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Nonlinearity of the inflation-output trade-off and time-varying price rigidity

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NONLINEARITY OF THE INFLATION-OUTPUT TRADE-OFF AND TIME-VARYING PRICE RIGIDITY

Antonia López-Villavicencio, Valérie Mignon

NON-TECHNICAL SUMMARY

The dynamics of inflation have changed substantially in most advanced economies over the past decades, leading to a renewal of interest for the Phillips curve in the literature. This growing empirical and theoretical literature proposes that inflation has become less responsive to fluctuations in output. Alternatively, a recent body of evidence has challenged the traditional Phillips curve, arguing variously that it may exhibit a wide range of forms including convexity, concavity and piecewise linearity. This literature notably puts forward that there is price stickiness up to a certain inflation (or trend inflation) level, thus questioning the traditional Phillips curve that assumes that relative price changes have linear effects on inflation.

Focusing on the traditional backward-looking Phillips curve, our aim in this paper is to test the constancy of the inflation trend level that erodes price rigidity in six advanced countries (Canada, France, Italy, Japan, United Kingdom and the United States) for the 1970:1-2012:2 period. We explicitly account for the impact of the inflation environment through the use of smooth transition regression (STR) models: the inflation-output relationship is modeled through a nonlinear regime-switching process, the link between both series depending upon the level—low or high—of inflation. In addition, we extend this nonlinear specification by accounting for potential changes in the threshold mean inflation. To this end we conduct nonlinear rolling analyses—that are without precedent to our best knowledge.

Our findings show that for the six considered countries, the slope of the Phillips curve is time varying, as well as the threshold trend inflation that erodes price rigidity. Moreover, our specification allows us to provide the threshold levels that tend to restore the inflation-output trade-off. These characteristics could not be captured by a static linear or nonlinear model, suggesting that the rich flexibility embedded in our proposed model may prove highly beneficial.

ABSTRACT

Relying on the backward-looking Phillips curve, we estimate the level of inflation that erodes price rigidity and investigate its time constancy. To this end, we employ smooth transition regression models with rolling regressions to account for varying threshold inflation levels. Studying six advanced countries over the 1970-2012 period, our results show that both the slope of the Phillips curve and the threshold trend inflation that erodes price rigidity are time varying. These characteristics could not be captured by a static linear or nonlinear model, illustrating the rich flexibility embedded in our proposed model.

JEL Classification: E31, C22.

Keywords: Phillips curve, inflation, price rigidity, nonlinearity, menu costs.

NON LINÉARITÉ DE LA RELATION PRODUCTION-INFLATION ET VARIABILITÉ DE LA RIGIDITÉ DES PRIX

Antonia López-Villavicencio, Valérie Mignon

RÉSUME NON TECHNIQUE

La dynamique de l'inflation a considérablement évolué dans la plupart des économies avancées au cours de la dernière décennie, conduisant à un regain d'intérêt pour l'étude de la courbe de Phillips. Une grande partie de la littérature théorique et empirique suggère notamment que l'inflation serait devenue moins sensible aux fluctuations de la production et du chômage. Parallèlement, une partie de la littérature a remis en cause la vision traditionnelle de la courbe de Phillips, montrant que cette dernière pouvait exhiber diverses formes, convexes, concaves ou encore non linéaires par morceaux. Ces travaux ont notamment mis en évidence l'existence d'une rigidité des prix jusqu'à un certain niveau d'inflation, remettant ainsi en cause la vision traditionnelle de la courbe de Phillips.

S'inscrivant dans le cadre de la courbe de Phillips traditionnelle, cet article a pour objectif d'estimer le niveau d'inflation qui affecte la rigidité des prix et d'étudier si celui-ci est ou non constant au cours du temps. Nous étudions six pays industrialisés (Canada, France, Italie, Japon, Royaume-Uni et Etats-Unis) de 1970 à 2012. Nous estimons des modèles à changement de régime à transition lisse afin de tenir compte de l'impact du niveau d'inflation : la relation production-inflation est modélisée par le biais d'un modèle à seuil, le lien entre les deux séries dépendant du niveau — faible ou élevé — de l'inflation. Nous recourons en outre à des régressions roulantes afin de rendre compte de seuils d'inflation variables au cours du temps.

