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Back to Basics: Sticky Prices in the Monetary Transmission Mechanism

Nicolás De Roux[*†]

Abstract

I use the measures of frequency of price adjustment in Nakamura and Steinsson (2008) to show that stickier price industries have higher levels of output response to monetary policy shocks. Using a Vector Auto-regression model, I build different measures of response to a monetary policy shock of 14 US industries. These measures are shown to be related to the level of price rigidity. More precisely, I find that if firms within an industry change prices twice as often as firms in another industry, output deviation from trend in response to a negative shock of 25 basis points will be 69 percentage points smaller in the less sticky industry. This result is stronger when I account for measurement error in the level of response.

Key words: monetary transmission mechanism, interest rate, sticky prices, financial frictions.

JEL Classification: E31, E40, E52

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VOLVIENDO A LO FUNDAMENTAL: LAS RIGIDECES EN PRECIOS Y EL MECANISMO DE TRANSMISIÓN MONETARIA

Nicolás De Roux[*†]

Resumen

En este documento utilizo las frecuencias en el ajuste de precios de Nakamura y Steinsson (2008) para mostrar que las industrias que son más rígidas en precios tienen niveles más altos de respuesta a un choque de política monetaria. Mediante un análisis de Vector Autoregresivo (VAR), construyo diferentes medidas de respuesta a un choque de política monetaria para 14 industrias en los Estados Unidos y muestro que están relacionadas con el nivel de rigidez en precios de la industria. Más precisamente, si las firmas de una industria cambian los precios con una frecuencia dos veces más alta que las de otra industria, la desviación del producto de su tendencia, en respuesta a un choque negativo de 25 puntos básicos, es 69 puntos porcentuales menor en la industria menos rígida. Este resultado es más fuerte cuando corrijo por error de medición en el nivel de respuesta.

Plabras clave: monetary transmission mechanism, interest rate, sticky prices, financial frictions.

Códigos JEL: E31, E40, E52

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1. Introduction

One of the cornerstones of Keynesian and New Keynesian theories is that aggregate demand is the driving force of short-run economic fluctuations. If demand shifts due to nominal or real factors, real output is affected. But the effect of a shift in aggregate demand depends crucially on the shape of the supply curve. The more elastic it is, the larger the effects of disturbances of the aggregate demand curve.

The work by Ball, Mankiw and Romer (1988) entitled *The New Keynesian Economics and the Output-Inflation Trade-Off* was among the firsts to find empirical evidence confirming the New Keynesian interpretation of business cycles. At the time, the neoclassical alternative to explain how monetary policy could affect output equilibrium was Lucas' imperfect information model (Lucas, 1972). Much of the contribution by Ball, Mankiw and Romer consisted in showing that cross-country evidence provides support to New Keynesian theories as opposed to Lucas' model. To do so, they start with a basic result from their model: higher average levels of inflation involve a) more frequent price adjustment, b) a steeper Phillips curve[1] and so c) a faster transformation of nominal demand changes into price changes. In this context of high average inflation, nominal shocks should have smaller real effects. The authors find that real output is less affected by changes in nominal demand in countries with higher levels of inflation. In other words, in these countries the Phillips curve is steeper.

From this perspective and at the country level, one can argue that each sector in a given economy faces specific aggregate supply and demand curves and that the interaction between them accounts for the fluctuations in real industry output. If this argument is correct, sectors with more elastic supply curves should show larger changes in output in response to aggregate demand shocks. Now, many models have stressed the direct relation between sticky prices and the slope of the supply curve. A larger prevalence of price stickiness is associated with a flatter supply curve. So, for example, if the frequency of price adjustment of the wood industry is low (indicating that wood prices are sticky), shifts in the aggregate demand for wood should have a high impact in the level of real production. The work by Ball, Mankiw and Romer establishes a relation between the frequency of price adjustment and the real effect of aggregate nominal demand at the country level; in this document, I establish the same relationship at the industry level for the US.

More specifically, the hypothesis of this document is that more rigid sectors (i.e. sectors with a low frequency of price adjustment) have higher levels of response to nominal disturbances implying that sticky prices play a central role in the real side of the monetary transmission mechanism[2]. I use the measures of frequency of price adjustment in Nakamura and Steinsson (2008) to show that stickier price industries have higher level of output response to monetary policy shocks. Using the vector

[1] The Phillips curve is in essence a reformulation of the aggregate supply curve.

[2] It is important to say that I focus exclusively on the real side (as opposed to the nominal side) of the monetary transmission mechanism. How nominal shocks affect prices, relative prices and inflation is a relevant and interesting question but falls outside the scope of the present work.

auto-regression (VAR) methodology, I build different measures of response to a monetary policy shock of 14 US industries. These measures are shown to be related to the level of price rigidity. More precisely, if firms within an industry change prices twice as often as firms in another industry, output deviation from trend in response to the shock will be 69 percentage points smaller in the less sticky industry. This result is consistent with the sticky price interpretation of economic fluctuations and of the monetary transmission mechanism.

The VAR-related literature has made successful attempts to explain how sector-specific real production reacts to monetary policy shocks and why the levels of response differ across industries (e.g. Ganley and Salmon, 1997, Dedola and Lippi, 2005). These studies provide valuable insights concerning the monetary transmission mechanism. But curiously enough, they did not use used the heterogeneity in output responses to prove the hypothesis that the level of response varies with the level of price rigidity of the industry. Instead, they focused on financial frictions to explain the different levels of response. In this document, I fill this gap by showing that industry specific levels of response to nominal shocks are also related to the level of price stickiness so that the supply side of the monetary transmission mechanism can be in part explained by sticky prices.

