

MODELS OF PRICE SETTING
AND INFLATION DYNAMICS

2024

BANCO DE **ESPAÑA**
Eurosistema

Documentos Ocasionales
N.º 2416

James Costain and Anton Nakov

MODELS OF PRICE SETTING AND INFLATION DYNAMICS

MODELS OF PRICE SETTING AND INFLATION DYNAMICS (*)

James Costain (**)

BANCO DE ESPAÑA

Anton Nakov (***)

EUROPEAN CENTRAL BANK

(*) This chapter is under preparation for the *Research Handbook of Inflation*, edited by Guido Ascari (University of Pavia) and Riccardo Trezzi (University of Geneva) for Edward Elgar Publishing.

(**) james.costain@bde.es.

(***) anton.nakov@ecb.int.

Documentos Ocasionales. N.º 2416

May 2024

<https://doi.org/10.53479/36592>

The Occasional Paper Series seeks to disseminate work conducted at the Banco de España, in the performance of its functions, that may be of general interest.

The opinions and analyses in the Occasional Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the Internet on its website at: <http://www.bde.es>.

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

© BANCO DE ESPAÑA, Madrid, 2024

ISSN: 1696-2230 (on-line edition)

Abstract

We review models of nominal price adjustment based on optimizing or near-optimal behavior, including menu cost models, generalized hazard function models and models of frictional decisions. We also discuss the role of real rigidities and assess the models' success in explaining retail microdata and inflation dynamics.

Keywords: sticky prices, nominal rigidities, state-dependent prices, inflation, menu costs, control costs, rational inattention.

JEL classification: E31, E71.

Resumen

El presente trabajo resume la literatura existente relativa a los modelos de ajuste de los precios nominales, centrándose en los modelos de comportamiento óptimo o casi óptimo. El documento abarca tres clases principales de mecanismos: 1) modelos que suponen un coste fijo (*menu cost*) al ajustar el precio nominal de un producto, 2) modelos en los que la probabilidad de ajuste del precio es una función creciente de las ganancias asociadas con dicho ajuste (*generalized hazard function*) y 3) modelos que suponen algún tipo de racionalidad acotada que conlleva fricciones en la toma de decisiones. El documento destaca también el papel clave de las rigideces reales en el reforzamiento del impacto de las rigideces nominales. Para concluir, el trabajo evalúa el éxito de estos modelos a la hora de explicar tanto la dinámica de precios en los datos microeconómicos del sector minorista como la dinámica de inflación en los datos macroeconómicos.

Palabras clave: precios rígidos, rigideces nominales, ajuste de precios dependiente del Estado, inflación, costes de menú, costes de control, inatención racional.

Códigos JEL: E31, E71.

I. Introduction

Nominal rigidities are central to macroeconomic modelling. Models in which prices are entirely flexible can have the property that *money is neutral*: an unexpected increase in the supply of money held by the private sector simply shifts up the aggregate price level proportionally, leaving real economic variables such as real output and employment unchanged. More generally, increased aggregate demand mostly raises prices, if prices are relatively flexible; but otherwise, a positive demand shock will cause real economic activity to expand, and will only gradually pass through to prices. Thus, given econometric evidence of large real effects from monetary policy shocks, mainstream models used for economic policy guidance are built on the assumption that nominal prices adjust sluggishly.¹ Imperfect competition is also a crucial component of these models (Blanchard and Kiyotaki, 1991). Under perfect competition, a firm that sets a price slightly higher than its competitors will lose all its business; hence models that assume sticky prices necessarily also assume that firms have some degree of market power.

Three *ad hoc* assumptions about nominal price rigidity are common. Taylor (1979), motivated by seasonal labor contract renegotiations, assumed that nominal wages (or prices) are updated intermittently, at regular intervals of T periods, remaining constant between the times of adjustment. Calvo (1983) instead assumed stochastically staggered updating, with a constant probability λ of nominal adjustment per period, implying that the nominal price (or wage) remains fixed for $T \equiv 1/\lambda$ periods on average. Calvo's framework typically simplifies model solution since – in contrast to Taylor's setup – it does not imply that a firm's behavior varies systematically with the time since it last adjusted. Rotemberg (1982) assumed that nominal adjustment is constrained by a cost function that is quadratic in the nominal price change (or wage change). Rotemberg's setup implies that prices and wages adjust continuously over time, which makes model solution even easier than the Calvo case, but makes it less obvious how to interpret and calibrate the model on the basis of microeconomic data, where intervals of nominal stickiness are widely observed.

This chapter reviews models of nominal price rigidity based on optimizing or near-optimal behavior. The mechanisms we review are often labelled as *state-dependent pricing* (SDP), since optimizing behavior implies that the probability of a price change should vary with aggregate and idiosyncratic shocks, in contrast with the *time-dependent* adjustments assumed by Taylor (1979) and Calvo (1983). We focus on retail price dynamics, only briefly mentioning other contexts where nominal rigidity matters, such as intermediate goods pricing and wage determination. We group the proposed microfoundations of price rigidity into four major streams. First, we consider models with a fixed cost for adjusting the nominal price, often called a *menu cost*. Second, we study models where the probability of adjusting the nominal price is a smoothly increasing function of the value gained by adjusting; several different economic mechanisms may give rise to a *generalized hazard function* of this type. Third, we consider models in which making accurate decisions is costly, either because the required information inputs are costly, or because the decision process itself is costly. Fourth, we analyze several sources of *real rigidities* that reinforce the impact of the *nominal rigidities* considered earlier.

Our goal in building microfounded models of sticky prices is to better understand the dynamics of inflation and its relationship with real activity at the macro level. This survey reviews models of firms' pricing behavior, and their fit to retail microdata. But the main purpose of research in this area is to better understand macroeconomic dynamics, including the causes of macroeconomic fluctuations and the optimal role of monetary policy. Crucial time series findings that clearly bear on monetary policy include *monetary non-neutrality*, the fact that looser monetary conditions appear to stimulate real activity temporarily (e.g. Christiano et al. (2005) and Smets and Wouters (2003)), and the *Phillips curve*, that is, the short-run positive correlation

¹For textbook expositions, see Woodford (2004) and Galí (2015).

between price and/or wage inflation and indicators of real activity, such as output and employment (see Chapter 8 of this Handbook). There is also evidence of *inflation persistence*: lagged inflation appears to predict future inflation (Fuhrer and Moore, 1995; Fuhrer, 2010; Galí et al., 2001), though this correlation appears weaker since the 1980s; and there is an *inflation-volatility correlation*: higher inflation is more volatile (Friedman, 1977; Kiley, 2007). Section VI briefly assesses what conclusions we can draw about these macroeconomic issues on the basis of the microfoundations we survey.

Earlier surveys. Previous literature reviews on price adjustment include Maćkowiak and Smets (2008), Klenow and Malin (2010), and Nakamura and Steinsson (2013). Since then, the literature has progressed in several ways. A surge of new data has shed light on the microeconomics of price setting. Numerical solution methods for heterogeneous-agent macro models have gone mainstream, but there have also been advances in analytical solutions for models with sticky prices. And while the menu cost approach remains influential, the incorporation of better models of decision-making and better models of competition into quantitative macro models has offered a deeper understanding of the economic mechanisms underpinning the sluggishness of prices.

A. Implications of staggered adjustment

Intermittent price changes induce inefficient price dispersion. The intermittent adjustments that motivate the Taylor (1979) and Calvo (1983) models, as well as most state-dependent models, have several implications that are common across frameworks. First, they cause price dispersion: if the prices of two identical items have been set at different times, and hence on the basis of different information, their prices are likely to differ. Inefficient dispersion in relative prices across items or goods – that is, price dispersion beyond that justified by differences in marginal costs – will then be reflected in an inefficient allocation of purchases. If inefficient dispersion due to staggered adjustment rises with inflation, this misallocation may be an important part of the social welfare loss due to inflation (see e.g., Benigno and Woodford (2003), Nakamura et al. (2018), and Blanco (2021)). On the other hand, if firms must pay higher costs to adjust nominal prices in response to higher inflation – as in Rotemberg (1982) and in most of the state-dependent models we discuss below – then the social welfare loss due to inflation will include those adjustment costs too.²

Staggering of individual price changes delays the adjustment of the aggregate price level, if firms' prices are *strategic complements*. Under monopolistic competition, each producer sets its price relative to the aggregate price level. If marginal costs are not too strongly increasing with output, then individual firms' price choices are likely to be *strategic complements*: each firm has an incentive to raise the price of its own products if other firms raise their prices (Bulow et al., 1985; Cooper and John, 1988).³ In this case, staggering slows down the aggregate nominal response to an increase in aggregate demand. Knowing that other firms' price changes will be delayed, any firm i that adjusts at time t raises its price by less than it would if it expected other firms to raise their prices at the same time. Moreover, firm i knows that other firms face the same incentive to attenuate their price increases, which further reduces firm i 's desired adjustment. Overall, the aggregate price level responds more slowly, making the real effects of monetary shocks and other demand shocks more persistent.⁴

²A thorough comparison of the Taylor, Calvo, and Rotemberg models is beyond this paper's scope. See Ascari (2004), Lombardo and Vestin (2007), and Ascari et al. (2011) for discussion.

³Woodford (2004), Chap. 3.1.3-3.1.4, discusses the determinants of strategic complementarity across firms' price setting decisions.

⁴Olivei and Tenreyro (2007) take advantage of the seasonality of wage adjustment to provide evidence on the role of staggering. They find that monetary shocks affect prices more quickly, and have smaller effects on real variables, in seasons when more wage adjustments occur.

Staggered nominal adjustment may cause or prolong inflationary spirals.

Lorenzoni and Werning (2023b) argue that when the current level of the real wage lies above firms' labor demand curve, but below workers' labor supply curve, their staggered updates of wages and prices will both tend to be in the upward direction.⁵ Under these circumstances, firms' price rises will increase workers' desired wage increases, and vice versa, producing a wage-price spiral (see also Blanchard (1986)). Likewise, sellers of competing products may have conflicting preferences regarding their *relative* prices. Lorenzoni and Werning (2023a), building on earlier work by Rowthorn (1977), show how inflationary trends may be driven by each firm's incentive to raise its nominal price in response to the nominal price increases of its suppliers and competitors.

⁵For example, this configuration would arise if, starting from a situation of labor market equilibrium, an adverse supply shock were to shift the labor demand curve down and left, or a positive wealth shock were to shift the labor supply curve up and left.

II. Menu costs

Early studies argued that small menu costs (MC) could have nontrivial effects on the dynamics of the real macroeconomy. If a firm with a smoothly differentiable profit function must pay a fixed cost κ to adjust its price, then there will be an *inaction region* around its optimal price p^* (Barro, 1972; Sheshinski and Weiss, 1977). Concretely, there will be lower and upper threshold prices s and S , where $s \leq p^* \leq S$, such that the firm leaves its current price p unchanged if $s < p < S$, because the gains from adjusting would be less than the cost κ . When the firm's current price p is below s or above S , it will instead be worthwhile to update its price, setting it equal to p^* . By the envelope theorem, under such an (S, s) *threshold strategy*, tiny menu costs may sustain a disproportionately large inaction region (Mankiw, 1985; Akerlof and Yellen, 1985a). The macroeconomic impact of menu costs – how much they delay nominal adjustment, and how much monetary shocks affect real output and employment – will be proportional to the width of the inaction region, $S - s$, potentially large even if menu costs are tiny.⁶

Nonetheless, some theoretical examples and quantitative simulations showed that money may be approximately neutral in a menu cost model. Assuming a constant inflationary trend π , and abstracting from any other shocks, the target price p^* and the adjustment thresholds s and S all shift upwards by π each period.⁷ A firm with price $p \in [s, s + \pi)$ at time t will fall below the lower threshold s by time $t + 1$, and will therefore adjust its price. Under the assumption that the initial distribution of prices p across products is uniform, Caplin and Spulber (1987) point out that an inflationary shock $\pi_t \neq \pi$ in this environment simply changes the fraction of products that fall below the lower threshold s by the same proportion, from $\frac{\pi}{S-s}$ to $\frac{\pi_t}{S-s}$.⁸ Hence monetary shocks in their environment are neutral, causing an immediate, proportional jump in the price level, with no effect whatsoever on real variables. While Caplin and Spulber's example is quite special, Golosov and Lucas Jr (2007) numerically solved a menu cost model with a distribution of idiosyncratic productivity shocks and a menu cost κ jointly calibrated to match the average frequency and the average size of price changes observed in US retail data. They then simulated the impact of money growth shocks. While money was not exactly neutral, they found that a surprise increase in the money supply had an extremely transitory impact, implying a small *cumulative impulse response* (CIR) for real variables; the variations in inflation and real variables died out almost entirely within one month, leaving only a shift in the aggregate nominal price level.⁹ This finding called into question whether microfounded models of price adjustment are consistent, in practice, with large and persistent real effects of monetary shocks.¹⁰

A key reason why prices react more (and real quantities less) in menu cost models is the *selection effect*: prices requiring a large increase are more likely to respond to an inflationary shock than prices requiring a small or negative change. In Caplin and Spulber (1987), all the additional price changes that occur in response to a surprise increase in inflation are increases affecting products that have hit the

⁶In other words, the observed macroeconomic effects can be “first order” (proportional to $S - s$) in response to menu costs that are only “second order” (proportional to $(S - s)^2$), or even smaller. The precise relation between the size of the menu costs and the width of the inaction region depends on model details. For example, in Sheshinski and Weiss (1977), the width of the inaction region is proportional to the cube root of the menu cost.

⁷All quantities mentioned here are in log terms. Note that the target price p^* and the thresholds s and S should all be understood as firm- and product-specific functions that depend on costs and demand and other shocks. Hence the current fixed nominal price p will typically “drift” over time relative to p^* , s , and S .

⁸This result depends on some technical assumptions which ensure that the price distribution remains uniform in the aftermath of the shock.

⁹The real impact of a monetary expansion is often summarized by the CIR (the integral under the impulse response function) of a real variable such as output or employment. This is more informative than reporting the size of the response on impact, since the CIR also takes persistence into account.

¹⁰Another paper that questioned whether price stickiness could generate persistent real effects was Chari et al. (2000). Woodford (2004), Chap. 3.1.4, attributes their findings to a calibration derived from the real business cycle literature that was not well suited to a sticky-price model.

lower threshold s . These increases (equal to $p^* - s$) are larger than the desired increase for any product that does not respond to the shock. In Golosov and Lucas Jr (2007), a surprise increase in inflation raises the number of large price increases (by pushing some prices down past the lower threshold s) and reduces the number of large price decreases (by keeping some prices below the upper threshold S). In contrast, the Calvo (1983) model implies no change in the adjustment probability after an inflationary shock, and those prices that do adjust are a random sample, so they are no more likely to require a large increase than those that fail to adjust. Hence the aggregate response of prices to an inflationary shock is stronger in an MC model than it is in a Calvo model with the same initial adjustment probability, both because of the *extensive margin* – the increased fraction of prices adjusting – and because of the *selection effect* – the systematic correlation between the adjustment probability and the size of the desired change.

A. *Menu costs meet microdata: Evidence from advanced economies*

As retail scanner data became available and computational methods for heterogeneous-agent models improved, a wave of new quantitative research sought to match microeconomic evidence and evaluate the real effects of monetary policy. Following the pathbreaking work of Bils and Klenow (2004) and Golosov and Lucas Jr (2007), the literature further explored large new micro datasets and developed quantitative macro models with state-dependent prices to explain the microeconomic patterns and to draw macroeconomic conclusions. Datasets from advanced economies – particularly data retrieved from scanners in retail stores, and data used to construct consumer price indices – shed light on price setting behavior at low, positive inflation rates; see especially Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008), Eichenbaum et al. (2011), Campbell and Eden (2014), and Nakamura et al. (2018); and Cavallo (2017, 2018) for the case of online prices. Data from a broader set of countries provided evidence on price setting at very low or high inflation rates, including deflationary and hyperinflationary conditions, as we discuss in the next subsection.