Nos résultats montrent que pour les six pays considérés, la pente de la courbe de Phillips, mais aussi le seuil d'inflation varient au cours du temps. La spécification que nous proposons permet de mettre en évidence des caractéristiques qui ne peuvent pas apparaître dans des modèles linéaires ou non linéaires statiques.

RÉSUMÉ COURT

S'inscrivant dans le cadre de la courbe de Phillips traditionnelle, cet article a pour objectif d'estimer le niveau d'inflation qui affecte la rigidité des prix et d'étudier si celui-ci est ou non constant au cours du temps. Pour cela, nous estimons des modèles à changement de régime à transition lisse en recourant à des régressions roulantes afin de rendre compte de seuils d'inflation temporellement variables. Etudiant six pays industrialisés sur la période 1970-2012, nous montrons que la pente de la courbe de Phillips, mais aussi le seuil d'inflation varient au cours du temps. La spécification que nous proposons permet de mettre en évidence des caractéristiques qui ne peuvent pas apparaître dans des modèles linéaires ou non linéaires statiques.

Classification JEL : E31, C22.

Mots clés : Courbe de Phillips curve, inflation, rigidité des prix, non-linéarité, coûts de catalogue.

NONLINEARITY OF THE INFLATION-OUTPUT TRADE-OFF AND TIME-VARYING PRICE RIGIDITY

Antonia López-Villavicencio*, and Valérie Mignon†

1. INTRODUCTION

The dynamics of inflation have changed substantially in most advanced economies over the past decades, leading to a renewal of interest for the Phillips curve in the literature.[1] This growing empirical and theoretical literature proposes that inflation has become less responsive to fluctuations in output (e.g. Roberts (2006), Kuttner and Robinson (2010) or Gordon (2011)).

Alternatively, a recent body of evidence has challenged the traditional Phillips curve, arguing variously that it may exhibit a wide range of forms including convexity, concavity and piecewise linearity (Laxton et al. (1999), Alvarez Lois (2000), Dolado et al. (2005)). This literature notably puts forward that there is price stickiness up to a certain inflation (or trend inflation) level, thus questioning the traditional Phillips curve that assumes that relative price changes have linear effects on inflation.

It is worth noting that considering that only large changes in prices matter in the inflation-output relationship implies that prices are rigid to a large extent. As it is well known, to justify the existence of monetary policy effects on the short run, the sticky price hypothesis has become central in the new Keynesian economy. This assumption rationalizes the existence of periods during which factors of production—typically labor—are under-utilized, with output being below its potential level.

Focusing on the traditional backward-looking Phillips curve, our aim in this paper is to test the constancy of the inflation trend level that erodes price rigidity in six advanced countries (Canada, France, Italy, Japan, United Kingdom and the United States) for the 1970:1-2012:2 period. We explicitly account for the impact of the inflation environment through the use of

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[1]For a recent survey, see Gordon (2011) and the special issue of *The North American Journal of Economics and Finance* published in August 2010.

smooth transition regression (STR) models: the inflation-output relationship is modeled through a nonlinear regime-switching process, the link between both series depending upon the level—low or high—of inflation. In addition, we extend this nonlinear specification by accounting for potential changes in the threshold mean inflation. To this end we conduct nonlinear rolling analyses—that are without precedent to our best knowledge.

The fact that prices are sticky up to a certain level has received various theoretical explanations. One of the most popular relies on the menu cost hypothesis. Mankiw (1985) and Ball et al. (1988) indeed consider that trend inflation is among the determinants of the slope of the Phillips curve. In this model of costly price adjustment, the frequency of price correction depends on firms' optimizing decisions. A decrease in trend inflation causes firms to adjust prices less frequently, which in turns implies a flatter Phillips curve and price rigidity in a low inflation environment. Alternatively, in a stable macroeconomic environment, where agents trust in price stability, there is less need to change prices. Finally, there might be structural inefficiencies that can prevent firms from changing prices.