As an alternative way to test my hypothesis (that more rigid sectors have higher levels of response to nominal disturbances), I use the measure of monetary policy shocks of Romer and Romer (2004) – a measure of policy stance that is free of endogeneity and anticipatory movements – and estimate industry-specific response to this type of shocks. Again, the heterogeneity across industries in the level of response is related to price rigidities.

The rest of the paper is organized as follows. Section 2 discusses previous literature on the sectoral response to monetary policy shocks and offers an alternative explanation of the different levels of response across industries, one that is related to price stickiness. In section 3, I use as robustness exercise the shocks of Romer and Romer (2004). I section 4, I discuss the results. Finally, section 4 concludes.

2. Sticky Prices and Sectoral Output Response to Monetary Policy Shocks

2.1. Previous Literature

The literature studying the sector specific response to monetary policy shocks is extensive and has covered a large number of countries. Ganley and Salmon (1997) estimate a VAR for different manufacturing sectors in England and find different levels of response of real sectoral production. The authors show that sectors with smaller firms are more prone to show higher levels of response to shocks, indicating that the credit channel of the monetary transmission mechanism is relevant[3]. For the

[3] The argument is as follows: Information on the creditworthiness of small firms is harder to obtain than for large firms. Thus, the latter have easier access to external funds from capital markets where information is pulled by rating agencies and dispersed investors use it to make decisions. Small

US, Barth and Ramey (2001) estimate the effects of monetary policy shocks across manufacturing industries and find significant differential levels of output and price response. They relate these differences to a cost channel of monetary policy: an increase in the interest rate increases the costs faced by firms if working capital is an essential component of production, which in turn reduces production and increases relative prices.

Some authors have argued that expenditure in durable goods is more interest rate sensitive than expenditure in non-durable goods either because it fluctuates more or because it is financed over several periods and involves interest payments. In the same line, Erceg and Levine (2006) using the VAR approach show that sectors that produce durable goods are more interest rate sensitive than sectors producing non-durables. One can interpret this result from an aggregate demand perspective: the magnitude of the shift of the sector specific demand depends on the durability of the sector's product. Aggregate demand for durables is affected to a greater extent by interest rate shocks than for non-durables.

In an analysis similar to Barth and Ramey's, Dedola and Lippi (2005) estimate a VAR for 21 manufacturing sectors in five countries of the OECD (including the US) and try to explain the heterogeneity in the levels of output response by the characteristics of the firms in each sector. After computing different measures of output response they regress the result on various measures of financial features which include: working capital, financial structure, short-term debt, industry mean size, financial leverage and interest rate burden. All these measures are related to a supply side channel of the monetary transmission mechanism. To account for the traditional demand channel, they include in their regressions a durability dummy. They find that most of the financial measures are significantly related to the level of response of the industry and with the expected sign[4]. They conclude that the output effect of monetary policy shocks depends on both the traditional demand channel and the supply channel, with the latter resting upon financial restrictions on the firms' production decisions.

None of the studies suggests that the industry level of response depends on its level of price rigidity. To the best of my knowledge, there are only two papers that directly relate output and price responses to monetary policy shocks and price rigidity. The first is by Bils, Klenow and Krystov (2003)[5]. These authors use measures of price stickiness across different consumption categories in the US and test the hypothesis that sticky-price goods are more responsive to monetary policy shocks. In order to

firms have to resort to banks instead because they usually have high expertise in risk evaluation. As a result, small firms are more dependent on bank loans, which in turn are more interest-rate sensitive. Harder access to other financing mechanisms makes their output more dependent on interest rates.

[4] For example, the working capital variable, a proxy of industry's short-term financing requirements is statistically significant and has the expected sign: industries with higher levels of working capital tend to have higher levels of response to monetary policy shocks. The durability dummy is also significant, suggesting that the traditional demand channel is of relevance. Even more, the heterogeneity they find in the levels of response is related to sector rather than country characteristics.

[5] In a paper closely related to this study, Nakamura and Steinsson (2010) study the implications on aggregate output of the heterogeneity of price adjustment in a menu cost model.

do so, they match series of prices and quantities consumed from the Bureau of Economic Analysis (BEA) with the BLS consumption categories for which they have previous estimates of the frequency of price adjustment. The interest rate shocks series is taken directly from the estimates of Christiano, Eichenbaum, and Evans (1999) that use the VAR approach to assess the impact of monetary policy on different macroeconomic variables. Bils, Klenow and Krystov conclude that the responses of relative quantities and prices do not correspond to those predicted by standard sticky price models: after a monetary expansion, prices for flexible goods decrease relative to prices of sticky goods and the relative quantities remain unchanged for the first year. As I discuss below, my results contrast sharply with their findings.

The second paper that uses US disaggregated data to test the validity of sticky price models is by Boivin, Giannoni and Mihov (2009). They gather 355 series on personal consumption expenditure and their respective prices from the BEA and use a factor-augmented vector auto-regression model (FAVAR) to study the fluctuations in disaggregated prices. This methodology allows them to distinguish the influences of macroeconomic shocks and sectoral shocks on sectoral prices. Among many important findings, one of their main conclusions is that sectoral prices respond differently to sectoral shocks than to macroeconomic shocks. This might explain why sticky price models are popular in explaining fluctuations of aggregated variables but have been criticized by authors working with disaggregated data.