For most products, price adjustments are typically large, with both positive and negative changes, though some very small changes occur too.¹¹ Even a brief glance at retail price data from advanced economies reveals that price changes are far too large to be explained primarily by the need to keep up with trend inflation. Both large increases and large decreases are observed. Changes in relative prices are largely transitory (Bils and Klenow, 2004), though a product’s relative price also tends to trend downwards with the time since it was introduced (Bils, 2009). These observations clearly suggest that price changes are driven in part by transitory idiosyncratic factors that are specific to individual products and/or firms; hence Golosov and Lucas Jr (2007) assumed Gaussian autoregressive idiosyncratic productivity shocks at the product level. However, the distribution of price changes is not Gaussian – some tiny price movements coexist with a fat-tailed distribution of large positive and negative changes, motivating Midrigan (2011) to suppose a fat-tailed distribution of idiosyncratic shocks. These patterns contrast with the distribution of price changes predicted by simple MC models, which imply a sharply bimodal histogram of adjustments for a given product, with one spike of price increases corresponding to prices that were reset after drifting down to the lower threshold s , and a second spike of decreases from prices that were reset after drifting up to the upper threshold S , with no smaller price changes in between.¹²

The great variability in the size of price adjustments is *not* driven primarily by price discounts (“sales”). Frequent price discounts are a prominent feature of retail

¹¹See especially Bils and Klenow (2004); Klenow and Kryvtsov (2008); Nakamura and Steinsson (2008), Facts 2 and 3; and Klenow and Malin (2010), Sec. 4. Relatedly, there is a great deal of price dispersion *in levels* across similar products, see for example Nakamura et al. (2018).

¹²However, Eichenbaum et al. (2014) argue that a many apparent instances of small changes are actually attributable to measurement error, and Cavallo (2018) finds that small changes are less common for online prices.

price dynamics in many countries, including the U.S. Distinguishing sales from other price adjustments can be a challenge for empirical researchers. One possibility is to rely on “sales flag” variables that are available in some datasets, such as CPI data. Another method is to apply “sales filters”, for example, by removing brief “V”-shaped deviations from (and back to) a previous price. Filtering approaches are used by Bils and Klenow (2004), Klenow and Kryvtsov (2008), and Kehoe and Midrigan (2015). Nakamura and Steinsson (2008) show that estimates of price change frequencies under the sales filtering and sales flag approaches are broadly similar. A third approach is to distinguish between “weekly” and “reference” prices, where the reference price is defined as the most common price within a given quarter (Eichenbaum et al., 2011). Regardless of the method, the “regular” (non-sale) component of prices continues to display large changes, of both signs, after removing sales.¹³

The incidence of retail sales is moderately countercyclical, and somewhat enhances aggregate price flexibility. Eichenbaum et al. (2011), Kehoe and Midrigan (2015), and Alvarez and Lippi (2020) studied models with multiple menu costs: a high cost for each “regular” price change, and a lower cost for “temporary” price changes. While this multiple MC structure helps explain microdata on retail sales, they found that the stickiness of regular prices is the main determinant of aggregate inflation dynamics and the degree of non-neutrality. Guimaraes and Sheedy (2011) built a model of *stochastic price discrimination* across heterogeneous consumers (see Sec. V.C below) and concluded that retailers’ choices about the timing of sales are *strategic substitutes*: each firm prefers to offer price discounts when its competitors are not offering them. Therefore, they conclude that the incidence of sales should not respond to macro shocks and fluctuations, making sales largely irrelevant for non-neutrality. Coibion et al. (2015) and Anderson et al. (2017) looked at sales over time in microdata on groceries, finding little effect of macroeconomic conditions on the frequency of sales, especially after controlling for geographic and category fixed effects. On the other hand, these authors show that consumers shift towards less expensive goods in aggregate downturns (see also Nord (2023)). In contrast, using CPI data with wider coverage across products and retailers, Kryvtsov and Vincent (2021) find that sales incidence is clearly countercyclical (roughly doubling during the Great Recession). They find that accounting for sales reduces the real impact of a monetary shock by roughly one third. Similarly, Sheremirov (2020) finds that sales reduce monetary non-neutrality by 20% to 25%.

The probability of a price change increases with the distance from the estimated target price. Empirically, the adjustment probability (the *adjustment hazard function*) increases smoothly as a function of the distance of the price from mean price of closely competing products. Estimates typically find that the hazard is strictly positive at its minimum, with some evidence of a “V”-shaped kink at zero, and some signs of asymmetry, with a more sharply increasing hazard for excessively low prices than for excessively high ones (Campbell and Eden, 2014; Eichenbaum et al., 2011; Karadi et al., 2021).¹⁴ While this demonstrates state-dependence, at the aggregate level the selection effect appears weak: inflationary shocks do not cause a substantial increase in the probability that relatively low prices are adjusted upwards (Karadi et al., 2021; Carvalho and Kryvtsov, 2022). In addition, hazard functions for any given product are largely flat as a function of price age.¹⁵ In contrast, simple MC models predict that the hazard should be zero immediately after an adjustment, and that it should increase with the age of the price, since the price may drift across the (S, s) bands over time.

¹³Nakamura and Steinsson (2008), Table VIII; Eichenbaum et al. (2011), Table 2.

¹⁴See also Caballero and Engel (1993a) and Willis (2000). In contrast, Sara-Zaror (2022) finds that the adjustment probability is shaped like the Greek letter “Υ”, decreasing sharply near the target price.

¹⁵See Nakamura and Steinsson (2008), Fact 5; Klenow and Malin (2010), Fact 9, and Luo and Villar (2021a). In contrast, the inferred hazard slopes down with the age of the price when averaging across products with heterogeneous adjustment hazards, since fast adjusters quickly drop out of the sample, leaving behind a sample of products with lower hazards.

Wage adjustments are notably synchronized and seasonal in some countries and industries, but there is little evidence of time dependence in retail price adjustments. There is some evidence of time-dependent behavior in wages and in services prices. For these items the Taylor (1979) model may apply (Olivei and Tenreyro, 2007). In general, nominal adjustment frequencies are extremely heterogeneous across sectors. Models show that the more sluggish sectors are particularly important for aggregate price stickiness, since flexible sectors may wait for adjustment by the sluggish sectors (Carvalho, 2006; Afrouzi and Bhattarai, 2023). Hence total stickiness is better summarized by the *median* adjustment frequency, or the mean duration, than by the *mean* frequency (Nakamura and Steinsson, 2010).

Higher-order moments of the price change distribution are also informative about non-neutrality. Vavra (2013) highlights two facts about price changes over the business cycle: the cross-sectional standard deviation of price changes is (i) countercyclical and (ii) positively correlated with the frequency of adjustment. He argues that this could be driven by countercyclical volatility of firm-specific shocks, which would boost the inflationary effects of monetary stimulus during recessions. Luo and Villar (2021b) argue that higher moments help diagnose monetary non-neutrality. They find that an inflationary shock reduces the *dispersion*, but not the *skewness*, of price changes. Standard MC models predict that skewness and dispersion both fall after an inflationary shock (while in the Calvo model both rise). The authors reconcile these observations with a stochastic menu cost model that has a strong Calvo component, which implies greater monetary non-neutrality than a standard MC model. Finally, Midrigan (2011) and Alvarez et al. (2016a) show that price change distributions appear highly *leptokurtic* (having higher kurtosis than a normal distribution, meaning excess weight on very small and very large changes), and likewise argue that this enhances non-neutrality.

B. Menu costs meet microdata: International evidence

While computational methods advanced, other authors have derived insights into the macroeconomics of menu costs analytically. Menu cost models have been especially successful in predicting how the size and frequency of price adjustments vary with the rate of trend inflation. International evidence is particularly relevant here, since it allows us to consider a wider range of inflation rates.¹⁶ Alvarez et al. (2019) derive some fundamental properties of menu cost models and contrast them with data from Argentina, over a sample period with very high and very low inflation rates.

Price adjustment behavior is symmetric around zero inflation, and the welfare losses from inflation are approximately a quadratic function of the inflation rate. Abstracting from a productivity trend, Alvarez et al. (2019) show that the frequency and size of adjustments should behave symmetrically around a zero inflation rate, and they verify that adjustment patterns are indeed approximately symmetric across comparable rates of inflation and deflation in Argentinian data. Symmetric behavior depends only on the assumption of a symmetric profit function, so given this assumption it also applies to the more general models of adjustment considered below.¹⁷ Symmetry also implies that the marginal effect of inflation on the adjustment frequency is zero at zero inflation. Therefore, near zero inflation, changes in inflation are attributable primarily to changes in the relative frequency of price increases and price decreases, as Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) observed in US data. Moreover, symmetry

¹⁶Early studies of price setting behavior under high inflation include Lach and Tsiddon (1992) and Gagnon (2009).

¹⁷However, symmetry of the profit function is not a generic property. For example, the constant elasticity of substitution (CES) model of monopolistic competition features an asymmetric profit function.

around zero implies that the welfare costs of inflation (both adjustment costs and price distortions) are minimized at zero inflation.¹⁸

As inflation approaches extremely high rates, the frequency and size of adjustments increases, with elasticities of roughly 2/3 and 1/3, respectively. Inflation equals the average adjustment frequency, $\bar{\lambda}$, times the average log price change \bar{x} . The model-independent identity $\pi = \bar{\lambda}\bar{x}$ implies that the elasticities of the frequency and the size of adjustments, with respect to inflation, must sum to one.¹⁹ In a simple MC model, these elasticities approach limiting values of 2/3 and 1/3 as inflation increases.²⁰ The standard deviation of prices will also increase asymptotically with the elasticity 1/3, like the size of price changes. Alvarez et al. (2019) find values close to these predictions in Argentinian data; regressing the adjustment probability on the inflation rate, they obtain a coefficient of 0.58.

¹⁸Given a symmetric profit function, these results follow from the fact that price changes are mostly driven by idiosyncratic shocks when inflation is low. In the case of a simple menu cost model, the first-order effect of a small shock to inflation is just a change in the proportion of prices hitting the upper and lower thresholds S and s . Any changes in the adjustment frequency and in the average absolute size of adjustment are second-order effects.

III. Smooth state dependence

Micro facts that seem inconsistent with the basic MC model motivate a more general class of state-dependent models, in which the adjustment probability rises smoothly with the value of adjusting. First, when the adjustment hazard is estimated as a function of the distance from the target price, it is found to be strictly positive and smoothly increasing (Eichenbaum et al., 2011; Campbell and Eden, 2014). This contrasts with the sharp rise in the adjustment probability, from zero to one, that should be observed near the (S, s) bands of a simple MC model. Moreover, direct attempts to measure the selection effect have failed to find it (Karadi et al., 2021). Furthermore, when the adjustment hazard is estimated at the product level as a function of the time since last adjustment, it is largely flat; simple MC models instead imply that the probability of a reset should increase with the age of the price (Klenow and Kryvtsov, 2008; Nakamura and Steinsson, 2008). Finally, the coexistence of very small and very large price changes, after controlling for sales and conditioning on a specific product, again contradicts the predictions of a simple MC model. These findings all seem to favor a smoother form of state dependence, instead of sharp (S, s) thresholds.

As a general principle, one would expect that firms are more likely to adjust their prices when the value of adjustment is larger. Some papers have studied models that impose this property directly, without taking a stand on why it holds. Caballero and Engel (1992, 1993b, 2007) analyzed models in which a firm’s probability of price adjustment is linearly increasing in the gap between its current price and its desired target price, based on the assumption that the value of adjustment is a quadratic function of this gap. They called this tractable form of adjustment behavior a *generalized hazard function* (GHF). Costain and Nakov (2011b,a) solved calibrated macro models with non-linear GHF behavior numerically. Allowing for idiosyncratic shocks at the firm level, they found that the models could match microeconomic evidence on the adjustment hazard and the distribution of price changes. Due to the smoothness of the adjustment hazard, these models generated a much weaker selection effect than the Golosov and Lucas Jr (2007) menu cost model, and therefore implied much greater non-neutrality.

Several different economic mechanisms can generate smooth state dependence in nominal adjustment.²¹ MC models generate smooth state dependence if the menu cost is stochastic, drawn *i.i.d.* from a smoothly-increasing cumulative distribution function, as in Dotsey et al. (1999) and Dotsey and Wolman (2020).²² Smoothness also results from an MC model with *economies of scope* in price setting, as in Midrigan (2011) and Alvarez and Lippi (2014), where a multi-product firm pays a single menu cost to reset the prices of all its products. The adjustment decision then depends on the *average* gap between the firm’s prices and their target values, so when updates occur, some will be large (reflecting a large gap) and others will be small (reflecting a small gap). A third

¹⁹To a first-order approximation, the identity can be expanded as $1 = \frac{d\bar{x}/\bar{x}}{d\pi/\pi} + \frac{d\bar{\lambda}/\bar{\lambda}}{d\pi/\pi}$.

²⁰Consider a firm subject to menu costs κ that faces a constant inflation trend π , and no other shocks, as in Sheshinski and Weiss (1977). If the loss due to log deviations x from the flexible optimal price can be approximated by a quadratic function Lx^2 , then the thresholds s and S will be symmetric around the flexible price. The size of adjustments will be $b = S - s$, with frequency $\lambda = \pi/b$, and the average loss due to deviations from the flexible price will be $b^{-1} \int_{-b/2}^{b/2} Lx^2 dx = Lb^2/12$. Hence the firm minimizes losses over time by minimizing $L\pi^2/12\lambda^2 + \kappa\lambda$, implying that the optimal adjustments are $b = \sqrt[3]{6\kappa\pi/L}$ with frequency $\lambda = \sqrt[3]{L\pi^2/6\kappa}$, implying elasticities $1/3$ and $2/3$, respectively. The same calculation applies to a model with idiosyncratic shocks, if inflation is sufficiently high to outweigh idiosyncratic factors.

²¹We will use “generalized hazard function” and “smooth state dependence” as synonyms that both indicate smooth adjustment. Klenow and Kryvtsov (2008) called GHF models the “second generation” of state-dependent pricing models, even though the first quantitative macro model with state-dependent pricing, Dotsey et al. (1999), was already a GHF model.

²²A particularly tractable stochastic menu cost framework is the “Calvo+” model of Nakamura and Steinsson (2010), in which the menu cost takes two possible values, $\kappa = 0$ or $\kappa = \bar{\kappa} > 0$. When $\kappa = 0$, the firm has a costless chance to adjust, as in Calvo (1983); when it equals $\kappa = \bar{\kappa}$, the firm may pay a fixed cost in order to adjust, as in Golosov and Lucas Jr (2007).

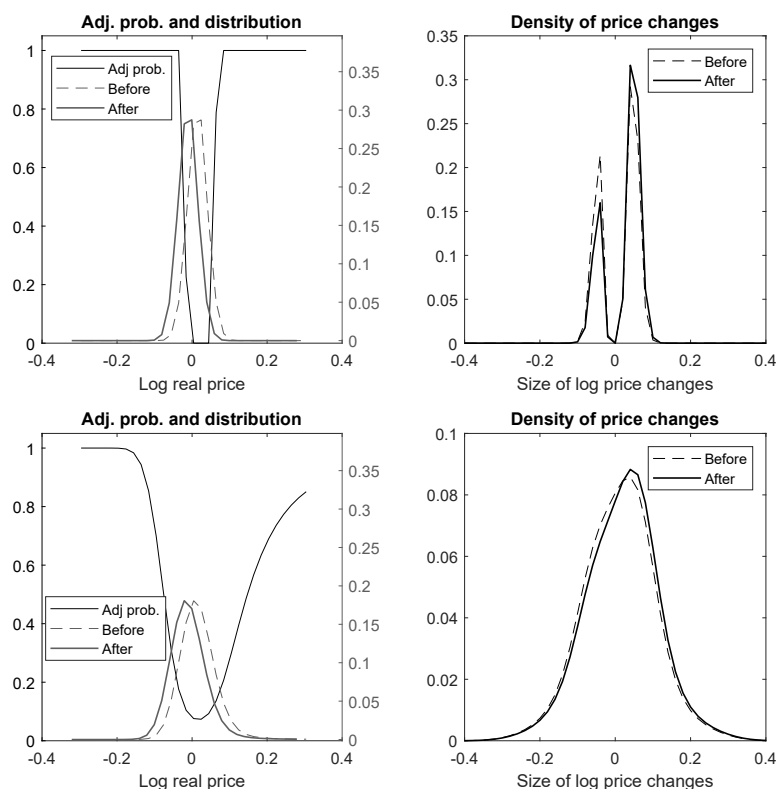


FIGURE 1. EFFECTS OF A POSITIVE MONEY GROWTH SHOCK. MC MODEL (TOP), GHF MODEL (BOTTOM).

explanation for smooth state dependence is managerial decision costs that increase with precision, as in Woodford (2009) and Costain and Nakov (2019), where a smooth policy is less costly to implement than one where the adjustment hazard jumps abruptly from zero to one at the precise point where the value of adjustment turns positive. Another mechanism is studied by Cavallo et al. (2023), who assume that the firm faces adjustment costs that are an increasing, convex function of the probability of a price change.