Other common explanations for price rigidity have also been proposed in the literature. The existence of capacity constraints (Lipsey (1960)), the inability of firms to distinguish precisely between aggregate and relative price shocks (Lucas (1973)), downward rigidities of nominal wages and on the labor market (Tobin (1972), Stiglitz (1986), Holzer and Montgomery (1993), Akerlof et al. (1996), Altonji and Devereux (1999)), global positive trend in inflation (Ball and Mankiw (1994)), consumer search with reference prices (Lewis (2003)) or with learning from prices (Benabou and Gertner (1993)), monopolistic competition between firms (Stiglitz (1984), Taylor (2000)), tacit collusion or implicit coordination behaviors among firms (Bhaskar (2002)) can be all captured by Phillips curves embodying nonlinear features.

The recent empirical literature tends to give support to this nonlinear hypothesis. Ball and Mazumder (2011) evidence that the Phillips curve in the United States has been relatively flat in the low-inflation period since the mid-1980s. In their estimation, the Phillips curve has flattened post-1984, and the 1985-2007 backward-looking Phillips curve, applied to median CPI inflation, continues to fit post-2007. Similarly, Doyle and Beaudry (2000) propose a changing nature of the Phillips-curve relationship in Canada and the United States over the 1961-99 period. In particular, they suggest that the slope of the Phillips curve has become much smaller, with a sharp reduction observed in the 1990s.

Remarkably, the previous theoretical and empirical studies provide limited information regarding the threshold level that erodes price (wage) rigidity. For instance, Akerlof et al. (1996) and Akerlof et al. (2000) develop a model in which downward nominal wage rigidity leads to a long-run trade-off between inflation and output when inflation is below 3% or unemployment is high enough. However, their definition of low and high inflation environment seems somewhat arbitrary. Also focusing on the United States, Ball and Mazumder (2011) suggest that inflation expectations stay fixed at a certain level—supposed to be 2.5% for core CPI inflation—regardless of any movements in actual inflation. Based on the behavior of actual inflation and of expectations (as measured by the Survey of Professional Forecasters), they find that expectations have been fully shock-anchored since the 1980s.

Investigating the euro area Phillips curve over the past three decades, Musso et al. (2007) show that, as a result of the structural change, the Phillips curve became flatter around a lower mean of inflation. They find however no significant evidence of nonlinearity—in particular in relation to the output gap. Gordon (1997), Yates (1998), Eliasson (2001), Aguiar and Martin (2005) also conclude that the evidence against the linearity of the Phillips curve is weak, while Dolado et al. (2005) suggest a nonlinear path for the euro area Philips curve, as well as Laxton and Debelle (1996), Eisner (1997) and Fauvel et al. (2002) for the United States.

Although it is difficult to empirically assess the functional form of the Phillips curve, understanding price rigidity is of primary importance for monetary policy. In particular, a few studies have accounted for asymmetries in price rigidity in the investigation of optimal monetary policy. Orphanides and Wieland (2000) and Dolado et al. (2005) show that monetary policy should be nonlinear if the Phillips curve is nonlinear. Specifically, our findings show that for the six considered countries, the slope of the Phillips curve is time varying, as well as the threshold trend inflation that erodes price rigidity. Our results have important policy implications. Indeed, if the Phillips curve remains flat or even nonexistent until inflation reaches a certain level, it could be easier to control inflation when the latter is low, since adjustments to excess demand are slower. Likewise, when inflation is below the estimated thresholds, monetary authorities could stimulate economic activity without creating inflationary pressures. However, if the slope is nonexistent or weak, the cost of reducing inflation, once established, would increase. On the whole, the nonlinear price rigidity tends to increase the cost of disinflationary monetary policy, while decreasing the benefit of expansionary monetary policy.

The paper is organized as follows. Section 2 introduces the methodology and describes the data. Section 3 presents the results and the related discussion. Finally, Section 4 concludes.

2. Methodology and data

2.1. The model

We first follow the empirical and traditional approach proposed by Gordon (1982) and Gordon (1997), known as the reduced-form Phillips curve. This approach assumes backward-looking expectations—expected inflation being determined by past inflation—and integrates supply shocks in the equation.