In a way, their paper is a response to the work of Bils, Klenow and Krystov (2003). By separating macroeconomic shocks from sectoral ones, they show that fluctuations in disaggregated prices are not completely at odds with sticky price models. Related to the results that will be presented below, they show that sectors in which prices respond less to shocks also show higher levels of response in consumption expenditure. They also show that more competitive industries have greater price flexibility. Both findings support the sticky price interpretation of output and price responses to monetary policy shocks. Nonetheless Boivin, Giannoni and Mihov focus on price dynamics and say little on the response of quantities to monetary policy shocks and its relation to price rigidity. Furthermore, they work with data on consumption expenditure that might not be directly related to the sector-specific dynamics of real output. In contrast, I focus on output fluctuations using indexes of production of different industries.

Most of the literature that has studied the sectoral response to monetary policy shocks has argued that the different responses between sectors relate to financial frictions. The papers that I just mentioned that use disaggregated US data to test the validity of sticky price theories have focused on prices and have not used data on real industry output to test the hypothesis that more rigid sectors have higher levels of response to nominal demand shocks. By using measures of frequency of price change and real industrial output, I show that industry specific levels of response are related to the level of price stickiness so that the supply side of the monetary transmission mechanism can be in part explained by sticky prices.

2.2. Data and Empirical Strategy

I estimate a VAR for fourteen industries in the US economy. The VAR is based on the following linear model of the economy:

$$\boldsymbol{Y}_t = \sum_{s=0}^{S} \boldsymbol{B}_s \boldsymbol{Y}_{t-s} + \sum_{s=1}^{S} \boldsymbol{C}_s \; i_{t-s} + \mathbf{A}^y \boldsymbol{v}_t^y \qquad (1)$$

$$p_t = \sum_{s=0}^{S} \boldsymbol{D}_s \boldsymbol{Y}_{j,t-s} + \sum_{s=1}^{S} \boldsymbol{g}_s p_{t-s} + \boldsymbol{v}_t^p \qquad (2)$$

Bold letters refer to a vector or a matrix. $\boldsymbol{Y}_t$ is a vector of non-policy macroeconomic variables. is the measure of monetary policy stance. $\boldsymbol{Y}_t$ depends on its lags and on monetary policy of previous periods. It is assumed that current monetary policy doesn´t affect current macroeconomic variables. $\boldsymbol{v}_t^y$ is a vector of shocks in the macroeconomic variables and $\boldsymbol{v}_t^p$ corresponds to the monetary policy shock. $\boldsymbol{B}_s$, $\boldsymbol{C}_s$, $\boldsymbol{A}^y$ and $\boldsymbol{D}_s$ are matrix coefficients.

I estimate the VAR using quarterly data. The included variables are (in order): (1) quarterly GDP: Natural Logarithm of Real GDP (in billions of chained 2000 dollars and seasonally adjusted at annual rates), hereafter denoted by $\boldsymbol{y}$. (2) Natural logarithm of quarterly industry production index (seasonally adjusted). (3) Implicit Price Deflator for Gross Domestic Product. (4) Index of Spot Commodity Prices. (5) FED's Fund Rate: Effective Federal Funds Rate (hereafter denoted by $\boldsymbol{i}$). The source for (1) and (3) is the BEA, (2) and (5) come from the Board of Governors of the Federal Reserve System (FRB) and (5) comes from the Commodity Research Bureau. For series where data was available in monthly frequency I took the simple averages to obtain the quarterly series. All 14 series of index of industrial production are available from the first quarter of 1972 to the fourth quarter of 2006. This is the time span used to estimate each VAR.

The inclusion of the Index of Commodity Prices is standard in the VAR literature and is meant to attenuate the "price puzzle" by controlling for supply shocks. The Effective Federal Funds Rate is our measure of monetary policy stance. Exogenous changes in this variable constitute our measure of monetary policy shocks. The ordering of the variables is also standard in the literature. As in much of the recent empirical work using the VAR approach, I assume that i does not affect the other variables in the current period. This assumption allows the identification of the system and to compute the impulse-response functions to a monetary policy shock. I include four lags for each variable (equivalent to one year because our observations are in quarterly data). I consider that comparison across industry specific VARs is more relevant if one assumes the same number of lags for all of them, even if the results of a test for the optimum number of lags says differently. I also included a constant term and allowed for a linear trend.

To test the hypothesis that sticky-price industries are more responsive to monetary policy shocks compared to less sticky industries, I need a reliable measure of their frequency of price adjustment. The work by Nakamura and Steinsson (2008) provides such a measure. These authors measure the frequency of price changes using disaggregated price data. They use two different data sets, the Consumer Price Index Research Data Base, a confidential source that contains the evolution of the individual prices of different products used to construct the Consumer Price Index (hereafter CPI) and an analogous database underlying the Producer Price Index (hereafter PPI). I focus on the PPI; this measure is more directly related to the production decisions of individual firms. However, Nakamura and Steinsson show that there is a high correlation with measures obtained using the CPI Research Data Base. The BLS computes PPI indexes for three stages of processing: finished goods, intermediate goods and crude materials. When computing PPI measures, the authors focus on finished goods. In this document I take the frequency of price adjustment of the 2-digit code PPI Categories, which are in essence a weighted median of frequencies of price changes at the 4 digit level (see Nakamura and Steinsson, 2008). I denote this frequency by r.

Regarding data on real industrial production, I use the seasonally adjusted Index of the FRB. The FBR reports disaggregated monthly indexes of industrial production for different sectors and types of goods. Data start in 1947 for the series with the most data. I use the 14 series that could be matched with one of the 15 categories in the 2-digit estimates of frequency of price adjustment by Nakamura and Steinsson. Only the PPI category “Farm Products” was left without a match in the FBR series. With the exception of “Energy”, all the indexes correspond to manufacturing. They range from “Wood Products” to “Motor Vehicles and parts”. However, the categories of the FRB index do not match perfectly with the categories of the PPI used in Nakamura and Steinsson. The match was done by keeping the greatest possible degree of resemblance between the categories. Table 1 shows the match and the associated frequency of price change. It also reports the code in the FRB classification and if it corresponds to durable or non-durable manufacturing. The total production of the industries I work with represented around 11% of total GDP in the US in 1998.