Figure 1 illustrates how the selection effect is reduced in a GHF model (bottom panels), compared with an MC model (top panels).²³ The figure shows how an expansionary monetary shock affects the density of real price levels (red, left panels) and the density of price changes (black, right panels). Before the shock hits, the densities are at their steady states (dashed lines). The monetary expansion reduces the real values of all nominal prices, shifting the density of real prices left (solid red lines, left panels). Under menu costs, this causes many prices to drift left past the lower adjustment threshold s , so that their adjustment probability jumps from zero to one (this probability is shown as a black line). Hence, in the top right panel, the number of price decreases falls substantially, while the number of price increases rises. Instead, in the GHF model, the adjustment probability always lies strictly between zero and one. The shock makes price increases (decreases) slightly more (less) likely. The whole distribution of price changes shifts slightly right, but the shape of the distribution is largely unchanged—many increases and decreases and small changes still occur. Without the powerful shift from decreases to increases of the MC model, the short-run impact on the price level is much reduced in the GHF framework, so the effect on real variables is larger.

In response to sufficiently costly deviations from their target prices, firms in state-dependent pricing models make large price adjustments quickly. As we

²³The figure compares the MC model of Golosov and Lucas Jr (2007) with the GHF model of Costain and Nakov (2019). Both models are calibrated to the same steady state adjustment frequency, and impose the same process of idiosyncratic cost shocks.

saw earlier for MC models, the hazard rate for price adjustment in GHF models becomes arbitrarily fast as inflation increases without bound. This is because GHF firms respond in a very flexible way to strong incentives. Hence, the largest price gaps across the distribution of products will be closed quickly in a GHF model. The same is not true in the Calvo model; hence the misallocation cost of price dispersion is much larger in the Calvo framework than it is in state-dependent models, especially as inflation increases (Costain and Nakov, 2011b). Likewise, this means that the economy will adjust more quickly to larger shocks in state-dependent models.²⁴ Quick adjustment means that sufficiently large monetary shocks may be approximately neutral, or may even lead to overshooting effects (Alexandrov, 2022). These general findings apply widely across state-dependent models. We discuss some more precise analytical results next.

A. Results on monetary non-neutrality in GHF and MC models

Several recent papers have evaluated the real effects of monetary policy across a large family of state-dependent pricing models, including GHF and MC models. Like menu cost models, GHF models share some analytical properties that can be sharply characterized. Building on earlier work by Gertler and Leahy (2008), Auclert et al. (2024) show that the New Keynesian Phillips Curve (NKPC) derived from a time-dependent model applies also, as a first-order approximation, to a wide range of state-dependent models. In particular, they show that the NKPC implied by state-dependent models is formally equivalent to the NKPC implied by a mixture of one or more Calvo models, but that the equivalent Calvo model has a price update frequency substantially higher than the frequency observed in microdata.²⁵ In other words, a local linear approximation to the dynamics of a state-dependent model has the same form as in the Calvo model, but requires a recalibration of the adjustment frequency that reduces the real effects of monetary policy. Importantly, they show that strategic complementarities in price setting between inputs and outputs affect the dynamics of state-dependent models in the same way they affect the Calvo model, increasing non-neutrality and flattening the Phillips curve.²⁶ This suggests that state-dependent models can explain large real effects of monetary policy – and can be approximated by the NKPC – if strategic complementarities are sufficiently strong.²⁷

The local equivalence between state-dependent and Calvo models also implies that the degree of monetary nonneutrality is related to simple *sufficient statistics* that can be measured in microdata. In a family of models without strategic complementarities, Alvarez et al. (2016a) and Alvarez et al. (2022) show that the real effects of a monetary expansion (as measured by the CIR) are directly proportional to the ratio of the kurtosis of the distribution of price changes to the adjustment frequency (i.e., the effects on a given sector can be inferred from price adjustment statistics in that sector).²⁸ Alvarez et al. (2023) extend this result, showing that the factor of proportionality increases when strategic complementarities are present.²⁹ Intuitively, the aggregate price level adjusts more quickly when the fraction of products that adjust in any given

²⁴See Karadi and Reiff (2018) for an analysis of a change in Hungarian tax policy in an MC model, and Cavallo et al. (2023) for an analysis of post-pandemic inflation in a GHF model.

²⁵Specifically, when inflation is close to zero, the Golosov and Lucas Jr (2007) model is equivalent to a mixture of two Calvo models, related to the intensive and extensive margins of adjustment. At higher inflation rates, it is equivalent to a mixture of more than two Calvo models.

²⁶When strategic complementarities are derived from the presence of a materials input with share $1 - \chi$ in the production function, the slope coefficient of the New Keynesian Phillips curve is reduced in proportion to χ . This result holds both in the Calvo model and in MC and GHF models; see Auclert et al. (2024), Prop. 5.

²⁷First-order equivalence of the dynamics of state-dependent and Calvo models does *not* imply that their welfare and policy implications are the same. Some progress on these issues is discussed below.

²⁸Baley and Blanco (2021) derive a related sufficient-statistics approach that allows for asymmetric policies, based on an assumption of asymmetric menu costs.

²⁹These papers study models of multiproduct firms with stochastic menu costs. Hence there are enough free parameters so that different values of kurtosis can be compared while fixing the frequency and size of adjustments.

period is higher; this fact is amply documented across economies and sectors with different adjustment frequencies (e.g. Gopinath and Itshokhi (2010)). On the other hand, higher kurtosis (greater dispersion in the size of price changes) spreads out the distribution of products across quantiles of the price gap, making them less likely to be bunched up near the (S, s) bands. Hence higher kurtosis reduces the selection effect and increases the real effects of monetary shocks. However, kurtosis is harder to measure in the data, since it is sensitive to outliers and errors, so the effect of the kurtosis of price changes on monetary non-neutrality is controversial (Hong et al., 2023; Alvarez et al., 2021).

New models of heterogeneous products seek to infer the distortions caused by inflation from measurements that are applicable across multiple forms of nominal rigidity. While prices vary substantially across similar products, it is hard to infer how much of this price dispersion is inefficient (Nakamura et al., 2018). Several recent papers have proposed a way to assess the distortions caused by inflation based on the fact that most products exhibit a downward trend in their relative prices over the time since they were first introduced.³⁰ Abstracting from idiosyncratic shocks, Adam and Weber (2019) point out that a firm could keep its relative price on target – without making any nominal adjustments – if the aggregate inflation rate were just sufficient to cause the desired downward trend in its relative price. When inflation instead differs from this product-specific desired trend, the product’s relative price will vary over time, due to intermittent adjustment towards the desired trend. They argue that the optimal inflation rate is the one which minimizes this excess price dispersion, on average across products. Thus, accounting for productivity trends alters the finding of Alvarez et al. (2019) that the optimal steady state inflation rate is zero; Adam and Weber (2019) estimate an optimal rate of roughly 1% *per annum* for the US. Adam et al. (2023) show that for a variety of time-dependent and state-dependent models, the excess price dispersion associated with inflation will be proportional to the squared deviation of the inflation rate from the product-specific preferred price trend. They find evidence for this effect on observed price dispersion in microdata.³¹ Aggregating across products, they calculate the marginal impact of inflation on the *inefficient* component of price dispersion. They conclude that most of the observed cross-sectional price dispersion across similar products is an efficient response to idiosyncratic factors, but that nonetheless, even in a low-inflation environment, variation in inflation can cause costly changes in price distortions.³²

³⁰Learning, technological progress, and fashions are some of the reasons why the efficient price of a given product is likely to decline with the time since its introduction, relative to other products.

³¹In line with the theory, the squared deviation of inflation from the product-specific preferred trend predicts price dispersion, but squared inflation itself does not.

³²According to their estimate in UK CPI data from 1996-2016, increasing inflation by roughly 3pp was associated with a 4pp increase in cross-sectional price dispersion across similar products. However, this estimate seems high in light of Alvarez et al. (2019), whose analysis would predict an increase of no more than 1pp.

IV. Frictional decisions

While menu costs may be given a clear physical interpretation as a cost of changing menus or price tags, economists have long argued that they are better seen as a stand-in for costs related to managerial decisions.³³ Costly aspects of choice may include learning about the environment, acquiring information about current conditions, storing and then retrieving information about the past, processing information and negotiating to arrive at a decision, and communicating decisions within the firm. Spending on management compensation and on information technology amply attests to the importance of these costs. Zbaracki et al. (2004) describes a case study of price setting in an industrial firm, showing that managerial decision-making and costs related to customer relationships (discussed in section V.C below) represent the lion’s share of the costs of price setting, while physical costs of adjustment are relatively trivial. Researchers have been making progress on better models of decision costs; prominent frameworks include *observation costs*, *control costs*, and *rational inattention*.

A. Sticky information, observation costs, and learning

The inflation persistence documented by Fuhrer and Moore (1995) motivated several models of price adjustment based on frictions in information acquisition. Rather like Calvo’s sticky price updating mechanism, Mankiw and Reis (2002) assumed that firms face *sticky information* (SI), meaning that each firm has constant probability of updating its information set each period. A firm then chooses a new time path $\{p_{t+s}\}_{s \geq 0}$ for prices at each time t that it receives an information update. Therefore, even though each firm’s price changes every period, inflation is persistent. Neither aggregate prices nor inflation react immediately to monetary shocks in their model; instead, inflation follows a hump-shaped path, having its maximum deviation several periods after a shock to monetary policy occurs. Mankiw and Reis (2006a,b) extend this framework to allow for updating of other choice variables, such as consumption, based on sticky information too. Coibion and Gorodnichenko (2015) show that under sticky information (and under rational inattention, to be discussed below), past forecast updates will predict future forecast errors, on average across forecasters. They validate this prediction in datasets from several countries encompassing forecasts and expectations for a variety of variables.

Sticky information models can be microfounded by assuming that a firm must pay a fixed *observation cost* (OC) to update its information set. Reis (2006) analyzes firms’ timing of information acquisition in an OC framework.³⁴ Alvarez et al. (2011) solve a model in which firms must pay an observation cost for each information update, as well as a menu cost each time that it adjusts its price. They calibrate their model using data on the frequency of firms’ price policy reviews, as well as data on the frequency and size of price changes, deriving analytical formulas to identify the relative sizes of menu costs and observation costs. Alvarez et al. (2016b) find that SI models produce large real effects of monetary shocks when there is either (i) a long average time between observations or (ii) a highly variable time between observations. When they endogenize the observation frequency under their OC framework, the time between observations is both long and variable, implying significant monetary non-neutrality.

Some forms of *learning* may also contribute to monetary non-neutrality. Ilut et al. (2020) show that as firms learn about their demand function from past sales data, under Knightian uncertainty, this may create “kinks” in the profit function that make observed prices resistant to change. At the same time, uncertainty regarding the relationship between aggregate and industry-level inflation leads to nominal rigidity. Argente and Yeh

³³See Akerlof and Yellen (1985a,b) for an early discussion.

³⁴Burstein (2006) develops a related setup in which a firm can pay a menu cost to update its planned time path for prices. Although his model supposes full information, his mechanism for inflation persistence is similar to that of the SI and OC literatures.

(2022) study a model in which firms can learn about their demand curves by varying their prices, and show that this “active” learning about prices weakens the selection effect. Both of these mechanisms make the aggregate price level less responsive to aggregate shocks.

B. Control costs

Models with *control costs* are based on the assumption that precise decisions are costly. While the SI and OC approaches assume that firms intermittently update their information completely, and thereafter make an optimal decision costlessly, other frameworks model the tradeoffs they face when choosing how accurately to make managerial decisions. One of these is the *control cost* (CC) framework, which models the choice of an action as a random variable – as a way of modelling error-prone behavior – and assumes that decision-makers can shrink their errors by dedicating more time (or effort, or other resources) to making choices. In this context, it is typically not cost-effective to strive for perfectly accurate decisions; instead, the manager trades off the benefit of a marginal reduction in errors against the marginal cost of more precise choice. This game-theoretic approach (Mattsson and Weibull, 2002) helps explain many puzzles arising in theory and in laboratory experiments.³⁵

Recently, control cost models have been applied to retail price and wage setting. Costain and Nakov (2015, 2019) and Costain et al. (2022) developed quantitative macro models with control costs on nominal adjustments. They distinguish between two margins of the adjustment process – the *timing decision* (choosing *when* to make a change), and the *reset decision* (choosing the new level at which the price or wage is fixed). They adopt a common, tractable form for the CC function: firms incur a cost proportional to the *relative entropy* of their chosen distribution of actions, calculated relative to an exogenous benchmark distribution. The benchmark distribution – called a *predisposition* by Steiner et al. (2017) – represents the probabilities that govern the firm’s actions if it devotes no time or resources to decision-making. This functional form implies that the adjustment hazard is a weighted binary logit, and that the distribution of prices conditional on updating follows a weighted multinomial logit.³⁶ By devoting sufficient resources to these two decisions, the firm could take the optimal action on each margin with probability one – but that would be excessive spending on management for negligible marginal gain. Instead, the firm maximizes profits by sometimes leaving its price fixed, and by tolerating small errors when it does adjust.

If the price reset decision is subject to control costs, then it is not optimal to correct small deviations from the target price. A manager who is aware that they (or their subordinates) make errors when resetting prices should optimally avoid making any adjustment until they perceive that the cost of deviating from the target price is large enough to justify the costs of setting the new price with adequate precision. Thus, a manager who faces a smoothly increasing cost of precision in the reset decision acts much like one who faces a menu cost, implying an inaction region around the optimal price. Costain and Nakov (2015) call this (*S, s*)-type behavior *precautionary price stickiness*. But in contrast to the MC approach, their CC framework implies that the new price is distributed randomly around the optimum. This may give rise to multiple adjustments in a row, if the first adjustment turns out to be a large error, which might help explain the bursts of readjustment documented by Campbell and Eden (2014), and the low autocorrelation of reset prices documented by Bils et al. (2012).

If the adjustment timing decision is subject to control costs, then the adjustment hazard is a smoothly increasing function of the gains from adjustment.

³⁵See, for example, Goeree and Holt (1999) and Goeree et al. (2016). Khaw et al. (2017) present laboratory evidence that decision makers’ actions exhibit randomness, even conditional on the information received, and are updated by intermittent jumps, even when their information is continually updated. Woodford (2020) surveys evidence on imprecise decision-making, including implications for price stickiness (Section 3.2.2).

³⁶In each of these two decisions, the weighting coefficients in the logit are the predispositions towards each possible action in the choice set.

The (S, s) behavior that results when control costs apply *only* to the reset decision generates very strong selection effects, just as it does in simple MC models. But this counterfactual behavior is eliminated if control costs affect the timing decision, as in Woodford (2009), Khaw et al. (2017), Costain and Nakov (2019), and Costain et al. (2022).³⁷ In these papers, costly choice of adjustment timing implies a GHF in the form of a weighted binary logit, so the adjustment hazard is a strictly positive, smoothly increasing function of the value of adjustment. The two margins of error in nominal adjustment in these papers play complementary roles in explaining the data. The presence of errors in reset decision helps explain micro evidence, such as the finding that the adjustment probability does not tend to zero near the target price, so that large and small price changes coexist, while the smooth state dependence implied by errors in the timing decision reduces the selection effect, helping explain macro evidence of monetary non-neutrality.³⁸

C. Rational inattention

Models with *rational inattention* are based on the assumption that processing information is costly.³⁹ Sims (1998, 2003) proposed that information costs might explain the sluggishness of many macroeconomic variables – not just nominal prices and wages, but also real variables such as consumption, investment, and employment. Specifically, his *rational inattention* (RI) framework assumes that decision-makers pay a cost proportional to the *mutual information* between their chosen actions and the underlying state variables.⁴⁰ A large literature has applied the RI framework to linear-quadratic (LQ) models with Gaussian shocks. Woodford (2003) showed that a limit on firms' information about aggregate demand shocks could amplify the size and persistence of their effects. Over the years, economists have solved RI models with more general types of signals. Maćkowiak and Wiederholt (2009) show that when firms can devote attention to idiosyncratic productivity shocks or to aggregate monetary shocks, they will choose to focus on productivity, since under a realistic calibration it matters more for their profits than monetary conditions do.⁴¹ This slows the response of the price level to monetary shocks and enhances monetary non-neutrality.⁴² On the other hand, Pasten and Schoenle (2016) point out that in a multi-product firm, tracking product-specific shocks becomes more costly, and there is more incentive to track aggregate shocks, since these affect all products. Such firms may therefore track aggregate shocks – including monetary shocks – more accurately, bringing these firms' behavior closer to monetary neutrality.