More in detail, the equation suggested by Gordon (1982) and Gordon (1997), also called the triangle model, is specified as a single reduced-form equation. In this specification, three elements can influence the dynamics of inflation: (i) the output gap, which determines the effect of goods or labor demand on prices and wages; (ii) the delays on prices, which describe the dynamics of anticipations and indexation; and (iii) shocks which can affect economic activity from the supply side. Therefore, our first estimated equation is the following one:

$$\pi_t = \alpha + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \gamma y_t^* + \phi s_t + \epsilon_t \tag{1}$$

where π, y^*, and s_t are the inflation rate, the output gap, and supply shocks, respectively and $\epsilon_t \sim N(0, \sigma_\epsilon^2)$. The estimated parameter γ in Equation (1) provides the symmetric slope, which constitutes our benchmark against which to judge any nonlinearity.

As previously mentioned, the existence of menu costs implies a nonlinearity in the Phillips curve (see Ball et al. (1988) for instance). According to this theory, because there are costs linked to prices changes, in periods of low trend inflation firms do not change their individual prices as frequently. This sluggishness in individual prices increases the degree of overall nominal rigidity in the economy, leading to a flatter Phillips curve. On the contrary, any sustainable increase in trend inflation tends to restore the Phillips curve. Consequently, the relevant output-inflation trade-off depends on the trend level of inflation.

This nonlinearity implies that the slope of the Phillips curve depends on the inflation environment, as described below in the case of a two-regime smooth transition regression (STR) model:

$$\pi_t = \alpha + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \gamma y_t^* + [\gamma^*(y_t^*) \times g(r_t; \xi, c)] + \phi s_t + \epsilon_t \tag{2}$$

where $g(r_t; \xi, c)$ is the transition function, ξ is the slope parameter that measures the speed of transition between regimes, r is the transition variable and c denotes the threshold parameter. The function $g(r_t; \xi, c)$ is a first-order logistic function, in which case the two regimes are associated with small and large values of the transition variable relative to the threshold value as follows:

$$g\left(r_t; \xi, c\right) = \left[1 + \exp\left(-\xi \prod_{j=1}^{m} \left(r_t - c_j\right)\right)\right]^{-1} \tag{3}$$

Equation (2) allows the parameter measuring the output-inflation trade-off to vary with the size or the sign of a set of conditioning information, contained in r_t. For our purpose, we include the inflation environment, which allows us to implicitly test the menu cost model.

Given that the function $g(r_t; \xi, c)$ is continuous and bounded between 0 and 1, depending on the realization of the transition variable, the slope of the Phillips curve will be specified by a continuum of parameters. In the two extreme regimes—when the transition variable reaches its lower and upper values—the estimated slope is $\widehat{\gamma}$ (first regime, when $g = 0$), and $\widehat{\gamma + \gamma^*}$ (second regime, when $g = 1$).[2] Whereas the elasticity in a linear model is constant and equal to $\widehat{\gamma}$ in Equation (1), it varies in time according to the value of the transition function in Equation (2). That is, with trend inflation as transition variable, the two regimes can be associated with low and high inflation environments, as in the menu cost theory. In addition, if $\widehat{\gamma}$ is non significant but $\widehat{\gamma} + \widehat{\gamma^*}$ is positive and significant, Equation (2) allows us to estimate the mean inflation that erodes price stickiness. We called the first regime the "price-rigidity" regime whereas the second regime reestablishes the inflation-output trade-off.

2.2. Data description

We consider quarterly data collected for Canada, France, Italy, Japan, the United Kingdom and the United States for the 1970:1-2012:2 period. All data were obtained from the OECD's Economic Outlook database. The inflation rate is defined as the seasonally adjusted annual rate of growth of the consumer price index. Regarding the potential output, it is calculated using the Hodrick-Prescott filter, and the output gap corresponds to the difference, in percentage points, between the real GDP and the potential GDP. We control for supply shocks by including the annual rate of growth of oil prices and nominal effective exchange rates (source IMF).

For the transition variable in Equation (2), we use trend inflation computed as the yearly (fourth-quarter) moving average of the inflation rate.

3. Results

3.1. Estimation of the linear and STR models

Full sample estimation results for the linear and nonlinear specifications in Equations (1) and (2) are presented in Table 1.[3] The results obtained from the static linear model show a positive and significant slope of the Phillips curve in all the countries with the exception of the United

[2] For more details, see Terasvirta and Anderson (1992) and van Dijk et al. (2002).