Table 1:
Match Between 2-digit code PPI Categories and Indexes of Industrial Production

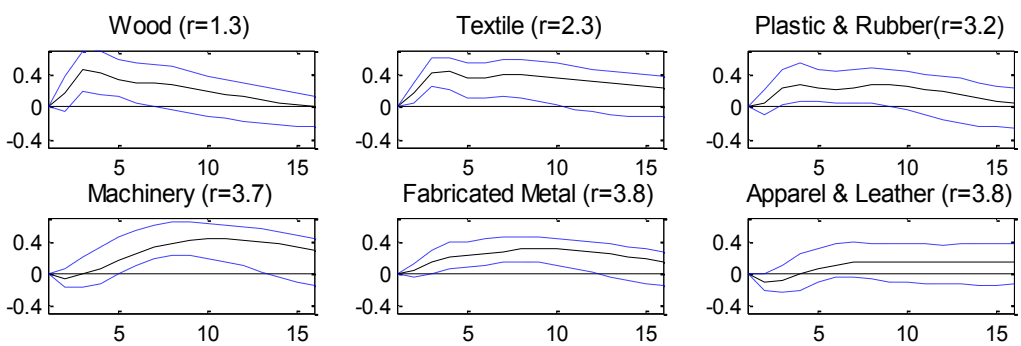
PPI Category	Frequency of Price Change	FRB Index of Production	Code	Durable or Non-Durable Manufacturing
Lumber and Wood Products	1.3	Wood Product	NAIC 321	Durable
Textile Products and Apparel	2.3	Textile and Products	NAICS 313,4	Nondurable
Rubber and Plastic Products	3.2	Plastics and Rubber Products	NAIC 326	Nondurable
Machinery and Equipment	3.7	Machinery	NAIC 333	Durable
Metal and Metal Products	3.8	Fabricated Metal Product	NAIC 332	Durable
Hides, Skins, Leather	3.8	Apparel and Leather Goods	NAICS 125,6	Nondurable
Nonmetallic Mineral Products	4.1	Nonmetallic Mineral Product	NAICS 327	Durable
Pulp, Paper and Allied Products	4.4	Paper	NAICS 322	Nondurable
Furniture and Household Durab	5.1	Furniture and Related Product	NAICS 337	Durable
Chemicals and Allied Products	6.1	Chemical	NAICS 325	Nondurable
Miscellaneous	16.5	Miscellaneous	NAICS 339	Durable
Processed Foods and Feeds	26.3	Food, beverage, and tobacco	NAICS 311,2	Nondurable
Transportation Equipment	27.3	Motor Vehicles and Parts	NAICS 3361-3	Durable
Fuels and Related Products and Power	48.7	Energy, total	.	Nondurable

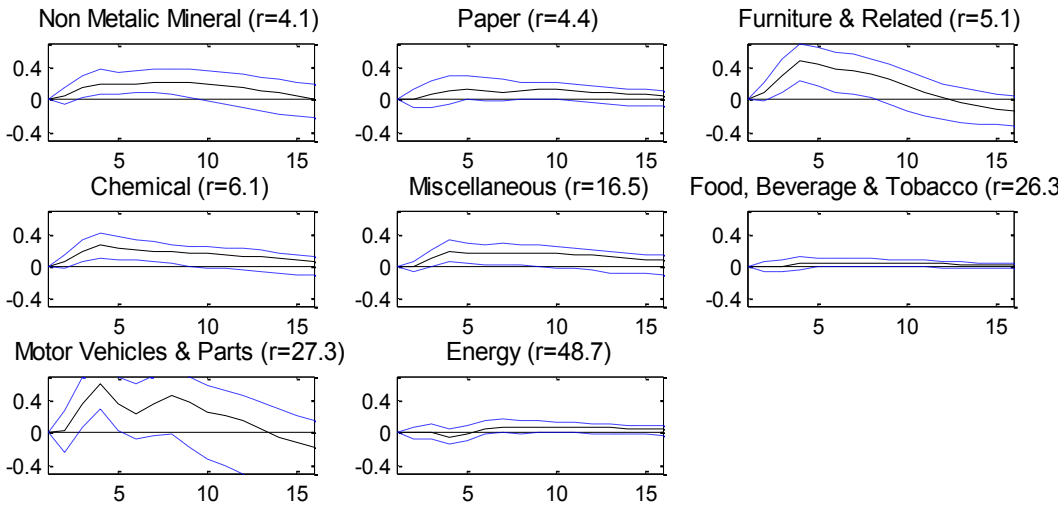
Source: Nakamura and Steinsson (2008) and Board of Governors of the Federal Reserve System

2.3 Results

After estimating each of our 14 industry specific VARs, I compute the respective response function of y to a negative shock in i of 25 basis points. Using bootstrapping, I obtain 95% confidence intervals. Figure 1 shows the impulse response function of each industry's y. The name of the respective industry index and the associated frequency of price change are shown above each response function. A higher **r** (i.e. a higher frequency of price adjustment) implies that the industry is less rigid. The level of rigidity goes down in the table moving from left to right and from top to bottom.