Rational inattention models help explain the sluggishness of the price level, expectations, and inflation. In RI models, information about shocks is not absorbed immediately; expectations, forecasts, and choices only assimilate this information gradually over time. Therefore, averaging across agents, errors in forecasts predict further revisions in the same direction, as Coibion and Gorodnichenko (2015) showed. This gradual adjustment of expectations also makes inflation persistent over time. Recently, Afrouzi and Yang (2021) fully solved the problem of optimal dynamic signal extraction in LQ-Gaussian RI models. They show that under RI, decision makers pay more attention to

³⁷The papers of Woodford (2009) and Khaw et al. (2017) study rational inattention models, but as we will see shortly, these can be viewed as a subset of CC models.

³⁸We have focused on CC models with relative entropy cost functions, in which firms make *ex post* errors. But the CC concept is more general, as Flynn and Sastry (2023) discuss. They prove existence and uniqueness of equilibrium, and analyze efficiency, in a large class of static CC models encompassing multiple dimensions of costly precision, such as imperfect formation of *ex ante* plans. As an example, they analyze a model of price rigidity based on Woodford (2003). Extending their results to dynamic contexts would be a valuable advance.

³⁹See Maćkowiak et al. (2023) for a recent review of the RI literature.

⁴⁰See Cover and Thomas (2006), Chap. 2, for discussion of relative entropy and mutual information.

⁴¹Likewise, Afrouzi (2023) shows that oligopolistic firms with fewer competitors shift their attention from aggregate to idiosyncratic shocks.

⁴²Maćkowiak and Wiederholt (2015) show that when consumers, likewise, face an RI constraint, their consumption level responds sluggishly to monetary shocks, helping match evidence of a hump-shaped IRF for real variables.

and Yang (2021) fully solved the problem of optimal dynamic signal extraction in LQ-Gaussian RI models. They show that under RI, decision makers pay more attention to a larger set of signals when information is more valuable or less costly, or when uncertainty is higher. As an application, they show that the Phillips curve may become flatter when the central bank is more hawkish, because firms stop paying attention to signals about monetary policy. Likewise, they find a more hump-shaped response of inflation to transitory shocks when firms are paying less attention.

Rational inattention models are control cost models in which the decision-maker's predisposition across the actions available is optimal. The RI and CC frameworks are very closely related, because mutual information is a special case of relative entropy. Matějka and McKay (2015) use this fact to show (in a static context) that an RI model is a CC model in which the cost function has relative entropy form, and the benchmark distribution across actions (the predisposition) is the optimal one. In other words, RI models are CC models with a specific interpretation of costs: precise decisions are costly because processing information is costly. From their equivalence result, it follows that the probability distribution across actions in an RI model is a weighted multinomial logit.⁴³ This is a general result that applies to all RI models, not only to the popular LQ-Gaussian case. Importantly, the optimal predisposition is very simple: it is just the unconditional distribution across actions. Steiner et al. (2017) extend this result to a dynamic context, showing that a dynamic RI model is equivalent to a dynamic CC model in which the predisposition is set optimally at each point in time. Morales-Jiménez and Stevens (2023) take advantage of these results to analyze U.S. price rigidities in a quantitative business cycle model; they approximate the dynamic RI solution by assuming a constant predisposition, equal to the steady-state distribution of prices, and then using this predisposition to compute a CC solution.⁴⁴

While the RI framework assumes information processing is costly, it abstracts from other relevant costs of cognition, such as the costs of storing and retrieving memories. The optimal predisposition derived by Matějka and McKay (2015) implicitly supposes that the decision-maker is acting in a familiar environment in which they remember how often they chose each possible action in the past. This assumption may be more plausible in a frequently-repeated static choice than in a more dynamic situation.⁴⁵ For example, Turen (2023) studies price setting in an RI macro model with Markov switching between aggregate states with low and high volatility of idiosyncratic shocks. Such a model is plausible if firms have lived in this environment long enough to know that there are two aggregate states, and to remember the relative frequencies of their price choices across the two states, and to adjust their signal strategies accordingly. The memory requirements underlying the general dynamic RI solution of Steiner et al. (2017) are vastly greater – agents must know (i.e., remember from past experience) the distribution of actions (i.e., the optimal predisposition) conditional on every possible information set. Given these fantastical demands on memory capacity and retrieval, it may be interesting to explore extensions of RI that impose limits on memory. This is a possible interpretation of the setup of Morales-Jiménez and Stevens (2023), where choices follow the logit probabilities implied by RI, except that the predisposition across the choice set is time-invariant, and equals the steady-state distribution of actions.⁴⁶ Implicitly, this may be seen as an assumption that firms learn from experience about payoffs, and hence about the optimal predisposition, but face memory constraints, so they cannot remember how

⁴³As was the case for CC models, the weights in the logit are the predispositions towards each possible action.

⁴⁴Their model incorporates *both* decision costs and menu costs. Their parameter estimates imply that the menu costs incurred by firms are small compared with the decision costs they incur.

⁴⁵Maćkowiak et al. (2023) suggest, in their survey of RI, that "... RI models best describe repetitive decisions with a great deal of available information."

⁴⁶By fixing a constant predisposition, this approximation reduces the degree of state dependence compared with the full RI solution of Steiner et al. (2017).

the distribution of actions varies across states. Instead, they only remember what the distribution looks like on average, across all aggregate states.⁴⁷

Optimal information processing can generate price jumps across a small number of discrete values. While the models of Maćkowiak and Wiederholt (2009, 2015) and Afrouzi and Yang (2021) help explain the sluggish dynamics of inflation and the aggregate price level, they say nothing about micro evidence on staggered price adjustments, because under the LQ-Gaussian specification they consider, prices vary continuously over time, just as they do in Rotemberg (1982). But this is a special case which does not reflect the generic behavior of RI models. Under most other functional forms, the predisposition generated by an RI model is *discrete*, meaning that the decision-maker economizes on information by considering only a small number of possible actions, even when there is a continuum of alternatives in the choice set (Fix, 1978). Matějka (2016) proposes that this aspect of RI behavior may be a microfoundation for discrete price adjustments followed by intervals of stickiness. However, no feature of his model ensures that this stickiness is *nominal*; instead, it generates discrete jumps across different *real* prices, followed by intervals at which the price is stuck at a given real value (and hence is varying over time in nominal terms).^{48,49} Stevens (2020) extends this framework to model “sales” behavior, allowing for two types of decision frictions: paying an observation cost reveals full information about the state, while between observations the firm adjusts its prices subject to an RI constraint, given the predisposition across *nominal* prices consistent with the most recent observation of the state. Hence a firm will jump back and forth across a small set of nominal price points for some time, until it updates its information again and selects a new set of price points to consider.

⁴⁷Whether this is the *optimal* way to use limited memory is an interesting question for further research. One of the first papers to analyze optimal memory use is Azeredo da Silveira and Woodford (2019).

⁴⁸To illustrate the form of stickiness in Matějka (2016), suppose firms face idiosyncratic productivity shocks, and no aggregate uncertainty, but there is a deterministic trend in aggregate money. In this context, RI firms will make discrete jumps across several *real* price levels, roughly tracking changes in marginal costs. While it maintains a given real price, a firm’s nominal price will vary continuously over time, trending with the money supply. The absence of nominal stickiness here could be fixed by adding additional frictions to the model, such as menu costs.

⁴⁹Dean and Neligh (2023) argue that RI imposes no structure of “cognitive distance” across the actions in the choice set, and they highlight behavioral paradoxes attributable to this missing structure. One way to understand the real versus nominal rigidity generated by the Matějka (2016) and Costain and Nakov (2019) models is that the former abstracts from the discrete jump in cognitive distance between the action $p_{t+1} = p_t$ (nominal price unchanged) and any action $p_{t+1} = p_t + \epsilon$, for $\epsilon \neq 0$. By treating the timing decision and the price reset decision as qualitatively distinct choices, the latter paper implicitly recognizes this gap in cognitive distance.

V. Real rigidities

The frictions that buffer aggregate price movements include real as well as nominal rigidities.⁵⁰ While *nominal rigidities* refer to costs or frictions that constrain the adjustment of a seller's nominal price, *real rigidities* refer to factors that reduce the responsiveness of that seller's target price to an aggregate demand shock (Romer, 2008). That is, nominal rigidities make nominal changes smaller and/or less likely conditional on the desired change in the price, while real rigidities reduce desired price changes. While microdata reject the strong selection effects implied by a simple MC model, even the muted selection from GHF models reduces the real effects of money shocks significantly. But many plausible mechanisms on the real side enhance these effects, so a realistic quantitative assessment of the impact of monetary policy needs to take them into account.⁵¹

A. Market power

Some degree of market power is an essential component of any theory of nominal stickiness. The idealized situation of perfect competition, with multiple sellers offering a uniform product at a single market clearing price, cannot really address the details of retail microdata, in which products are differentiated across space, brands, and characteristics, with high price dispersion even across closely substitutable products. When instead firms have market power, customers' demand reacts smoothly to price decisions, so a firm does not lose all of its demand if it keeps its price fixed while other firms lower theirs. In other words, market power is a form of real rigidity, reducing sellers' desired price adjustments in response to shocks, which makes it possible, in equilibrium, for nominal rigidities to affect macroeconomic outcomes.

Variable elasticity of demand can strengthen non-neutrality, but may make it hard to explain price dispersion. The textbook framework of monopolistic competition, following Blanchard and Kiyotaki (1991), assumes that the elasticity of demand is constant, and equal across all products. Kimball (1995) instead proposed a variable-elasticity demand function such that a given product's demand falls more sharply when its price exceeds those of competing products. His framework strengthens strategic complementarities across competing products, making the seller of any product reluctant to adjust its price until competitors adjust theirs. Gopinath and Itshokhi (2010) show that Kimball's framework helps explain the fact that passthrough of costs to prices is lower for producers that adjust prices less frequently. But in a quantitative model with many products per sector, where each seller takes the sectoral price index as given, Klenow and Willis (2016) find that the *micro* real rigidities of Kimball (1995) cannot be very strong, because otherwise idiosyncratic price fluctuations would necessarily remain small (see also Blanco et al. (2022)). In contrast, they argue that *macro* real rigidities linking output prices with input prices are a plausible amplifier of nominal rigidity.

Oligopolistic competition between a small, finite number of competitors amplifies the real effects of monetary policy without eliminating price dispersion. One reason the Blanchard and Kiyotaki (1991) framework is so tractable is that each firm only needs to consider demand for its own unique product relative to aggregate demand.

⁵⁰The real incentives that reinforce nominal frictions have been described in several closely related ways. Expressing quantities in logs, Romer (2008) says that a firm i exhibits *real rigidity* when its desired price deviation from the aggregate price index, $p_i^* - P$, is not very responsive to the output gap y , i.e., when the elasticity $\partial(p_i^* - P)/\partial y$ is small. Following Cooper and John (1988), a firm i exhibits *strategic complementarity* in price setting if its desired price p_i^* responds positively to a change in the aggregate price index P , or to an index of its competitors' prices.

⁵¹Beyond the real factors that reinforce nominal rigidity that we discuss here, many forms of strategic complementarity arise due to frictions in financial markets. Financial frictions have been a major area of macroeconomic research since the financial crisis of 2007-2009, and are now a standard building block of New Keynesian models. This chapter will not attempt to summarize the interactions between financial frictions and nominal rigidities. An influential paper in this area is Gilchrist et al. (2017), which argued that many firms were reluctant to lower prices in the crisis because they were unable to obtain sufficient liquidity to expand output.

In reality, almost any product has some close substitutes sold by other firms, so oligopoly may be a better model of competition than monopoly. But taking oligopoly seriously is complex, since it implies that price setting is a game played between competitors – each firm must consider the prices set by its competitors. Mongey (2021) studies monetary policy in a stochastic menu cost (GHF) model with two oligopolistic competitors in each sector. In his framework, strategic complementarities operate at the sectoral level, rather than the aggregate level. This makes it possible for shocks at the product and sector levels to drive large fluctuations in the prices of individual products. At the same time, it strongly amplifies nominal rigidity in response to aggregate shocks, as each oligopolistic competitor is reluctant to pay the cost of changing its price unless the others do too.⁵² In fact, he shows that the presence of menu costs raises the equilibrium markup in a given sector – so firms may actually benefit from frictions (as long as their competitors face them too). Covarrubias (2022) extends the analysis to more than two competitors per sector, and considers equilibria in which oligopolists collude to keep prices high.⁵³ Afrouzi (2023) shows that the effects of dynamic oligopoly are strengthened under rational inattention, as firms with fewer competitors shift their attention from aggregate shocks towards shocks affecting their competitors.

B. Input-output structure

Various types of nominal rigidities affecting different agents and different sectors are likely to complement one another in reducing and delaying adjustments in the aggregate price level. For example, wage rigidity makes firms' marginal costs sticky, and hence makes prices stickier. In practice, this may mean that wage rigidity is more important for sluggishness of the aggregate price level than price stickiness *per se*, because even if firms can adjust flexibly, their chosen prices will react sluggishly to aggregate shocks if their marginal costs are sluggish (Erceg et al., 2000; Blanchard and Galí, 2007; Costain et al., 2022).⁵⁴

Sticky prices of input suppliers reinforce price stickiness of their customers, and in practice the stickiest sectors of the economy matter most for the sluggishness of aggregate prices. Models in which price rigidity differs across products typically find that prices are strategic complements, and that therefore the stickiest prices matter most for aggregate dynamics because their stickiness feeds through to the decisions of more flexible sectors (Carvalho, 2006; Nakamura and Steinsson, 2010). This strategic complementarity can go both through relations with competitors, and through relations with suppliers. A particularly tractable case of strategic complementarity, originally from Basu (1995), is a production function with a materials input consisting of the same CES product bundle as final consumption. In this case, Klenow and Willis (2016) showed that materials inputs could substantially increase monetary non-neutrality in an MC model; more recently Auclert et al. (2024) proved this analytically for MC and GHF models. Models with a more detailed network of input-output relationships also find strategic complementarity in price setting, with stickier sectors having an oversized effect. Most of these papers are based on time-dependent price adjustment (Pasten et al., 2020; Ghassibe, 2021; Rubbo, 2023; Luo and Villar, 2023; Afrouzi and Bhattarai, 2023). Input-output models with state-dependent prices are still rare; a recent example is Antonova (2023). However, it seems likely that the key insights – strategic complementarity, and the importance of the stickiest sectors – will be robust across different models of frictions.

⁵²Wang and Werning (2022) also find that an oligopolistic game enhances strategic complementarities and monetary non-neutrality, in a Calvo model that abstracts from idiosyncratic shocks.

⁵³For tractability, Mongey (2021) focuses on Markov equilibria. In the collusive equilibria studied by Covarrubias (2022), markups are even higher than those in a Markov equilibrium.

⁵⁴For evidence on nominal wage rigidity, see Dickens et al. (2007), Barattieri et al. (2014), and Grigsby et al. (2021).

When buyers and sellers enter a long-term relationship, the prices at a given point in time may have no allocative role; instead, allocations may be governed by the long-run value of the relationship. Nakamura and Steinsson (2011) model the price dynamics of a firm with a long-term link to its customers, following Phelps and Winter (1970) and Rotemberg and Woodford (1991). Specifically, they consider a habit-forming good, so that customers care both about current and future prices, since they know they may become partially locked in to a relationship with the seller. This implies a time inconsistency problem: the firm wishes initially to attract customers by promising a low price, but thereafter it has an incentive to raise its price, taking advantage of customers' dependence on its product. Hence it is mutually beneficial if the firm and its customers can enter into an *implicit contract* governing the price. They find that if the firm has superior information about its costs and demand, then the optimal incentive-compatible contract is one in which the firm commits to never exceed a "price cap". But when it faces favorable idiosyncratic shocks, it is free to lower its price below the cap, providing a possible explanation for a sticky "regular" prices with more flexible sales. These results echo the evidence from Zbaracki et al. (2004) that expenditures on relationships are a large part of the costs of price setting, and from Bewley (2002) that fear of antagonizing partners is a key incentive for non-adjustment.

