services Consumer Inflation to a shock in monetary policy interest rate under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	-0.12	-0.505**	0.047	0.373**
2	-0.044	-0.427	0.017	0.6*
3	0.271	-0.364	-0.127	0.821*
4	0.468	-0.388	-0.399	0.78
5	0.743	-0.455	-0.232	0.994
6	0.999	-0.41	-0.353	1.173
7	1.295*	-0.292	-0.402	1.595
8	1.399*	-0.129	-0.245	1.918*
9	1.325	0.128	-0.454	2.007*
10	1.273	0.112	-0.938	2.025
11	1.293	0.02	-1.443	2.129
12	1.324	0.235	-1.848*	2.353
13	1.381	0.44	-2.149*	2.631*
14	1.406	0.491	-2.881*	2.752*
15	0.846	0.496	-3.483**	2.586
16	0.35	0.523	-3.817**	2.579
17	0.123	0.547	-4.304**	2.56
18	-0.147	0.412	-4.694**	2.588
19	-0.097	0.388	-5.079**	2.576
20	-0.246	0.334	-5.502**	2.685
21	-0.467	0.425	-5.981**	2.831
22	-0.823	0.115	-6.813**	3.048
23	-1.148	-0.178	-7.374**	3.36
24	-0.996	-0.534	-7.756**	3.714*

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 8: Accumulated response of New Vehicles Consumer Inflation to a shock in monetary policy interest rate under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	-3.166**	-0.44	-0.816	-1.395**
2	-3.983**	-0.27	-2.357**	-2.126**
3	-4.55**	-0.16	-3.341**	-2.519*
4	-4.859**	-0.01	-3.958**	-3.516**
5	-5.694**	-0.10	-5.412***	-4.686***
6	-7.442***	-0.18	-6.236***	-5.188***
7	-8.81***	0.01	-7.412***	-5.197**
8	-9.127***	0.05	-8.617***	-4.662**
9	-10.659***	0.20	-9.922***	-4.637*
10	-12.841***	0.09	-11.302***	-5.032**
11	-14.692***	-0.32	-12.086***	-5.049*
12	-16.443***	-0.63	-12.906***	-5.553**
13	-17.431***	-0.70	-14.375***	-6.017**
14	-17.334***	-0.69	-15.773***	-6.568**
15	-17.373***	-0.65	-17.637***	-7.943**
16	-18.409***	-0.59	-19.232***	-9.444***
17	-19.501***	-0.89	-20.446***	-9.849***
18	-20.639***	-0.83	-20.677***	-10.149**
19	-21.885***	-0.97	-21.471***	-11.157***
20	-23.915***	-1.56	-22.679***	-13.005***
21	-25.494***	-1.93	-23.809***	-14.747***
22	-26.328***	-2.24	-24.498***	-15.609***
23	-26.806***	-2.17	-24.604***	-14.953***
24	-26.84***	-1.53	-25.414***	-15.124***

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 9: Accumulated response of Producer Inflation to a shock in monetary policy interest rate under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	-3.562	-2.58	-2.84*	-0.108
2	-5.254	-2.69	-6.436**	-2.855
3	-6.787	-4.19	-10.618***	-5.857
4	-6.068	-5.98	-12.315***	-7.833
5	-3.576	-8.57	-13.213***	-7.828
6	-3.583	-7.40	-13.139**	-10.195
7	-5.422	-7.36	-14.426**	-10.002
8	-7.628	-6.06	-16.077**	-10.625*
9	-9.072	-2.16	-19.019**	-10.894
10	-10.436	0.01	-22.997**	-11.178
11	-14.123*	1.18	-26.272**	-12.232
12	-16.66*	5.32	-26.88**	-11.247
13	-17.967*	7.21	-30.589**	-7.924
14	-23.206**	7.54	-33.714**	-8.616
15	-27.876**	6.45	-33.234**	-8.761
16	-30.712**	3.61	-30.889*	-9.524
17	-30.7**	3.97	-27.828	-9.481
18	-29.771**	2.24	-25.761	-8.441
19	-26.842**	0.99	-26.174	-8.989
20	-25.61**	1.27	-25.816	-9.819
21	-23.912*	1.64	-24.369	-9.943
22	-21.446*	3.12	-24.126	-9.551
23	-21.771	5.41	-21.374	-6.923
24	-21.241	7.89	-18.282	-6.074

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 10: Accumulated response of Consumer Inflation to a shock in monetary policy interest rate (2-year treasury bond) under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	0.012	-0.094	-0.344	0.553*
2	-0.335	-0.369	-1.004*	0.8
3	-0.231	-0.659	-1.451*	1.107
4	-0.434	-1.264	-1.822	0.875
5	-0.598	-2.362*	-2.445**	0.389
6	-1.009	-2.967*	-2.678**	-0.228
7	-1.268	-3.214*	-3.028*	-0.367
8	-1.701	-3.468*	-4.088**	-0.73
9	-2.346	-3.322*	-4.724**	-0.771
10	-2.809	-2.943	-5.097**	-0.618
11	-3.142	-2.221	-5.658**	-0.854
12	-3.754*	-1.664	-6.675**	-1.046
13	-4.207*	-2.154	-7.996**	-0.916
14	-4.566*	-2.771	-8.915***	-0.512
15	-5.389**	-3.267	-9.12**	-0.714
16	-6.016**	-3.97	-8.772**	-0.763
17	-5.924**	-4.229	-8.056*	-0.505
18	-5.646*	-4.594	-8.087*	0.152
19	-5.48*	-5.595	-9.13*	-0.179
20	-5.868**	-6.19	-10.251**	-0.953
21	-6.17**	-6.708*	-10.84**	-1.43
22	-5.583**	-7.184*	-11.194**	-0.872
23	-5.701**	-7.796*	-11.505**	-0.56
24	-6.168**	-8.357*	-11.715**	-0.273

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$

Table 11: Accumulated response of Consumer Inflation to a shock in monetary policy interest rate (Federal Funds surprises as Instrument) under different regimes

Horizon	R1 Low GSCP, Low HD	R2 High GSCP Low HD	R3 Low GSCP High HD	R4 High GSCP High HD
1	-0.873**	-0.894**	-1.588***	-0.478
2	-1.487***	-1.037	-2.702***	-0.641
3	-1.968***	-1.892**	-4.219***	-1.395*
4	-1.837*	-2.54**	-4.865***	-2.111*
5	-1.128	-2.896**	-4.949***	-2.129
6	-1.297	-2.747**	-4.64**	-2.213
7	-0.965	-2.441*	-4.395**	-1.37
8	-0.649	-1.951	-4.976**	-0.66
9	-1.193	-1.092	-5.369**	0.056
10	-1.716	-0.624	-5.958**	0.456
11	-2.582	-0.434	-7.669**	-0.597
12	-3.265	0.242	-9.097**	-0.725
13	-3.313	0.052	-10.378**	0.035
14	-3.605	-0.657	-11.328**	0.708
15	-4.777*	-1.311	-11.704***	0.284
16	-6.1**	-2.841	-12.096**	-0.291
17	-6.819***	-3.637	-12.174**	-0.786
18	-6.805**	-4.519	-12.911**	-0.436
19	-6.388**	-5.2	-14.196**	-0.632
20	-6.557**	-5.545	-15.582**	-1.366
21	-6.791**	-6.234*	-16.724**	-1.966
22	-6.714**	-7.093*	-17.826**	-1.523
23	-7.089**	-7.546*	-18.108**	-0.878
24	-7.368**	-7.846	-18.057**	-0.013

Statistical significance: $* < 0.10, ** < 0.05, *** < 0.01$