Figure 1:
Industry Production Response to a Negative Monetary Policy Shock of 25 Basis Points at Quarter 0 (percentage deviation from trend) and 95% Confidence Intervals





Notice that a negative monetary policy shock is associated almost in every case with an increase in production. Because the indexes are in logs, the vertical axis shows percentage deviations from trend. For example, Wood output increases immediately after the shock and reaches a maximum deviation from trend of 0.5% after three quarters. Wood production returns to its trend level after four years. Its evolution after the shock follows the familiar hump shaped pattern obtained with real GDP. Most of the industries follow a similar contour but the levels of response show high heterogeneity. For industries such as Food, Beverage and Tobacco and Energy, there is practically no deviation from trend.

With the obtained response functions, I build the following two measures of response to the monetary policy shock:

1. Total Deviation: total deviation of the industry product index from trend. In other words, I take the sum of the deviations between the estimated value of **y** and the horizontal axis, for each one of the first 16 quarters after the shock (equivalent to four years). Using bootstrapping, I also compute the standard deviation of this estimate.[6]

2. Significant Deviation: total deviation of the industry product index taking only statistical significant deviations (95% level). In other words, I take the sum of the deviations between the estimated value of **y** and the horizontal axis, but only for those quarters where the product level is statistically different from 0 (see Figure 1).

[6] To do so, I compute 1000 impulse response functions using random sampling with replacement of the error terms obtained in the estimation of the VAR. For each one of these response functions, I compute the sum of the deviations between the estimated value of **y** and the horizontal axis, for each one of the first 16 quarters after the shock. This yields a distribution of the response estimate.

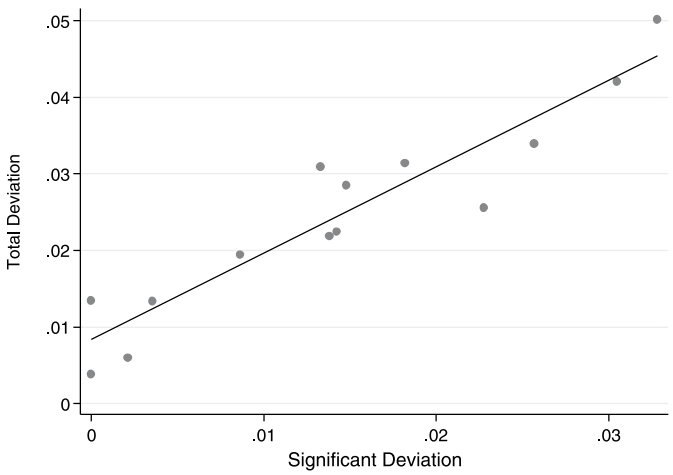
Table 2 shows the results. For Wood Products, for example, real output deviates statistically from trend during five quarters, reaching a peak deviation of 0.5%, a Total Deviation of 3.14 percentage points and a Significant Deviation of 1.8. As expected, the level of heterogeneity is high and for Apparel and Leather Goods and Food, Beverage and Tobacco, there is no statistically significant deviation. Figure 2 shows a scatter plot of the two measure of response. As expected, both measures are highly correlated (the correlation equals 0.94).

Table 2:
Measures of Response to a Negative Monetary Policy Shock of 25 Basis Points

Industry	Total Deviation (percentage points)		Significant Deviation (percentage points)
	Point Estimate	Standard Deviation	
Wood Product	3.14	1.10	1.82
Textile and Products	5.01	1.34	3.28
Plastics and Rubber Products	2.85	1.32	1.48
Machinery	4.21	1.04	3.05
Fabricated Metal Product	3.40	0.88	2.57
Apparel and Leather Goods	1.35	1.43	0.00
Nonmetallic Mineral Product	2.19	0.93	1.38
Paper	1.34	0.59	0.36
Furniture and Related Product	2.56	1.03	2.28
Chemical	2.24	0.51	1.42
Miscellaneous	1.94	0.68	0.86
Food, beverage, and tobacco	0.39	0.21	0.00
Motor Vehicles and Parts	3.10	2.11	1.33
Energy, total	0.60	0.36	0.21

Source: own calculations

Figure 2:
Correlation between the Measures of Response



I proceed to relate the measures of response with the level of price stickiness of the industry. Figure 3 shows scatter plots of each measure against the natural logarithm of the industry frequency of price adjustment (r) and the unconditional linear fit. Higher r implies lower level of price stickiness. Notice that there is a strong and negative unconditional correlation between the frequency of price adjustment and all measures of response. Sticky-price industries show higher levels of response that less sticky ones. To establish this relation in a more rigorous manner, I run simple Ordinary Least Squares (OLS) regressions of the measures of response against $\ln(r)$. Because of differences in output durability, each industry might exhibit different aggregate demand shifts to the same monetary policy shock. Thus, in the regressions, I include a dummy that takes a value of 1 if the industry output is durable. Because the output response is measured with error, I also report results for the Total Deviation measure using Variance-weighted Least Squares using the conditional standard deviations reported in table 2.