Likewise, in the search-and-matching theory of labor markets, matching incentives are driven by the long-run expected value of the match. Sunk costs of search are another source of lock-in to a buyer-seller relationship, raising issues similar to those in Nakamura and Steinsson (2011).⁵⁵ Typically, in search and matching (SaM) models, the incentives to form a match depend on the present discounted value of the surplus available to a matched pair. Whether the wage payment from the employer to the worker is sticky after the match is formed is not necessarily relevant. What matters for hiring incentives is whether the present discounted value of wages the firm expects to pay to the worker over the lifetime of the match reacts flexibly to shocks. Under Nash bargaining, with no additional frictions, aggregate shocks mostly pass through to the wage, making it hard to explain large fluctuations in vacancies and employment (Shimer, 2010; Blanchard and Galí, 2010). Several forms of wage rigidity can help explain employment fluctuations in SaM models. Hall (2005) considers a model with a wage norm, while Gertler and Trigari (2009) and Gertler et al. (2008) assume that a firm intermittently updates the wage, in Calvo fashion, for its whole workforce. Both of these wage frictions affect newly hired workers (not just continuing jobs), making them relevant for real effects on employment. More recently, Morales-Jiménez (2022) offers a state-dependent model of wage rigidity, showing that rational inattention on the worker's side can make the wage sluggish for new hires in a SaM model, complementing the findings of Woodford (2003) and Maćkowiak and Wiederholt (2009) that RI on the firm's side makes prices sluggish.

Search-theoretic analysis of consumer behavior helps explain equilibrium price dispersion. The literature on consumer search across products has focused on explaining dispersion across the prices of similar goods.⁵⁶ Burdett and Judd (1983) modelled price dispersion in an environment where a consumer searching across products sometimes observes several prices before making a purchase. If consumers then select among identical products by buying the cheapest offer, firms may be indifferent between selling a larger quantity at a low price, or a smaller quantity at a higher price; indeed, in their equilibrium, firms must be indifferent between setting a continuum of different prices. Head et al. (2012) extend their model to a dynamic monetary economy, pointing out that a

⁵⁵In an influential early critique, Barro (1977) questioned whether nominal rigidity could explain monetary non-neutrality. Considering labor markets, he argued that worker-firm relationships were likely to be governed by implicit contracts in which stickiness of the wage at a given point in time would have no allocative effect.

⁵⁶Recent work on consumer search includes Sara-Zaror (2022), who shows that low, positive inflation may be welfare-enhancing since it encourages consumer search.

model where firms are indifferent across an interval of prices can reproduce almost any pattern of staggered price adjustment from microdata, since firms are in fact indifferent between adjusting their prices or leaving them fixed. But since this mechanism relies only on indifference, without any frictions, it generates full monetary neutrality.

Equilibrium price dispersion can also be sustained by *stochastic price discrimination* across heterogeneous consumers. Heterogeneity in demand elasticities is another factor that may leave firms indifferent between lower and higher prices. A firm may offer a product at a high price that only attracts its most loyal customers, or they may sell a larger quantity by offering a lower price that draws in “bargain hunters” too. Varian (1980) modelled sales by assuming that retailers randomize between high and low prices in order to maximize profits when selling to heterogeneous consumers. Guimaraes and Sheedy (2011) embedded his mechanism into a dynamic macro model with a Calvo friction on “regular” price changes. They showed that firms’ (flexible) decisions about when to offer retail sales are *strategic substitutes*— a retailer contemplating sales prefers to attract a higher share of high-elasticity customers by offering discounted prices on a given product category at a different time than its competitors. Hence firms have little incentive to change the fraction of products on sale in response to aggregate shocks. Since regular prices are sticky, and sales are strategic substitutes, the Guimaraes and Sheedy (2011) framework generates strong real effects of monetary shocks. Kryvtsov and Vincent (2021) likewise study a model of sales based on consumer heterogeneity, in which the “regular” price is stickier than the “sale” price. In their model, households choose how much of their time to spend shopping. This makes the fraction of high-elasticity demand endogenously countercyclical, which then gives firms a greater incentive to offer sales in recessions, enabling them to match the countercyclicality of sales incidence in their data, generating a mild reduction in monetary non-neutrality.

Ultimately, what matters for macroeconomic outcomes is whether micro rigidities aggregate to macro rigidity. Head et al. (2012) rightly point out that observing intervals of price stickiness at the micro level need not imply that the aggregate price level is sticky. Whether micro stickiness aggregates into macro sluggishness may depend on the details of price- and wage-setting decisions, and how these propagate across agents. For example, Hall and Milgrom (2008) show that subtly different forms of wage negotiation may increase or decrease real wage rigidity, affecting the stickiness of firms’ marginal costs and hence the cyclicity of output and employment. Likewise, we saw that strategic complementarities between oligopolistic competitors amplify nominal rigidities more strongly than those between individual and aggregate prices (Mongey, 2021). Head et al. (2012) do not discuss what incentives – or what information flows – are needed in their setting to convince some firms to make the adjustments that keep in place a price distribution that ensures indifference over an interval of prices. Further work linking the costs of decision-making with the microfoundations of search and matching (see e.g., Cheremukhin et al. (2020)) might help clarify the plausibility of an equilibrium like that of Head et al. (2012). This could also help unify the microfoundations of sticky nominal prices with those of sticky relationships, as Sims (1998) anticipated.

VI. Implications for inflation dynamics

Smoothly state-dependent pricing models are simultaneously consistent with key empirical facts from micro and macro data, including the large real effects of monetary policy shocks. While the basic MC model implies that money is almost neutral (Golosov and Lucas Jr, 2007), GHF models derived from diverse microfoundations imply substantially stronger real effects of monetary shocks.⁵⁷ The SDP models that predict strong real effects are typically also compatible with micro evidence showing that the adjustment hazard is a smooth, strictly positive function, and that price changes vary greatly in size. In other words, models consistent with the macro effects of money are ones in which the selection effect is statistically and economically significant but relatively weak. This numerical finding is reinforced by the analytical result, valid across many models, that the cumulative impulse response (CIR) of real output to a monetary shock, at a low steady-state inflation rate, is proportional to the kurtosis of the price change distribution and inversely proportional to the adjustment frequency (Alvarez et al., 2016a, 2022). The non-neutrality implied by GHF adjustment is reinforced by strategic complementarities (Alvarez et al., 2023), including those between the prices of inputs and outputs (Costain et al., 2022; Auclert et al., 2024) and those across prices of oligopolistic competitors (Mongey, 2021; Afrouzi, 2023).

Recent equivalence results show that state-dependent pricing models share the same aggregate dynamics as *ad hoc* pricing models, as long as key parameters are adjusted appropriately. The dynamics of most state-dependent models, when inflation is low, are equivalent to those of the Calvo model, with adjusted parameters (Auclert et al., 2024; Alvarez et al., 2022). This result applies both to smoothly state-dependent pricing (GHF) models and to simple menu cost models, but the smoother adjustment hazard of the former class implies more sluggish convergence of the aggregate price level, enhancing non-neutrality. Hence, aggregate dynamics at low inflation rates are consistent with GHF models, but can be approximated by Calvo models. *Ceteris paribus*, GHF models imply an intermediate level of stickiness, greater than that of MC models, but less than that of Calvo. Economic mechanisms that can generate GHF behavior, helping to explain both the staggering of price changes and the smoothness of the hazard function, include frictions in decisions governing the *timing* of price changes (Woodford, 2009; Alvarez et al., 2017; Costain and Nakov, 2019) and economies of scope in price setting by multiproduct firms (Midrigan, 2011).⁵⁸

Table 1 compares the real effects of monetary policy across two smoothly state-dependent models and similar Calvo models. We report the CIR of real output in response to a 1% money supply growth shock with monthly autocorrelation 0.8, in GHF models with sticky prices on final goods only (Costain and Nakov, 2019), or with sticky prices on final goods and sticky wages on the labor input (Costain et al., 2022). These models are calibrated to microdata on retail price changes (both columns) and on wage changes (last column), implying a monthly adjustment hazard of 15% (8.3%) for prices (wages). To fit the observed distributions of price and wage changes, the models suppose product- and job-specific productivity shocks. We first compare these SDP models with the standard Calvo (1983) setup, which abstracts from idiosyncratic productivity shocks (“Calvo RANK”): using the same adjustment hazards, the Calvo models imply real effects 2.5 to 2.8 times greater than the smooth SDP models.⁵⁹ To make clear that

⁵⁷Papers demonstrating the potential of smooth hazard functions to enhance monetary non-neutrality include some agnostic models (Costain and Nakov, 2011a; Dotsey and Wolman, 2020) and some models based on specific classes of microfoundations (Midrigan, 2011; Alvarez et al., 2016b, 2017; Costain and Nakov, 2019).

⁵⁸However, these two mechanisms may conflict with each other (Pasten and Schoenle, 2016).

⁵⁹Concretely, the CIR rises from 5.5 to 13.9 in the scenario with final goods only; the CIR is much larger given strategic complementarity between price- and wage-setting, yielding a value of 19 under SDP, or 51 under Calvo. These numbers represent the integral under the impulse response function, at monthly rates; they can be divided by three to compute the CIR at a quarterly rate.

TABLE 1—MATCHING REAL EFFECTS FROM SDP MODELS WITH CALVO MODELS^a

Model:	Final goods	Goods and labor
<i>Using empirical frequencies:</i>		
Output CIR, SDP ^a	5.5	19
Output CIR, Calvo RANK ^a	13.9	51
Output CIR, Calvo HANK ^a	14.4	–
<i>Using adjusted frequencies:</i>		
Output CIR, Calvo RANKadj ^a	5.5	19
Calvo parameter, prices ^b	0.31	0.15
Calvo parameter, wages ^b	–	0.30

Note: ^aThe CIR refers to the area under the real output impulse response function, calculated at monthly frequency. Model supposes trend inflation equals 2% per year. The SDP models are calibrated to give a monthly price reset hazard of 15% and a monthly wage reset hazard of 8.3%.

^b“Calvo parameter” refers to the monthly frequency of price or wage adjustment. In the top panel, SDP models are compared to Calvo models with the same adjustment frequencies (Calvo RANK and Calvo HANK). In the bottom panel, the Calvo parameters are altered, to generate the same CIR as the SDP models.

the idiosyncratic shocks are not the main difference between our SDP and Calvo scenarios, the table also reports a Calvo model (“Calvo HANK”) with the same adjustment frequency and the same product-specific shock processes as the SDP model; the CIR of the Calvo model hardly changes. The second panel of the table asks how much the Calvo hazard would have to be increased in order to obtain the same non-neutrality as the SDP model. In the specification with final goods only, a rough doubling the adjustment hazard, from 0.15 to 0.31 monthly, gives the same non-neutrality as the SDP model. In the case with sticky prices and wages, we hold the price reset hazard fixed, and find that the wage reset hazard must be more than tripled in the Calvo case – from 0.083 to 0.30 monthly – to give the same CIR as the SDP model.

Retail sales moderately enhance aggregate price flexibility, but do not contradict the general conclusion that nominal rigidity matters for macroeconomic dynamics. Several economic mechanisms may explain the large, frequent price jumps associated with retail sales without calling into question the stickiness of “regular” prices. Implicit contracts between retailers and customers may permit downward but not upward flexibility of final goods prices (Nakamura and Steinsson, 2011); stochastic price discrimination across heterogeneous consumers may induce uncorrelated jumps across a set of distinct nominal price points (Guimaraes and Sheedy, 2011); information processing frictions may cause prices to respond sluggishly to shocks, but to adjust through discrete jumps (Matějka, 2016; Stevens, 2020). While abstracting from sales is reasonable in simple macromodels, modelling sales may be crucial for matching the finer details of microdata. Better reconciling the stickiness of “regular” prices with the flexibility of sales could also help elucidate the nature of frictions throughout the economy.

In spite of their equivalence to Calvo (1983) for the first-order impact of small shocks, state-dependent models imply that price changes are rapid and flexible when circumstances warrant. At very high inflation rates, the state-dependent adjustment frequency rises in proportion to inflation, and the quantitative predictions of MC models fit data from hyperinflationary environments well (Alvarez et al., 2019). Likewise, sufficiently large macroeconomic shocks propagate very quickly to prices, so their real impact is similar to what a flexible-price model would imply (Karadi and Reiff, 2018; Cavallo et al., 2023). Therefore there are decreasing returns to the real output gains from a large monetary stimulus (Ascari and Haber, 2022; Alexandrov, 2022). Similarly, the fact that the adjustment frequency rises with inflation implies that the Phillips curve becomes steeper at higher inflation rates (Costain et al., 2022; Afrouzi and Yang, 2021). Further-

more, the flexibility of SDP behavior – when necessary – reduces the welfare losses caused by frictions, because firms tend to adjust before suffering especially costly deviations from their targets. This reduces the welfare costs of inflation in SDP models, compared with the Calvo and Taylor frameworks. Hence, while Schmitt-Grohé and Uribe (2004) found that optimal steady-state inflation is very close to zero in a Calvo model, recent analyses find higher optimal inflation rates. Adam and Weber (2019) find an optimal inflation rate of 1% *per annum*, due to idiosyncratic productivity trends in a model of product turnover, while Blanco (2021) calculates an optimal rate of 3.5% *per annum* due to the lower welfare costs of inflation under SDP.

Real rigidities and frictions in information flow help explain the sluggishness of the inflation rate, as well as that of prices. Staggered adjustment driven by menu costs or control costs helps explain why the aggregate *price level* is sluggish, but does not, on its own, explain why the *inflation rate* is persistent. Like Calvo frictions, these frictions are entirely forward-looking, so they slow the convergence of the price level after an aggregate shock, but the adjustment begins as soon as the shock hits. Hence even though prices are sluggish, the inflation rate jumps immediately after a shock, unless it is held back by some institutional constraints such as indexation of wages or prices (Galí et al., 2005). However, strategic complementarities slow down the convergence of prices even more, and if they are sufficiently strong they can also make the inflation rate persistent, giving rise to a hump-shaped inflation response to a monetary shock (Alvarez et al., 2023). In particular, real rigidities due to input-output networks enhance inflation persistence under all the classes of frictions considered here, as inflationary shocks filter gradually from primary inputs to final goods retail prices. Quantifying inflation persistence in state-dependent pricing models with an input-output structure is a relevant challenge for future research. Finally, frictions relating to information flow – whether in the form of sticky information, observation costs, or rational inattention – can stop news about aggregate shocks from filtering immediately into price and wage setting decisions, making the inflation rate sluggish too (Mankiw and Reis, 2002; Woodford, 2003; Maćkowiak and Wiederholt, 2009; Afrouzi and Yang, 2021).

Acknowledgments

We thank the editors and F. Lippi, R. Rigato, L. Stevens, and H. Weber for vital feedback. The views expressed in this chapter are the personal opinions of the authors, and do not necessarily reflect the views of the European Central Bank, the Eurosystem, or the Banco de España.