[3] For the ease of exposition, we only report the estimated value of the output gap coefficient, but complete results are available upon request to the authors.

Kingdom. However, as has been discussed above, Equation (1) may be too restrictive because it does not account for potential nonlinear effects coming from the inflation environment. In other words, excess demand would exert the same effect on inflation even when inflation is relatively low.

Table 1 – Linear and nonlinear estimated elasticities

	Linear	Nonlinear		
		At lower trend inflation	At higher trend inflation	Threshold
	$\widehat{\gamma}$	$\widehat{\gamma}$	$\widehat{\gamma}+\widehat{\gamma^*}$	$\widehat{c}$
Canada	0.089 (2.35)	−0.005 (−0.08)	0.131 (3.00)	2.96
France	0.101 (2.68)	0.004 (0.10)	0.338 (5.61)	3.92
Italy	0.134 (2.77)	−0.004 (−0.06)	0.378 (5.38)	10.23
Japan	0.111 (2.44)	−0.057 (−0.83)	2.891 (4.60)	12.72
UK	0.078 (1.45)	0.068 (1.34)	1.547 (4.30)	20.21
US	0.179 (5.63)	−0.002 (−0.05)	0.275 (7.76)	3.72

Notes: (1) $\widehat{\gamma}$ is the estimated elasticity in the lower regime (when trend inflation is below the threshold level $\widehat{c}$) in Equation (2); (2) $\widehat{\gamma}+\widehat{\gamma^*}$ is the estimated elasticity when $g = 1$ in Equation (2); (3) t-statistics are given in parentheses.

However, as the results from the nonlinear specification (columns 3 to 5 in Table 1) clearly show, the relationship between output and inflation strongly depends on the inflation environment, justifying the use of our regime-switching model.

More specifically, when trend inflation is below 3-4% in Canada, France and the United States, economic slack has no noticeable effect on inflation (i.e. prices are rigid); $\widehat{\gamma}$ being not significant in the first regime. However, for an inflation environment above this level, the slope becomes positive and significant. The estimated slope in a sizable inflation environment is considerably larger than the symmetric elasticity.

The previous result implies that the general inflation environment, captured by the trend level, is a significant determinant of the Phillips curve slope, as suggested by the menu cost model. In other words, the inflationary cost of stimulating demand by 1% is significantly higher in an environment in which inflation is rising.

While the estimates of the trend inflation threshold are relatively low for Canada, France and the United States, this is not the case in Italy, Japan and the United Kingdom. In these three countries, the values of both the estimated threshold level for trend inflation and the slope are extremely high. In fact, the estimated threshold levels in these countries are only observed for years before 1980. This motivates extending the static STR model to a model that captures the changing nature of the threshold inflation that erodes price rigidity.

3.2. Rolling regressions

Though informative about the static inflation-output trade-off, the previous results do not provide a full satisfactory approach to analyze the changing nature of the Phillips curve. In particular, they do not provide any information regarding the time variation of the slope or price rigidity over time.

To overcome this empirical difficulty, we extend the previous nonlinear model by accounting for the potential change in the threshold mean inflation by conducting 20-year rolling regressions. We opt for this robust rolling estimation technique with a window length of 80 quarters because it balances our desire to investigate the richest possible range of regimes with the data requirements of our STR model. The advantage of our proposed model lies in its greater flexibility, as it can capture the time variation of the relationship of interest without imposing any prior beliefs on the time-varying nature of the data generating process. On the whole, our model allows not only the slope but also the threshold dividing both regimes to be time-varying, providing a fully dynamic specification.

Figures 1 and 2 present the results of rolling linear and nonlinear estimations, i.e. the time series of inflation-output elasticities, as well as those of threshold mean inflation levels. In the case of the nonlinear rolling estimation, the figures depict the elasticity at the extreme regime—when $g = 1$ in Equation (2) and $\gamma + \gamma^*$ is significant at the 5% level.

Several interesting findings can be drawn from the rolling analysis. First, concerning the linear estimation, the slopes of the Phillips curves in Canada, Italy, and the United States are significant only for windows starting at the beginning of the sample period and ending around the years 2000-2002. In the case of France and Japan, the slope is significant for an even shorter period. The estimates in United Kingdom, in turn, are significant for windows starting at the end of the 1990s and ending at the end of the 2000s. This flattening in the Phillips curve is in accordance with previous empirical evidence (see Roberts (2006), Kuttner and Robinson (2010), and Ball and Mazumder (2011) among others).