Figure 3:
Measures of Response and Frequency of Price Adjustment.
(Higher r implies more flexible prices)

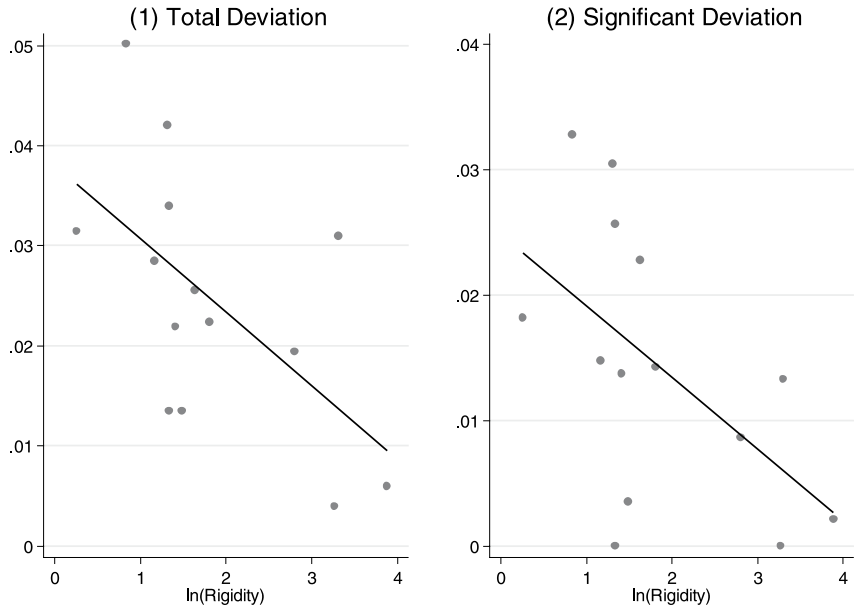


Table 3:
OLS Regressions: Measures of Response and Frequency of Price Adjustment.
(Higher r implies more 6flexible prices)

	Total Deviation		**Significant Deviation**
	OLS	Variance-weighted Least Squares	OLS
ln r	-0.0069**	-0.0075***	-0.0052**
	(0.0028)	(0.0018)	(0.0023)
Durable Dummy	0.0079	0.0098**	0.008
	(0.0057)	(0.0046)	(0.0047)
Constant	0.033***	0.031***	0.020***
	(0.0068)	(0.0057)	(0.0056)
Observations	14	14	14
R-squared	0.449		0.453

Notes: Standard error in parenthesis. * significant at 10%, ** significant at 5%, ***significant at 1%.

The regression results confirm the findings displayed in Figure 2. For both measures of response, frequency of price adjustment has the expected negative sign. It is significant at the 5% level for Total Deviation and at the 1% level when I account for measurement error. For Significant Deviation, it is significant at the 5% level. Thus, higher price stickiness (lower r) is associated with higher levels of response of industrial output to a monetary policy shock. The Durability Dummy is only significant when I account for measurement error, but the sign is consistent across specifications. As expected, the magnitude of the shift in sectoral aggregate demand is correlated with the total perturbation of sectoral output. The estimated coefficient for ln(r) in column one is -0.0069. Therefore, a 1% decrease in the frequency of price adjustment is associated with an increase of 0.69 percentage points in significant total output deviation from trend, in response to a negative shock of 25 basis points. In other words, if firms within an industry change prices twice as often as firms in another industry, output deviation from trend in response to the shock will be 69 percentage points smaller in the less sticky industry. This result is even stronger when one accounts for measurement error.

One of the problems of the usual VAR approach is that it doesn´t take into account that the observed interest rate might contain FED's reactions to the anticipation of future macroeconomic variables. In the following section I use Romer and Romer's (2004) measure of monetary policy shocks to take into account this endogeneity problem. The results obtained with this approach are consistent with the results of the previous sections.

3. Accounting for the Endogeneity of the Shocks

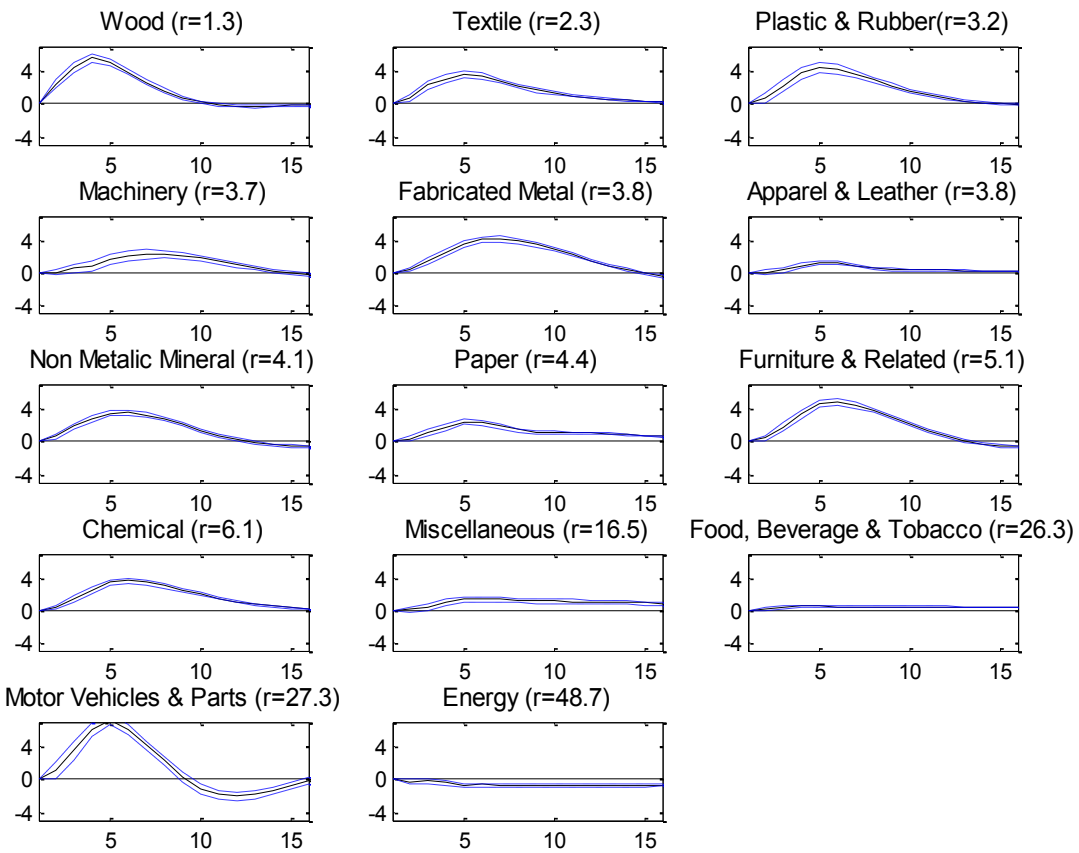
To deal with the problem of the exogenous character of the shocks obtained using the VAR approach and as an analogous way to test my hypothesis (more rigid sectors are more responsive to monetary policy shocks), I conducted exercises similar to those in Romer & Romer (2004) but using industry disaggregated data. The authors use a narrative method consisting in studying the FED's records meetings to obtain the FED's "intended" rate –a measure of monetary policy stance free of the effects that macroeconomic variables have in the FED's observed fund rate-. They then regress this measure on the FED's internal forecast to obtain a measure of monetary policy shocks free of endogeneity and anticipatory movements.