References

- Adam, Klaus, Andrey Alexandrov and Henning Weber. (2023). "Inflation distorts relative prices: Theory and evidence". Discussion Papers, 18088, Centre for Economic Policy Research. <https://cepr.org/publications/dp18088>
- Adam, Klaus, and Henning Weber. (2019). "Optimal trend inflation". *American Economic Review*, 109(2), pp. 702-737. <https://doi.org/10.1257/aer.20171066>
- Afrouzi, Hassan. (2023). "Strategic inattention, inflation dynamics, and the non-neutrality of money". NBER Working Paper Series, 31796, National Bureau of Economic Research. <https://doi.org/10.3386/w31796>
- Afrouzi, Hassan, and Saroj Bhattarai. (2023). "Inflation and GDP dynamics in production networks: A sufficient statistics approach". NBER Working Paper Series, 31218, National Bureau of Economic Research. <https://doi.org/10.3386/w31218>
- Afrouzi, Hassan, and Choongryul Yang. (2021). "Dynamic rational inattention and the Phillips curve". CESifo Working Paper, 8840, Center for Economic Studies. <https://doi.org/10.2139/ssrn.3770462>
- Akerlof, George A., and Janet L. Yellen. (1985a). "Can small deviations from rationality make significant differences to economic equilibria?". *American Economic Review*, 75(4), pp. 708-720. <https://www.jstor.org/stable/1821349>
- Akerlof, George A., and Janet L. Yellen. (1985b). "A near-rational model of the business cycle, with wage and price inertia". *The Quarterly Journal of Economics*, 100(Supplement), pp. 823-838. <https://doi.org/10.1093/qje/100.Supplement.823>
- Alexandrov, Andrey. (2022). "The effects of trend inflation on aggregate dynamics and monetary stabilization". Discussion Paper Series, 216, Collaborative Research Center Transregio 224. <https://www.crctr224.de/research/discussion-papers/archive/dp216>
- Alvarez, Fernando, Martín Beraja, Martín Gonzalez-Rozada and Pablo Andrés Neumeyer. (2019). "From hyperinflation to stable prices: Argentina's evidence on menu cost models". *The Quarterly Journal of Economics*, 134(1), pp. 451-505. <https://doi.org/10.1093/qje/qjy022>
- Alvarez, Fernando, Andrea Ferrara, Erwan Gautier, Hervé Le Bihan and Francesco Lippi. (2021). "Empirical investigation of a sufficient statistic for monetary shocks". NBER Working Paper Series, 29490, National Bureau of Economic Research. <https://doi.org/10.3386/w29490>
- Alvarez, Fernando, Hervé Le Bihan and Francesco Lippi. (2016a). "The real effects of monetary shocks in sticky price models: A sufficient statistic approach". *American Economic Review*, 106(10), pp. 2817-2851. <https://doi.org/10.1257/aer.20140500>
- Alvarez, Fernando, and Francesco Lippi. (2014). "Price setting with menu cost for multiproduct firms". *Econometrica*, 82(1), pp. 89-135. <https://doi.org/10.3982/ECTA10662>
- Alvarez, Fernando, and Francesco Lippi. (2020). "Temporary price changes, inflation regimes, and the propagation of monetary shocks". *American Economic Journal: Macroeconomics*, 12(1), pp. 104-152. <https://doi.org/10.1257/mac.20180383>
- Alvarez, Fernando, Francesco Lippi and Aleksei Oskolkov. (2022). "The macroeconomics of sticky prices with generalized hazard functions". *Quarterly Journal of Economics*, 137(2), pp. 989-1038. <https://doi.org/10.1093/qje/qjab042>
- Alvarez, Fernando, Francesco Lippi and Luigi Paciello. (2011). "Optimal price setting with observation and menu costs". *The Quarterly Journal of Economics*, 126(4), pp. 1909-1960. <https://doi.org/10.1093/qje/qjr043>

- Alvarez, Fernando, Francesco Lippi and Luigi Paciello. (2016b). "Monetary shocks in models with inattentive producers". *The Review of Economic Studies*, 83(2), pp. 421-459. <https://doi.org/10.1093/restud/rdv050>
- Alvarez, Fernando, Francesco Lippi and Luigi Paciello. (2017). "Monetary shocks in models with observation and menu costs". *Journal of the European Economic Association*, 16(2), pp. 353-382. <https://doi.org/10.1093/jeea/jvx013>
- Alvarez, Fernando, Francesco Lippi and Panagiotis Souganidis. (2023). "Price setting with strategic complementarities as a mean field game". *Econometrica*, 91(6), pp. 2005-2039. <https://doi.org/10.3982/ECTA20797>
- Anderson, Eric, Benjamin Malin, Emi Nakamura, Duncan Simester and Jón Steinsson. (2017). "Informational rigidities and the stickiness of temporary sales". *Journal of Monetary Economics*, 90, pp. 64-83. <https://doi.org/10.1016/j.jmoneco.2017.06.003>
- Antonova, Anastasiia. (2023). State-dependent pricing and cost-push inflation in a production network economy. Manuscript, Aix-Marseille Univ. https://www.ecb.europa.eu/press/conferences/shared/pdf/20231004_mon_pol_conference/Antonova_paper.pdf
- Argente, David, and Chen Yeh. (2022). "Product life cycle, learning, and nominal shocks". *Review of Economic Studies*, 89(6), pp. 2992-3054. <https://doi.org/10.1093/restud/rdac004>
- Ascari, Guido. (2004). "Staggered prices and trend inflation: some nuisances". *Review of Economic Dynamics*, 7(3), pp. 642-667. <https://doi.org/10.1016/j.red.2004.01.002>
- Ascari, Guido, Efrem Castelnuovo and Lorenza Rossi. (2011). "Calvo vs. Rotemberg in a trend inflation world: An empirical investigation". *Journal of Economic Dynamics and Control*, 35(11), pp. 1852-1867. <https://doi.org/10.1016/j.jedc.2011.06.002>
- Ascari, Guido, and Timo Haber. (2022). "Non-linearities, state-dependent prices and the transmission mechanism of monetary policy". *Economic Journal*, 132(641), pp. 37-57. <https://doi.org/10.1093/ej/ueab049>
- Auclert, Adrien, Rodolfo Rigato, Matthew Rognlie and Ludwig Straub. (2024). "New pricing models, same old Phillips curves?". *The Quarterly Journal of Economics*, 139(1), pp. 121-186. <https://doi.org/10.1093/qje/qjad041>
- Azere do da Silveira, Rava, and Michael Woodford. (2019). "Noisy memory and over-reaction to news". *AEA Papers and Proceedings*, 109, pp. 557-561. <https://doi.org/10.1257/pandp.20191049>
- Baley, Isaac, and Andrés Blanco. (2021). "Aggregate dynamics in lumpy economies". *Econometrica*, 89(3), pp. 235-1246. <https://doi.org/10.3982/ECTA17344>
- Barattieri, Alessandro, Susanto Basu and Peter Gottschalk. (2014). "Some evidence on the importance of sticky wages". *American Economic Journal: Macroeconomics*, 6(1), pp. 70-101. <https://doi.org/10.1257/mac.6.1.70>
- Barro, Robert J. (1972). "A theory of monopolistic price adjustment". *The Review of Economic Studies*, 39(1), pp. 17-26. <https://doi.org/10.2307/2296440>
- Barro, Robert J. (1977). "Long-term contracting, sticky prices, and monetary policy". *Journal of Monetary Economics*, 3(3), pp. 302-316. [https://doi.org/10.1016/0304-3932\(77\)90024-1](https://doi.org/10.1016/0304-3932(77)90024-1)
- Basu, Susanto. (1995). "Intermediate goods and business cycles: Implications for productivity and welfare". *American Economic Review*, 85(3), pp. 512-531. <https://www.jstor.org/stable/2118185>
- Benigno, Pierpaolo, and Michael Woodford. (2003). "Optimal monetary and fiscal policy: A linear-quadratic approach". *NBER Macroeconomics Annual*, 18, pp. 271-333. <https://doi.org/10.1086/ma.18.3585260>
- Bewley, Truman F. (2002). *Why Wages Don't Fall during a Recession*. Harvard Univ. Press. <https://doi.org/10.2307/j.ctv1pncnkx>
- Bils, Mark. (2009). "Do higher prices for new goods reflect quality growth or inflation?". *The Quarterly Journal of Economics*, 124(2), pp. 637-675. <https://doi.org/10.1162/qjec.2009.124.2.637>

- Bils, Mark, and Peter J. Klenow. (2004). "Some evidence on the importance of sticky prices". *Journal of Political Economy*, 112(5), pp. 947-985. <https://doi.org/10.1086/422559>
- Bils, Mark, Peter J. Klenow and Benjamin A. Malin. (2012). "Reset price inflation and the impact of monetary policy shocks". *American Economic Review*, 102(6), pp. 2798-2825. <https://doi.org/10.1257/aer.102.6.2798>
- Blanchard, Olivier. (1986). "The wage price spiral". *The Quarterly Journal of Economics*, 101(3), pp. 543-566. <https://doi.org/10.2307/1885696>
- Blanchard, Olivier, and Jordi Galí. (2007). "Real wage rigidities and the New Keynesian model". *Journal of Money, Credit and Banking*, 39(S1), pp. 35-65. <https://doi.org/10.1111/j.1538-4616.2007.00015.x>
- Blanchard, Olivier, and Jordi Galí. (2010). "Labor markets and monetary policy: A New Keynesian model with unemployment". *American Economic Journal: Macroeconomics*, 2(2), pp. 1-30. <https://doi.org/10.1257/mac.2.2.1>
- Blanchard, Olivier, and Nobuhiro Kiyotaki. (1991). "Monopolistic competition and the effects of aggregate demand". In N. Gregory Mankiw and David Romer (eds.), *New Keynesian Economics*. MIT Press. Vol. 1, pp. 345-376. <https://www.jstor.org/stable/1814537>
- Blanco, Andrés. (2021). "Optimal inflation target in an economy with menu costs and a zero lower bound". *American Economic Journal: Macroeconomics*, 13(3), pp. 108-141. <https://doi.org/10.1257/mac.20180198>
- Blanco, Andrés, Corina Boar, Callum Jones and Virgiliu Midrigan. (2022). "Nonlinear inflation dynamics in menu cost economies". Finance and Economics Discussion Series, 2024-005, Board of Governors of the Federal Reserve System. <https://doi.org/10.17016/FEDS.2024.005>
- Bulow, Jeremy, John Geanakoplos and Paul Klemperer. (1985). "Multimarket oligopoly: Strategic substitutes and complements". *Journal of Political Economy*, 93(3), pp. 488-511. <https://doi.org/10.1086/261312>
- Burdett, Kenneth, and Kenneth Judd. (1983). "Equilibrium price dispersion". *Econometrica*, 51(4), pp. 955-970. <https://doi.org/10.2307/1912045>
- Burstein, Ariel T. (2006). "Inflation and output dynamics with state-dependent pricing decisions". *Journal of Monetary Economics*, 53(7), pp. 1235-1257. <https://doi.org/10.1016/j.jmoneco.2005.05.006>
- Caballero, Ricardo J., and Eduardo M. R. A. Engel. (1992). "Beyond the partial-adjustment model". *American Economic Review*, 82(2), pp. 360-364. <https://www.jstor.org/stable/2117428>
- Caballero, Ricardo J., and Eduardo M. R. A. Engel. (1993a). "Heterogeneity and output fluctuations in a dynamic menu-cost economy". *Review of Economic Studies*, 60(1), pp. 95-119. <https://doi.org/10.2307/2297814>
- Caballero, Ricardo J., and Eduardo M. R. A. Engel. (1993b). "Microeconomic rigidities and aggregate price dynamics". *European Economic Review*, 37(4), pp. 697-711. [https://doi.org/10.1016/0014-2921\(93\)90081-K](https://doi.org/10.1016/0014-2921(93)90081-K)
- Caballero, Ricardo J., and Eduardo M. R. A. Engel. (2007). "Price stickiness in S_s models: New interpretations of old results". *Journal of Monetary Economics*, 54(S1), pp. 100-121. <https://doi.org/10.1016/j.jmoneco.2007.06.020>
- Calvo, Guillermo A. (1983). "Staggered prices in a utility-maximizing framework". *Journal of Monetary Economics*, 12(3), pp. 383-398. [https://doi.org/10.1016/0304-3932\(83\)90060-0](https://doi.org/10.1016/0304-3932(83)90060-0)
- Campbell, Jeffrey R., and Benjamin Eden. (2014). "Rigid prices: Evidence from U.S. scanner data". *International Economic Review*, 55(2), pp. 423-442. <https://doi.org/10.1111/iere.12055>
- Caplin, Andrew S., and Daniel F. Spulber. (1987). "Menu costs and the neutrality of money". *The Quarterly Journal of Economics*, 102(4), pp. 703-725. <https://doi.org/10.2307/1884277>
- Carvalho, Carlos. (2006). "Heterogeneity in price stickiness and the real effects of monetary shocks". *Frontiers in Macroeconomics*, 2(1). <https://doi.org/10.2202/1534-6021.1320>
- Carvalho, Carlos, and Oleksiy Kryvtsov. (2022). "Price selection". *Journal of Monetary Economics*, 124, pp. 56-75. <https://doi.org/10.1016/j.jmoneco.2021.07.003>

- Cavallo, Alberto. (2017). "Are online and offline prices similar? Evidence from large multi-channel retailers". *American Economic Review*, 107(1), pp. 283-303. <https://doi.org/10.1257/aer.20160542>
- Cavallo, Alberto. (2018). "Scraped data and sticky prices". *The Review of Economics and Statistics*, 100(1), pp. 993-1019. https://doi.org/10.1162/REST_a_00652
- Cavallo, Alberto, Francesco Lippi and Ken Miyahara. (2023). "Large shocks travel fast". NBER Working Paper Series, 31659, National Bureau of Economic Research. <https://doi.org/10.3386/w31659>
- Chari, V. V., Patrick Kehoe and Ellen McGrattan. (2000). "Sticky-price models of the business cycle: Can the contract multiplier solve the persistence problem?". *Econometrica*, 68(5), pp. 1151-1179. <https://doi.org/10.1111/1468-0262.00154>
- Cheremukhin, Anton, Paulina Restrepo-Echevarria and Antonella Tutino. (2020). "Targeted search in matching markets". *Journal of Economic Theory*, 185(104956). <https://doi.org/10.1016/j.jet.2019.104956>
- Christiano, Lawrence, Martin Eichenbaum and Charles Evans. (2005). "Nominal rigidities and the dynamics effects of a shock to monetary policy". *Journal of Political Economy*, 113(1), pp. 1-45. <https://doi.org/10.1086/426038>
- Coibion, Olivier, and Yuriy Gorodnichenko. (2015). "Information rigidity and the expectations formation process: A simple framework and new facts". *American Economic Review*, 105(8), pp. 2644-2678. <https://doi.org/10.1257/aer.20110306>
- Coibion, Olivier, Yuriy Gorodnichenko and Gee Hee Hong. (2015). "The cyclicalities of sales, regular and effective prices: Business cycle and policy implications". *American Economic Review*, 105(3), pp. 993-1029. <https://doi.org/10.1257/aer.20121546>
- Cooper, Russell, and Andrew John. (1988). "Coordinating coordination failures in Keynesian models". *The Quarterly Journal of Economics*, 103(3), pp. 441-463. <https://doi.org/10.2307/1885539>
- Costain, James, and Anton Nakov. (2011a). "Distributional dynamics under smoothly state-dependent pricing". *Journal of Monetary Economics*, 58(6-8), pp. 646-665. <https://doi.org/10.1016/j.jmoneco.2011.11.006>
- Costain, James, and Anton Nakov. (2011b). "Price adjustments in a general model of state-dependent pricing". *Journal of Money, Credit and Banking*, 43(2-3), pp. 385-406. <https://doi.org/10.1111/j.1538-4616.2010.00378.x>
- Costain, James, and Anton Nakov. (2015). "Precautionary price stickiness". *Journal of Economic Dynamics and Control*, 58, pp. 218-234. <https://doi.org/10.1016/j.jedc.2015.06.012>
- Costain, James, and Anton Nakov. (2019). "Logit price dynamics". *Journal of Money, Credit and Banking*, 51(1), pp. 43-78. <https://doi.org/10.1111/jmcb.12559>
- Costain, James, Anton Nakov and Borja Petit. (2022). "Flattening of the Phillips curve with state-dependent prices and wages". *The Economic Journal*, 132(642), pp. 546-581. <https://doi.org/10.1093/ej/ueab063>
- Covarrubias, Matias. (2022). "Dynamic oligopoly and monetary policy: A deep reinforcement learning approach". Manuscript, Banco de España. <https://www.matias-covarrubias.com/jobmarketpaper>
- Cover, Thomas M., and Joy A. Thomas. (2006). *Elements of Information Theory*. 2nd ed. Wiley. <https://doi.org/10.1002/047174882X>
- Dean, Mark, and Nathaniel Neligh. (2023). "Experimental tests of rational inattention". *Journal of Political Economy*, 131(12), pp. 878-901. <https://doi.org/10.1086/725174>
- Dickens, William, Lorenz Goette, Erica Groshen, Steinar Holden, Julian Messina, Mark Schweitzer, Jarkko Turunen and Melanie Ward. (2007). "How wages change: Micro evidence from the International Wage Flexibility Project". *Journal of Economic Perspectives*, 21(2), pp. 195-214. <https://doi.org/10.1257/jep.21.2.195>
- Dotsey, Michael, Robert G. King and Alexander L. Wolman. (1999). "State-dependent pricing and the general equilibrium dynamics of money and output". *The Quarterly Journal of Economics*, 114(2), pp. 655-690. <https://doi.org/10.1162/003355399556106>