Second, we can observe from the nonlinear rolling results that the estimated elasticity is higher than in the linear case. Moreover, except in the case of Japan, once threshold effects are taken into account, there is no flattening of the curve for most of the period. In fact, this result is particularly evident in the case of the United States where the elasticity rather than being non significant—as erroneously stated in the previous literature—becomes highly important.

The right-hand side figures show that the threshold levels for price rigidity are higher at the beginning of the period for all the countries, those levels being between 2-3.5% at the end of the period. Combining left-hand side and right-hand side figures, one can remark that Canada and the United States exhibit a quite similar pattern. During the first part of the period under study, linear and nonlinear rolling elasticities are both significant and the threshold trend inflation is quite high. In the second part of the period, only the nonlinear elasticities are significant, and the threshold inflation level has strongly diminished. The inflation level that erodes price rigidity is around 3.5% for the United States and 3% for Canada.

In Italy, our results evidence a very important decline in the threshold trend inflation that erodes price rigidity. Indeed, whereas during the seventies and eighties, excess demand would have important effects on prices for a trend inflation well above 10%, by the end of the period this level is found to be considerably lower. Regarding France, the nonlinear rolling elasticities are significant until windows ending in 2004, while the linear ones are rarely significant. The threshold level that erodes price rigidity is quite stable, being around 2.5%. The fact that in recent times there is no trade-off between inflation and the output gap in France but the elasticity of the output gap is significant in Italy when trend inflation is above 2.7%, implies an additional source of asymmetry in the euro zone that should be considered by the European Central Bank when designing its monetary policy.

In the case of the United Kingdom, there has been an important reduction in the trend inflation that erodes price rigidity. Indeed, whereas economic slack has no noticeable effects on inflation for a trend inflation below 5 to 10% for windows covering the second half of the seventies and the eighties, this level is no higher than 3% for windows starting in 1991 and ending in 2011-2012.

Finally, in the case of Japan, the linear and nonlinear Phillips curves are not specially significant for a very long period of time. The output-inflation trade-off in the linear rolling estimation becomes steeper at the end of the sample period. This result implies that excess demand (supply) increases (decreases) inflation independently of the inflation environment. It is important to remark that, contrary to the rest of the countries in our sample, the main interest for the Japanese monetary authorities for several years was to prevent the economy falling into a deflation spiral as standard estimates suggest that the output gap was negative for a long period of time.

On the whole, our findings show that the threshold inflation level that erodes price stickiness has decreased over time, and that inflation tends to become more sensitive to output fluctuations for lower price variations than at the beginning of the period.

4. Conclusion

The aim of this paper is to investigate the existence of the Phillips curve by paying a particular attention to price rigidity. More specifically, based on the menu cost proposition, we aim at estimating the level of inflation that erodes price rigidity and testing whether this threshold level is constant over time.

To this end, we rely on the estimation of smooth transition regression models using rolling regressions to account for possible time-varying threshold inflation levels. Studying Canada, France, Italy, Japan, United Kingdom, and the United States, our results show that the slope of the Phillips curve is time varying, as well as the threshold trend inflation that erodes price rigidity. Moreover, our specification allows us to provide the threshold levels that tend to restore the inflation-output trade-off. These characteristics could not be captured by a static linear or nonlinear model, suggesting that the rich flexibility embedded in our proposed model may prove highly beneficial.

Our findings have important consequences and policy implications. First, while the full dynamics of inflation cannot be captured by a simple Phillips curve—supply shocks matter—our results show that the conclusion according to which the Phillips curve does not exist (Atkeson and Ohanian (2001), Uhlig (2010)) is false. Second, backward-looking Phillips curves are useful to explain the behavior of inflation once nonlinearities are taken into account. Third, the broadly accepted view that the current observation of a nearly horizontal Phillips curve may best be interpreted as a sign of well-executed, neutral stance, monetary policy should be questioned. Finally, the fact that the Phillips curve is nonlinear and time-varying provides substantial scope for opportunistic policymaking in the sense of Orphanides and Wilcox (2002) in the "price-rigid" regime. A precise evaluation of the threshold defining this regime—as the one we provide—allows policymakers to reduce interest rates in order to foster economic growth without fear of the inflationary consequences. However, exceeding the threshold may introduce significant inflationary pressures into the economy.