I took their new measure of monetary policy shocks in monthly frequency and obtained the simple quarter average. I then estimated by OLS the following regression for each one of the fourteen industries using data ranging from 1972 quarter 1 (beginning of industry production indexes series) to 1996 quarter 4 (the end of Romer and Romer series):

$$y_{j,t} = a_{j,0} + \sum_{k=1}^{4} b_{j,k} y_{t-k} + \sum_{k=1}^{4} c_{j,k} S_{t-k}$$

where is natural log of the production index of industry j in quarter t. is the new measure of monetary policy shocks during quarter t (the simple average of the corresponding months). As in Romer & Romer and most of the VAR literature, I assume that monetary policy has no effects on contemporary production. Romer & Romer use 24 lags for industrial production (given that their data is in monthly frequency this is equivalent to 8 quarters) and 36 lags for the policy shock (12 quarters). I use only 4 lags in my specification for consistency with the previous VAR analysis. After estimating (3), I obtain the response to a negative monetary policy shock of 25 basis points. Figure 4 shows the results with bootstrapped 95% confidence intervals. It is worth noting that the new measure of monetary policy shocks refers specifically to macroeconomic shocks and not sector specific shocks. But the way in which it is constructed suggests that it is also orthogonal to sector-specific factors.

Figure 4:
Industry Production Response to a Negative Monetary Policy Shock of 25 Basis Points at quarter 0 (percentage deviation from trend) and 95% Confidence Intervals.
Romer and Romer (2004) Shocks



Notice that in general a negative monetary policy shock is associated with a positive and highly significant response. For the wood industry for example, after five quarters the production index is 4 percentage points above its trend level. It is worth noting that the level of response using the Romer and Romer measure is superior to that of the aggregated VAR. For example, the maximum level of deviation of the wood industry in the aggregated VAR is near 0.4%, 10 times lower than the obtained in this section. This result is consistent with Romer and Romer's finding that their measure of monetary policy shocks has bigger, faster and more long lasting effects on aggregated output.

To test the hypothesis that more rigid sectors have a higher level of response than less rigid ones, I construct the same measures of response of the previous section and conduct the same exercises. Notice that the high levels of significance (given by the narrow confidence intervals) imply that the two measures of response are closer than in Section 2. I then obtain scatter plots and the corresponding OLS regressions (figure 5 and table 5). As in section 2, the estimated coefficients for ln(r) are negative and significant in all specifications. Thus, with Romer and Romer's measure of monetary policy shocks, I also obtain the result that more rigid sectors show higher levels of response to monetary policy shocks.

Figure 5:
Measures of Response and Frequency of Price Adjustment.
Romer and Romer (2004) Shocks

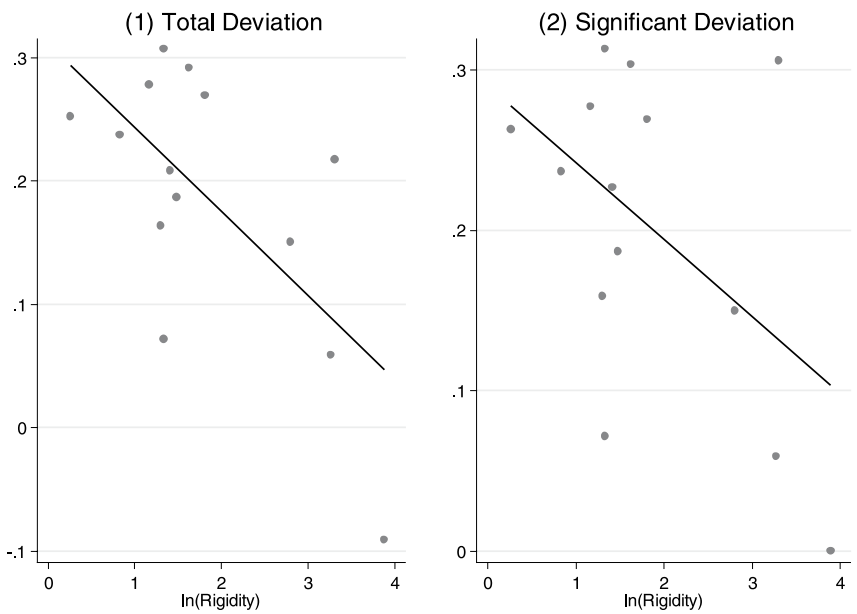


Table 5:
OLS Regressions: Measures of Response and Frequency of Price Adjustment.
Romer and Romer (2004) Shocks

	Total Deviation		Significant Deviation
	OLS	Variance-weighted Least Squares	OLS
ln r	-0.064**	-0.044***	-0.043*
	(0.022)	(0.0028)	(0.022)
Durable Dummy	0.067	0.10***	0.078
	(0.044)	(0.0058)	(0.045)
Constant	0.27***	0.20***	0.24***
	(0.053)	(0.0064)	(0.054)
Observations	14	14	14
R-squared	0.524		0.411

Notes: Standard error in parenthesis. * significant at 10%, ** significant at 5%, ***significant at 1%.