- Dotsey, Michael, and Alexander L. Wolman. (2020). "Investigating nonneutrality in a state-dependent pricing model with firm-level productivity shocks". *International Economic Review*, 61(1), pp. 159-188. <https://doi.org/10.1111/iere.12420>
- Eichenbaum, Martin, Nir Jaimovich and Sergio Rebelo. (2011). "Reference prices, costs, and nominal rigidities". *American Economic Review*, 101(1), pp. 234-262. <https://doi.org/10.1257/aer.101.1.234>
- Eichenbaum, Martin, Nir Jaimovich, Sergio Rebelo and Josephine Smith. (2014). "How frequent are small price changes?". *American Economic Journal: Macroeconomics*, 6(2), pp. 137-155. <https://doi.org/10.1257/mac.6.2.137>
- Erceg, Christopher J., Dale W. Henderson and Andrew T. Levin. (2000). "Optimal monetary policy with staggered wage and price contracts". *Journal of Monetary Economics*, 46(2), pp. 281-313. [https://doi.org/10.1016/S0304-3932\(00\)00028-3](https://doi.org/10.1016/S0304-3932(00)00028-3)
- Fix, Steven L. (1978). "Rate distortion functions for squared error distortion measures". In *Proceedings of the Sixteenth Annual Allerton Conference on Communication, Control, and Computing*, pp. 704-711.
- Flynn, Joel, and Karthik Sastry. (2023). "Strategic mistakes". *Journal of Economic Theory*, 212, pp. 281-313. <https://doi.org/10.1016/j.jet.2023.105704>
- Friedman, Milton. (1977). "Nobel lecture: Inflation and unemployment". *American Economic Review*, 85(3), pp. 451-472. <https://doi.org/10.1086/260579>
- Fuhrer, Jeff. (2010). "Inflation persistence". In *Handbook of Monetary Economics*. North-Holland, vol. 3, pp. 423-486. <https://doi.org/10.1016/B978-0-444-53238-1.00009-0>
- Fuhrer, Jeff, and George Moore. (1995). "Inflation persistence". *The Quarterly Journal of Economics*, 110(1), pp. 127-159. <https://doi.org/10.2307/2118513>
- Gagnon, Etienne. (2009). "Price setting during low and high inflation: Evidence from Mexico". *The Quarterly Journal of Economics*, 124(3), pp. 1221-1263. <https://doi.org/10.1162/qjec.2009.124.3.1221>
- Galí, Jordi. (2015). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and its Applications*. 2nd ed. Princeton Univ. Press. <https://doi.org/10.1515/jcbtp-2017-0009>
- Galí, Jordi, Mark Gertler and J. David López-Salido. (2001). "European inflation dynamics". *European Economic Review*, 45(7), pp. 1237-1270. [https://doi.org/10.1016/S0014-2921\(00\)00105-7](https://doi.org/10.1016/S0014-2921(00)00105-7)
- Galí, Jordi, Mark Gertler and J. David López-Salido. (2005). "Robustness of the estimates of the hybrid New Keynesian Phillips curve". *Journal of Monetary Economics*, 52(6), pp. 1107-1118. <https://doi.org/10.1016/j.jmoneco.2005.08.005>
- Gertler, Mark, and John Leahy. (2008). "A Phillips curve with an Ss foundation". *Journal of Political Economy*, 116(3), pp. 533-572. <https://doi.org/10.1086/589522>
- Gertler, Mark, Luca Sala and Antonella Trigari. (2008). "An estimated monetary DSGE model with unemployment and staggered nominal wage bargaining". *Journal of Money, Credit and Banking*, 40(8), pp. 1713-1764. <https://doi.org/10.1111/j.1538-4616.2008.00180.x>
- Gertler, Mark, and Antonella Trigari. (2009). "Unemployment fluctuations with staggered Nash wage bargaining". *Journal of Political Economy*, 117(1), pp. 38-86. <https://doi.org/10.1086/597302>
- Ghassibe, Mishel. (2021). "Monetary policy and production networks: An empirical investigation". *Journal of Monetary Economics*, 119, pp. 21-39. <https://doi.org/10.1016/j.jmoneco.2021.02.002>
- Gilchrist, Simon, Raphael Schoenle, Jae Sim and Egon Zakrajšek. (2017). "Inflation dynamics during the financial crisis". *American Economic Review*, 107(3), pp. 785-823. <https://doi.org/10.1257/aer.20150248>
- Goeree, Jacob, Eli Palfrey, David E. Lebow and Jeremy B. Rudd. (2016). *Quantal Response Equilibrium: A Stochastic Theory of Games*. Princeton Univ. Press. <https://doi.org/10.1515/9781400880928>

- Goeree, Jacob K., and Charles A. Holt. (1999). "Stochastic game theory: For playing games, not just for doing theory". *Proceedings of the National Academy of Sciences*, 96(19), pp. 10564-10567. <https://doi.org/10.1073/pnas.96.19.10564>
- Golosov, Mikhail, and Robert E. Lucas Jr. (2007). "Menu costs and Phillips curves". *Journal of Political Economy*, 115(2), pp. 171-199. <https://doi.org/10.1086/512625>
- Gopinath, Gita, and Oleg Itshokhi. (2010). "Frequency of price adjustment and pass-through". *The Quarterly Journal of Economics*, 125(2), pp. 675-727. <https://doi.org/10.1162/qjec.2010.125.2.675>
- Grigsby, John, Erik Hurst and Ahu Yildirmaz. (2021). "Aggregate nominal wage adjustments: New evidence from administrative payroll data". *American Economic Review*, 111(2), pp. 428-471. <https://doi.org/10.1257/aer.20190318>
- Guimaraes, Bernardo, and Kevin D. Sheedy. (2011). "Sales and monetary policy". *American Economic Review*, 101(2), pp. 844-76. <https://doi.org/10.1257/aer.101.2.844>
- Hall, Robert E. (2005). "Employment fluctuations with equilibrium wage stickiness". *American Economic Review*, 95(1), pp. 50-65. <https://doi.org/10.1257/0002828053828482>
- Hall, Robert E., and Paul R. Milgrom. (2008). "The limited influence of unemployment on the wage bargain". *American Economic Review*, 98(4), pp. 1653-1674. <https://doi.org/10.1257/aer.98.4.1653>
- Head, Allen, Lucy Qiao Liu, Guido Menzio and Randall Wright. (2012). "Sticky prices: A New Monetarist approach". *Journal of the European Economic Association*, 10(5), pp. 939-973. <https://doi.org/10.1111/j.1542-4774.2012.01081.x>
- Hong, Gee Hee, Matthew Klepacz, Ernesto Pasten and Raphael Schoenle. (2023). "The real effects of monetary shocks: Evidence from micro pricing moments". *Journal of Monetary Economics*, 139, pp. 1-20. <https://doi.org/10.1016/j.jmoneco.2023.06.004>
- Ilut, Cosmin, Rosen Valchev and Nicolas Vincent. (2020). "Paralyzed by fear: Rigid and discrete pricing under demand uncertainty". *Econometrica*, 88(5), pp. 1899-1938. <https://doi.org/10.3982/ECTA14234>
- Karadi, Peter, and Adam Reiff. (2018). "Menu costs, aggregate fluctuations, and large shocks". *American Economic Journal: Macroeconomics*, 11(3), pp. 111-146. <https://doi.org/10.1257/mac.20160054>
- Karadi, Peter, Raphael Schoenle and Jesse Wursten. (2021). "Measuring price selection in microdata: It's not there". Working Paper, 2566, European Central Bank. <https://doi.org/10.2139/ssrn.3867034>
- Kehoe, Patrick, and Virgiliu Midrigan. (2015). "Prices are sticky after all". *Journal of Monetary Economics*, 75, pp. 35-53. <https://doi.org/10.1016/j.jmoneco.2014.12.004>
- Khaw, Mel Win, Luminita Stevens and Michael Woodford. (2017). "Discrete adjustment to a changing environment: Experimental evidence". *Journal of Monetary Economics*, 91, pp. 88-103. <https://doi.org/10.1016/j.jmoneco.2017.09.001>
- Kiley, Michael T. (2007). "Is moderate-to-high inflation inherently unstable?". *International Journal of Central Banking*, 3(2), pp. 173-201. <https://www.ijcb.org/journal/ijcb07q2a6.htm>
- Kimball, Miles. (1995). "The quantitative analytics of the basic neomonetarist model". *Journal of Money, Credit and Banking*, 27(4), pp. 1241-1277. <https://doi.org/10.2307/2078048>
- Klenow, Peter J., and Oleksiy Kryvtsov. (2008). "State-dependent or time-dependent pricing: Does it matter for recent us inflation?". *The Quarterly Journal of Economics*, 123(3), pp. 863-904. <https://doi.org/10.1162/qjec.2008.123.3.863>
- Klenow, Peter J., and Benjamin A. Malin. (2010). "Microeconomic evidence on price-setting". In *Handbook of Monetary Economics*. North-Holland, vol. 3, pp. 231-284. <https://doi.org/10.1016/B978-0-444-53238-1.00006-5>

- Klenow, Peter J., and Jonathan L. Willis. (2016). "Real rigidities and nominal price rigidity". *Economica*, 83(331), pp. 443-472. <https://doi.org/10.1111/ecca.12191>
- Kryvtsov, Oleksiy, and Nicolas Vincent. (2021). "The cyclicity of sales and aggregate price flexibility". *Review of Economic Studies*, 88(1), pp. 334-377. <https://doi.org/10.1093/restud/rdaa050>
- Lach, Saul, and Daniel Tsiddon. (1992). "The behavior of prices and inflation: An empirical analysis of disaggregated price data". *Journal of Political Economy*, 100(2), pp. 349-389. <https://doi.org/10.1086/261821>
- Lombardo, Giovanni, and David Vestin. (2007). "Welfare implications of Calvo vs. Rotemberg pricing assumptions". Working Paper, 770, European Central Bank. <https://doi.org/10.2139/ssrn.991610>
- Lorenzoni, Guido, and Ivan Werning. (2023a). "Inflation is conflict". NBER Working Paper Series, 31099, National Bureau of Economic Research. <https://doi.org/10.3386/w31099>
- Lorenzoni, Guido, and Ivan Werning. (2023b). "Wage-price spirals". *Brookings Papers on Economic Activity*, Fall 2023. https://www.brookings.edu/wp-content/uploads/2023/09/5_Lorenzoni-Werning_unembargoed.pdf
- Luo, Shaowen, and Daniel Villar. (2021a). "The price adjustment hazard function: Evidence from high inflation periods". *Journal of Economic Dynamics and Control*, 130(104135). <https://doi.org/10.1016/j.jedc.2021.104135>
- Luo, Shaowen, and Daniel Villar. (2021b). "The skewness of the price change distribution: A new touchstone for sticky price models". *Journal of Money, Credit and Banking*, 53(1), pp. 41-72. <https://doi.org/10.1111/jmcb.12700>
- Luo, Shaowen, and Daniel Villar. (2023). "Propagation of shocks in an input-output economy: Evidence from disaggregated prices". *Journal of Monetary Economics*, 137, pp. 26-46. <https://doi.org/10.1016/j.jmoneco.2023.05.004>
- Maćkowiak, Bartosz, Filip Matějka and Mirko Wiederholt. (2023). "Rational inattention: A review". *Journal of Economic Literature*, 61(1), pp. 226-273. <https://doi.org/10.1257/jel.20211524>
- Maćkowiak, Bartosz, and Frank Smets. (2008). "On implications of micro price data for macro models". Working Paper, 960, European Central Bank. <https://doi.org/10.2139/ssrn.1291169>
- Maćkowiak, Bartosz, and Mirko Wiederholt. (2009). "Optimal sticky prices under rational inattention". *American Economic Review*, 99(3), pp. 769-803. <https://doi.org/10.1257/aer.99.3.769>
- Maćkowiak, Bartosz, and Mirko Wiederholt. (2015). "Business cycle dynamics under rational inattention". *The Review of Economic Studies*, 82(4), pp. 1502-1532. <https://doi.org/10.1093/restud/rdv027>
- Mankiw, N. Gregory. (1985). "Small menu costs and large business cycles: A macroeconomic model of monopoly". *The Quarterly Journal of Economics*, 100(2), pp. 529-537. <https://doi.org/10.2307/1885395>
- Mankiw, N. Gregory, and Ricardo Reis. (2002). "Sticky information versus sticky prices: A proposal to replace the new Keynesian Phillips curve". *The Quarterly Journal of Economics*, 117(4), pp. 1295-1328. <https://doi.org/10.1162/003355302320935034>
- Mankiw, N. Gregory, and Ricardo Reis. (2006a). "Pervasive stickiness". *American Economic Review*, 96(2), pp. 164-169. <https://doi.org/10.1257/000282806777211937>
- Mankiw, N. Gregory, and Ricardo Reis. (2006b). "Sticky information in general equilibrium". *Journal of the European Economic Association*, 5(2-3), pp. 603-613. <https://doi.org/10.1162/jeea.2007.5.2-3.603>
- Matějka, Filip. (2016). "Rationally inattentive seller: Sales and discrete pricing". *The Review of Economic Studies*, 83(3), pp. 1125-1155. <https://doi.org/10.1093/restud/rdv049>
- Matějka, Filip, and Alisdair McKay. (2015). "Rational inattention to discrete choices: A new foundation for the multinomial logit model". *American Economic Review*, 105(1), pp. 272-98. <https://doi.org/10.1257/aer.20130047>

- Mattsson, Lars-Göran, and Jörgen W. Weibull. (2002). "Probabilistic choice and procedurally bounded rationality". *Games and Economic Behavior*, 41(1), pp. 61-78. [https://doi.org/10.1016/S0899-8256\(02\)00014-3](https://doi.org/10.1016/S0899-8256(02)00014-3)
- Midrigan, Virgiliu. (2011). "Menu costs, multiproduct firms, and aggregate fluctuations". *Econometrica*, 79(4), pp. 1139-1180. <https://doi.org/10.3982/ECTA6735>
- Mongey, Simon. (2021). "Market structure and monetary non-neutrality". NBER Working Paper Series, 29233, National Bureau of Economic Research. <https://doi.org/10.3386/w29233>
- Morales-Jiménez, Camilo. (2022). "The cyclical behavior of unemployment and wages under information frictions". *American Economic Journal: Macroeconomics*, 14(1), pp. 301-331. <https://doi.org/10.1257/mac.20180404>
- Morales-Jiménez, Camilo, and Luminita Stevens. (2023). "Price Rigidities in U.S. Business Cycles". Manuscript, Univ. of Maryland. https://econweb.umd.edu/~stevens/papers/MJS_Rigidities.pdf
- Nakamura, Emi, and Jón Steinsson. (2008). "Five facts about prices: A reevaluation of menu cost models". *The Quarterly Journal of Economics*, 123(4), pp. 1415-1464. <https://doi.org/10.1162/qjec.2008.123.4.1415>
- Nakamura, Emi, and Jón Steinsson. (2010). "Monetary non-neutrality in a multi-sector menu cost model". *The Quarterly Journal of Economics*, 125(3), pp. 961-1013. <https://doi.org/10.1162/qjec.2010.125.3.961>
- Nakamura, Emi, and Jón Steinsson. (2011). "Price setting in forward-looking customer markets". *Journal of Monetary Economics*, 58(3), pp. 220-233. <https://doi.org/10.1016/j.jmoneco.2011.06.004>
- Nakamura, Emi, and Jón Steinsson. (2013). "Price rigidity: Microeconomic evidence and macroeconomic implications". *Annual Review of Economics*, 5, pp. 133-163. <https://doi.org/10.1146/annurev-economics-061109-080430>
- Nakamura, Emi, Jón Steinsson, Patrick Sun and Daniel Villar. (2018). "The elusive costs of inflation: Price dispersion during the U.S. great inflation". *The Quarterly Journal of Economics*, 133(4), pp. 1933-1980. <https://doi.org/10.1093/qje/qjy017>
- Nord, Lukas. (2023). *Shopping, Demand Composition, and Equilibrium Prices*. Manuscript, European University Institute. <https://doi.org/10.2139/ssrn.4178271>
- Olivei, Giovanni, and Silvana Tenreyro. (2007). "The timing of monetary policy shocks". *American Economic Review*, 97(3), pp. 636-663. <https://doi.org/10.1257/aer.97.3.636>
- Pasten, Ernesto, and Raphael Schoenle. (2016). "Rational inattention, multi-product firms and the neutrality of money". *Journal of Monetary Economics*, 80, pp. 1-16. <https://doi.org/10.1016/j.jmoneco.2016.04.004>
- Pasten, Ernesto, Raphael Schoenle and Michael Weber. (2020). "The propagation of monetary policy shocks in a heterogeneous production economy". *Journal of Monetary Economics*, 116. <https://doi.org/10.1016/j.jmoneco.2019.10.001>
- Phelps, Edmund S., and Sidney G. Winter. (1970). "Optimal price policy under atomistic competition". In Edmund S. Phelps (ed.), *Microeconomic Foundations of Employment and Inflation Theory*. W.W. Norton.
- Reis, Ricardo. (2006). "Inattentive producers". *The Review of Economic Studies*, 73(3), pp. 793-821. <https://doi.org/10.1111/j.1467-937X.2006.00396.x>
- Romer, David. (2008). "Real rigidities". In Steven Durlauf and Lawrence Blume (eds.), *New Palgrave Dictionary of Economics*. 2nd ed. Palgrave MacMillan. https://doi.org/10.1057/978-1-349-95121-5_2475-1
- Rotemberg, Julio J. (1982). "Monopolistic price adjustment and aggregate output". *Review of Economic Studies*, 49(4), pp. 517-531. <https://doi.org/10.2307/2297284>
- Rotemberg, Julio J., and Michael Woodford. (1991). "Markups and the business cycle". In Olivier Blanchard and Stanley Fischer (eds.), *NBER Macroeconomics Annual*. MIT Press, vol. 6, pp. 63-129. <https://doi.org/10.1086/654159>