Figure 1 – Linear and nonlinear rolling estimates and trend inflation for price rigidity. Note: (1) Doted line indicates non significance (Source: authors' calculations).

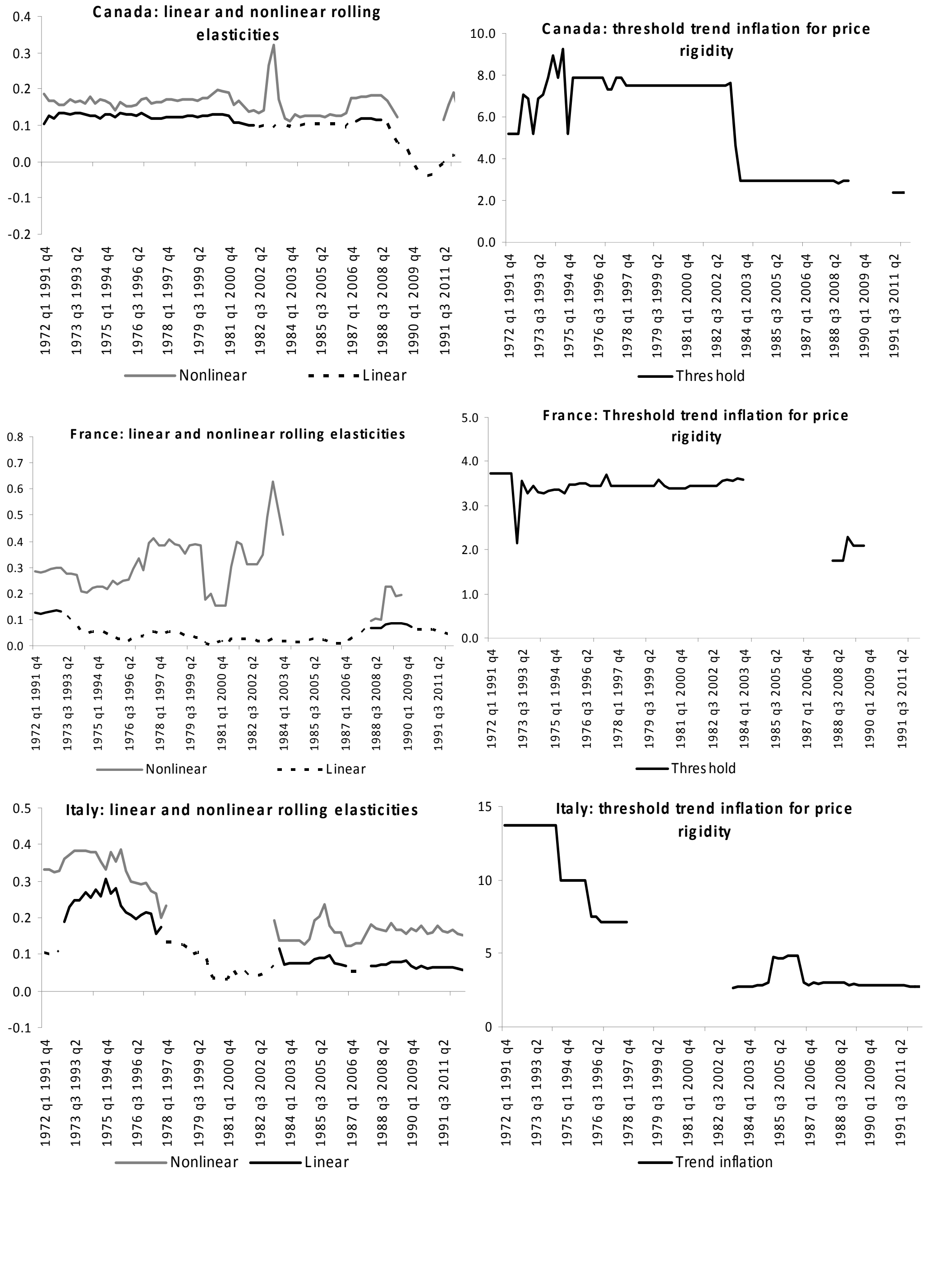
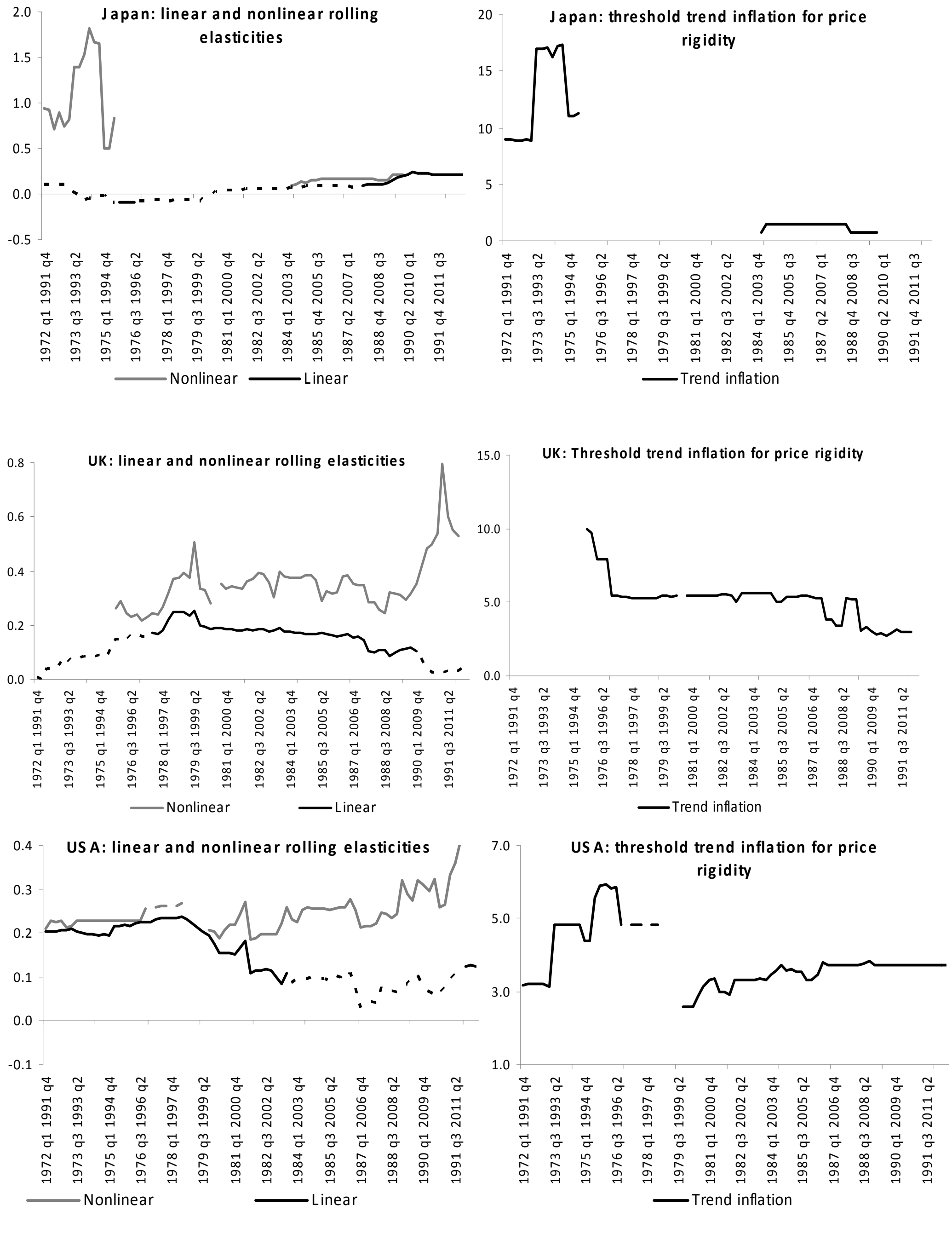


Figure 2 – Linear and nonlinear rolling estimates and trend inflation for price rigidity. Note: (1) Doted line indicates non significance (Source: authors' calculations).



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