4. Discussion

The findings of the two previous sections confirm the claim that sectoral output fluctuations can be explained from a New Keynesian perspective. Sectors with higher levels of price rigidity have less steep aggregate supply curves so that a shift in aggregate demand, once I control for output durability, is associated with higher levels of deviation from initial equilibrium. Our results contrast sharply with those of Bils, Klenow and Krystov (2003), who find that the level of response of quantities consumed to a monetary policy shock is not associated with the level of price rigidity. The following reasons might explain the differences. Because the monetary policy innovation series is taken directly from a VAR that does not include sector specific measures of output, Bils, Klenow and Krystov estimate the response to aggregate interest rate shocks and not sector-specific shocks. Also, the relationship between price stickiness and the level of response should be analyzed at a disaggregated level. When the authors distinguish between “flexible price goods” and “sticky price goods” they might be losing valuable information that accounts for our result. Finally, I work with industry production indexes, a more adequate measure than BEA consumption quantities if one is to assess the validity of sticky price models.

However, our regression estimates have to be interpreted with care. First of all, the number of observations is small. Secondly, because the method of estimation is simply OLS I don´t take explicit account of possible endogeneity problems. So strictly speaking, I cannot claim that the level of price rigidity causes the level of sectoral output response. Nonetheless and to the best of my knowledge, there is no theoretical or even intuitive reason for the regressions to have a problem of simultaneity: the level of response of sectoral output should not explain the frequency of price changes. The most probable cause of endogeneity is omitted variable bias. It is possible that a variable omitted from the regression is related to both output response to monetary policy shocks and level of price rigidity.

Those who claim that financial rigidities are the sole driving force of the supply side of the monetary transmission mechanism can argue that financial restrictions lie behind levels of price rigidity (or are at least correlated with them) and thus, that they constitute the fundamental cause of heterogeneity in the level of response across industries. This possibility is nevertheless implausible for two reasons.

First, the literature that has studied why prices are sticky hasn´t found financial rigidities to be one of the main causes. In the spirit of Blinder et al. (1998), Aucreamanne and Druant (2007) conducted surveys among 2000 Belgian firms across a wide range of industries. They asked explicitly about the reasons for leaving prices unchanged and established a ranking of the principal causes of price stickiness. Of fifteen possible reasons, most of which have no relation with financial restrictions, implicit and explicit contracts with clients occupied the first and second place respectively: firms restrain themselves from changing prices out of a concern not to displease and lose their customers. The third reason is the shape of the marginal cost curve. A flatter curve implies that the real rigidity (i.e. the real incentives a firm has to leave prices unchanged when facing a change in their demand) is higher. Related to financial frictions, only two reasons appear in the paper and they don´t seem to have particular relevance: liquidity constraints and countercyclical financing costs (marginal costs might be higher in times of recession because external financing becomes more expensive).

Second, in *The Timing of Monetary Policy Shocks*, Olivei and Tenreyro (2007) use the VAR approach to show that in the US the response of real GDP to monetary policy shocks depends on the quarter in which it takes place. If the shock takes place in the first or second quarter of the year, the effect on real output is considerable and statistically significant. Instead, if it occurs in the third or fourth quarter, there is no significant effect on output. The aggregate response (i.e. non quarter dependent) of real GDP obtained by traditional VAR studies is a result of the aggregation of the quarterly dependent responses. The authors argue that most of the wage bargains in the US take place at the end and the beginning of the year so that shocks taking place in the first and second quarter aren´t incorporated in the respective wage changes. They calibrate a Dynamic Stochastic General Equilibrium model (DSGE) and show that a realistic amount of uneven staggering of wage contracts along quarters can generate similar quarter dependent responses than those obtained using their VAR estimation.

The empirical evidence in Olivei and Tenreyro's supports the sticky price explanation of the monetary transmission mechanism: even if financial frictions play a role, they don´t constitute the whole story. If the response to monetary policy shocks depended only on financial frictions, output response should not depend on the quarter in which the shock takes place. Even more, if one extends their analysis to sectoral production indexes, the response to monetary policy shocks is found to be quarter dependent[7].

Considering that the level of price rigidity is strongly related to the level of response to monetary policy shocks, which also depends on the quarter in which the shock takes place, an explanation of the supply side of the monetary transmission mechanism that rests only upon financial frictions seems implausible. Price rigidity in both wages and prices -which are also related between them- has to play a role.

5. Concluding Remarks

By matching Nakamura and Steinsson (2008) frequency of price adjustment with indexes of industrial production, I show that sectors with higher level of price stickiness have higher levels of response to nominal disturbances. This finding supports the view that sticky prices play an important role in the monetary transmission mechanism.

One immediate policy implication emerges from the results of the paper. Countries where sticky price sectors account for an important fraction of GDP compared to less sticky sectors should have bigger output costs of disinflations, relative to countries where the opposite is true. Therefore, the industry composition of the economy is of relevance for monetary policy making. Further research should investigate this implication.

[7] Results are available upon request.

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