- Rowthorn, Robert J. (1977). "Conflict, inflation and money". *Cambridge Journal of Economics*, 1(3), pp. 215-239. <https://www.jstor.org/stable/23596632>
- Rubbo, Elisa. (2023). "Networks, Phillips curves, and monetary policy". *Econometrica*, 91(4), pp. 1417-1455. <https://doi.org/10.3982/ECTA18654>
- Sara-Zaror, Francisca. (2022). "Expected inflation and welfare: The role of consumer search". Manuscript, Univ. of Chicago. <https://doi.org/10.2139/ssrn.4127502>
- Schmitt-Grohé, Stephanie, and Martín Uribe. (2004). "Optimal fiscal and monetary policy under sticky prices". *Journal of Economic Theory*, 114(2), pp. 198-230. [https://doi.org/10.1016/S0022-0531\(03\)00111-X](https://doi.org/10.1016/S0022-0531(03)00111-X)
- Sheremirov, Viacheslav. (2020). "Price dispersion and inflation: New facts and theoretical implications". *Journal of Monetary Economics*, 114, pp. 59-70. <https://doi.org/10.1016/j.jmoneco.2019.03.007>
- Sheshinski, Eytan, and Yoram Weiss. (1977). "Inflation and costs of price adjustment". *The Review of Economic Studies*, 44(2), pp. 287-303. <https://doi.org/10.2307/2297067>
- Shimer, Robert. (2010). *Labor Markets and Business Cycles*. Princeton Univ. Press. <https://doi.org/10.1515/9781400835232>
- Sims, Christopher A. (1998). "Stickiness". *Carnegie-Rochester Conference Series on Public Policy*, 49, pp. 317-356. [https://doi.org/10.1016/S0167-2231\(99\)00013-5](https://doi.org/10.1016/S0167-2231(99)00013-5)
- Sims, Christopher A. (2003). "Implications of rational inattention". *Journal of Monetary Economics*, 50(3), pp. 665-690. [https://doi.org/10.1016/S0304-3932\(03\)00029-1](https://doi.org/10.1016/S0304-3932(03)00029-1)
- Smets, Frank, and Raf Wouters. (2003). "An estimated dynamic stochastic general equilibrium model of the euro area". *Journal of the European Economic Association*, 1(5), pp. 1123-1175. <https://doi.org/10.1162/154247603770383415>
- Steiner, Jakub, Colin Stewart and Filip Matejka. (2017). "Rational inattention dynamics: Inertia and delay in decision-making". *Econometrica*, 85(2), pp. 521-553. <https://doi.org/10.3982/ECTA13636>
- Stevens, Luminita. (2020). "Coarse pricing policies". *Review of Economic Studies*, 87(1), pp. 420-453. <https://doi.org/10.1093/restud/rdz036>
- Taylor, John B. (1979). "Staggered wage setting in a macro model". *The American Economic Review*, 69(2), pp. 108-113. <https://www.jstor.org/stable/1801626>
- Turen, Javier. (2023). "State-dependent attention and pricing decisions". *American Economic Journal: Macroeconomics*, 15(2), pp. 161-189. <https://doi.org/10.1257/mac.20210038>
- Varian, Hal. (1980). "A model of sales". *American Economic Review*, 70(4), pp. 651-659. <https://www.jstor.org/stable/1803562>
- Vavra, Joseph. (2013). "Inflation dynamics and time-varying volatility: New evidence and an Ss interpretation". *The Quarterly Journal of Economics*, 129(1), pp. 215-258. <https://doi.org/10.1093/qje/qjt027>
- Wang, Olivier, and Iván Werning. (2022). "Dynamic oligopoly and price stickiness". *American Economic Review*, 112(8), pp. 2815-2849. <https://doi.org/10.1257/aer.20201739>
- Willis, Jonathan. (2000). "Estimation of adjustment costs in a model of state-dependent pricing". Tech. Rep., RWP 00-07, Federal Reserve Bank of Kansas City. <https://doi.org/10.2139/ssrn.272413>
- Woodford, Michael. (2003). "Imperfect common knowledge and the effects of monetary policy". In Philippe Aghion, Roman Frydman, Joseph Stiglitz and Michael Woodford (eds.), *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*. Princeton Univ. Press. <https://doi.org/10.1515/9780691223933-004>

- Woodford, Michael. (2004). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton Univ. Press. <https://doi.org/10.1515/9781400830169>
- Woodford, Michael. (2009). "Information-constrained state-dependent pricing". *Journal of Monetary Economics*, 56(Supplement), pp. S100-S124. <https://doi.org/10.1016/j.jmoneco.2009.06.014>
- Woodford, Michael. (2020). "Modeling imprecision in perception, valuation, and choice". *Annual Review of Economics*, 12, pp. 579-601. <https://doi.org/10.1146/annurev-economics-102819-040518>
- Zbaracki, Mark J., Mark Ritson, Daniel Levy, Shantanu Dutta and Mark Bergen. (2004). "Managerial and customer costs of price adjustment: direct evidence from industrial markets". *Review of Economics and Statistics*, 86(2), pp. 514-533. <https://doi.org/10.1162/003465304323031085>

BANCO DE ESPAÑA PUBLICATIONS

OCCASIONAL PAPERS

- 2220 LUIS ÁNGEL MAZA: An estimation of the carbon footprint in Spanish credit institutions' business lending portfolio. (There is a Spanish version of this edition with the same number).
- 2221 SUSANA MORENO SÁNCHEZ: The EU-UK relationship: regulatory divergence and the level playing field.
- 2222 ANDRÉS ALONSO-ROBISCO and JOSÉ MANUEL CARBÓ: Inteligencia artificial y finanzas: una alianza estratégica.
- 2223 LUIS FERNÁNDEZ LAFUERZA, MATÍAS LAMAS, JAVIER MENCÍA, IRENE PABLOS and RAQUEL VEGAS: Analysis of the usability of capital buffers during the crisis precipitated by COVID-19. (There is a Spanish version of this edition with the same number).
- 2224 SONSOLES GALLEGO, ISABEL GARRIDO and IGNACIO HERNANDO: IMF precautionary facilities and their use in Latin America. (There is a Spanish version of this edition with the same number).
- 2301 LAURA HOSPIDO, CARLOS SANZ and ERNESTO VILLANUEVA: Air pollution: a review of its economic effects and policies to mitigate them.
- 2302 IRENE MONASTEROLO, MARÍA J. NIETO and EDO SCHETS: The good, the bad and the hot house world: conceptual underpinnings of the NGFS scenarios and suggestions for improvement.
- 2303 ADRIÁN LÓPEZ GONZÁLEZ: Inteligencia artificial aplicada al control de calidad en la producción de billetes.
- 2304 BELÉN AROCA MOYA: Conceptos, fundamentos y herramientas de neurociencia, y su aplicación al billete.
- 2305 MARÍA ALONSO, EDUARDO GUTIÉRREZ, ENRIQUE MORAL-BENITO, DIANA POSADA and PATROCINIO TELLO-CASAS: Un repaso de las diversas iniciativas desplegadas a nivel nacional e internacional para hacer frente a los riesgos de exclusión financiera.
- 2306 JOSÉ LUIS ROMERO UGARTE, ABEL SÁNCHEZ MARTÍN and CARLOS MARTÍN RODRÍGUEZ: Alternatives to the evolution of wholesale banking operations in the Eurosystem. (There is a Spanish version of this edition with the same number).
- 2307 HENRIQUE S. BASSO, OURANIA DIMAKOU and MYROSLAV PIDKUYKO: How inflation varies across Spanish households.
- 2308 LAURA CRESPO, NAJIBA EL AMRANI, CARLOS GENTO and ERNESTO VILLANUEVA: Heterogeneidad en el uso de los medios de pago y la banca *online*: un análisis a partir de la Encuesta Financiera de las Familias (2002-2020).
- 2309 HENRIQUE S. BASSO, OURANIA DIMAKOU and MYROSLAV PIDKUYKO: How consumption carbon emission intensity varies across Spanish households.
- 2310 IVÁN AUCIELLO-ESTÉVEZ, JOSEP PIJOAN-MAS, PAU ROLDAN-BLANCO and FEDERICO TAGLIATI: Dual labor markets in Spain: a firm-side perspective.
- 2311 CARLOS PÉREZ MONTES, JORGE E. GALÁN, MARÍA BRU, JULIO GÁLVEZ, ALBERTO GARCÍA, CARLOS GONZÁLEZ, SAMUEL HURTADO, NADIA LAVÍN, EDUARDO PÉREZ ASENJO and IRENE ROIBÁS: Systemic analysis framework for the impact of economic and financial risks (There is a Spanish version of this edition with the same number).
- 2312 SERGIO MAYORDOMO and IRENE ROIBÁS: The pass-through of market interest rates to bank interest rates. (There is a Spanish version of this edition with the same number).
- 2313 CARLOS PÉREZ MONTES, ALEJANDRO FERRER, LAURA ÁLVAREZ ROMÁN, HENRIQUE BASSO, BEATRIZ GONZÁLEZ LÓPEZ, GABRIEL JIMÉNEZ, PEDRO JAVIER MARTÍNEZ-VALERO, SERGIO MAYORDOMO, ÁLVARO MENÉNDEZ PUJADAS, LOLA MORALES, MYROSLAV PIDKUYKO and ÁNGEL VALENTÍN: Individual and sectoral analysis framework for the impact of economic and financial risks. (There is a Spanish version of this edition with the same number).
- 2314 PANA ALVES, CARMEN BROTO, MARÍA GIL and MATÍAS LAMAS: Risk and vulnerability indicators for the Spanish housing market.
- 2215 ANDRÉS AZQUETA-GAVALDÓN, MARINA DIAKONOVA, CORINNA GHIRELLI and JAVIER J. PÉREZ: Sources of economic policy uncertainty in the euro area: a ready-to-use database.
- 2316 FERNANDO GARCÍA MARTÍNEZ and MATÍAS PACCE: The Spanish electricity sector in the face of rising gas prices and the Government measures rolled out in response. (There is a Spanish version of this edition with the same number).
- 2317 ROBERTO BLANCO and SERGIO MAYORDOMO: Evidence on the impact of the public guarantee and direct aid schemes on Spanish firms during the covid-19 crisis. (There is a Spanish version of this edition with the same number).
- 2318 ISABEL GARRIDO and IRUNE SOLERA: Has the 2021 general SDR allocation been useful? For what and for whom?
- 2319 ROBERTO BLANCO, ELENA FERNÁNDEZ, MIGUEL GARCÍA-POSADA and SERGIO MAYORDOMO: An estimation of the default probabilities of Spanish non-financial corporations and their application to evaluate public policies.
- 2320 BANCO DE ESPAÑA: In-person access to banking services in Spain: 2023 Monitoring Report. (There is a Spanish version of this edition with the same number).

- 2321 EDUARDO AGUILAR GARCÍA, MARIO ALLOZA FRUTOS, TAMARA DE LA MATA, ENRIQUE MORAL-BENITO, IÑIGO PORTILLO PAMPIN and DAVID SARASA FLORES: Una primera caracterización de las empresas receptoras de fondos NGEU en España.
- 2401 ALEJANDRO MORALES, MANUEL ORTEGA, JOAQUÍN RIVERO and SUSANA SALA: How to identify all companies worldwide. Experience with the legal entity identifier (LEI). (There is a Spanish version of this edition with the same number).
- 2402 XAVIER SERRA and SONSOLES GALLEGO: An initial stocktake of the IMF's resilience and sustainability trust as a channel for using special drawing rights. (There is a Spanish version of this edition with the same number).
- 2403 PABLO HERNÁNDEZ DE COS: The role of macroprudential policy in the stabilisation of macro-financial fluctuations. Conference on Financial Stability/Banco de Portugal, Lisbon (Portugal), 2 October 2023.
- 2404 MORTEZA GHOMI, SAMUEL HURTADO and JOSÉ MANUEL MONTERO: Analysis of recent inflation dynamics in Spain. An approach based on the Blanchard and Bernanke (2023) model. (There is a Spanish version of this edition with the same number).
- 2405 PILUCA ALVARGONZÁLEZ, MARINA ASENSIO, CRISTINA BARCELÓ, OLYMPIA BOVER, LUCÍA COBREROS, LAURA CRESPO, NAJIBA EL AMRANI, SANDRA GARCÍA-URIBE, CARLOS GENTO, MARINA GÓMEZ, PALOMA URCELAY, ERNESTO VILLANUEVA and ELENA VOZMEDIANO: The Spanish Survey of Household Finances (EFF): description and methods of the 2020 wave.
- 2406 ANA GÓMEZ LOSCOS, MIGUEL ÁNGEL GONZÁLEZ SIMÓN and MATÍAS JOSÉ PACCE: Short-term real-time forecasting model for spanish GDP (Spain-STING): new specification and reassessment of its predictive power. (There is a Spanish version of this edition with the same number).
- 2407 OLYMPIA BOVER, LAURA CRESPO, SANDRA GARCÍA-URIBE, MARINA GÓMEZ-GARCÍA, PALOMA URCELAY and PILAR VELILLA: Micro and macro data on household wealth, income and expenditure: comparing the Spanish Survey of Household Finances (EFF) to other statistical sources.
- 2408 ÁNGEL ESTRADA and CARLOS PÉREZ MONTES: Un análisis de la evolución de la actividad bancaria en España tras el establecimiento del gravamen temporal de la ley 38/2022.
- 2409 PABLO A. AGUILAR, MARIO ALLOZA, JAMES COSTAIN, SAMUEL HURTADO and JAIME MARTÍNEZ-MARTÍN: The effect of the European Central Bank's asset purchase programmes on Spain's public finances. (There is a Spanish version of this edition with the same number).
- 2410 RICARDO BARAHONA and MARÍA RODRÍGUEZ-MORENO: Estimating the OIS term premium with analyst expectation surveys.
- 2411 JOSÉ MANUEL CARBÓ, HOSSEIN JAHANSHAHLOO and JOSÉ CARLOS PIQUERAS: Análisis de fuentes de datos para seguir la evolución de *Bitcoin*.
- 2412 IVÁN KATARYNIUK, RAQUEL LORENZO ALONSO, ENRIQUE MARTÍNEZ CASILLAS and JACOPO TIMINI: An extended Debt Sustainability Analysis framework for Latin American economies.
- 2413 Encuesta Financiera de las Familias (EFF) 2022: métodos, resultados y cambios desde 2020.
- 2414 ÁNGEL ESTRADA, CARLOS PÉREZ MONTES, JORGE ABAD, CARMEN BROTO, ESTHER CÁCERES, ALEJANDRO FERRER, JORGE GALÁN, GERGELY GANICS, JAVIER GARCÍA VILLASUR, SAMUEL HURTADO, NADIA LAVÍN, JOËL MARBET, ENRIC MARTORELL, DAVID MARTÍNEZ-MIERA, ANA MOLINA, IRENE PABLOS and GABRIEL PÉREZ-QUIRÓS: Análisis de los riesgos sistémicos cíclicos en España y de su mitigación mediante requerimientos de capital bancario contracíclicos.
- 2415 CONCEPCIÓN FERNÁNDEZ ZAMANILLO and LUNA AZAHARA ROMO GONZÁLEZ: Facilitadores de la innovación 2.0: impulsando la innovación financiera en la era *fintech*.
- 2416 JAMES COSTAIN and ANTON NAKOV: Models of price setting and inflation dynamics.