Drivers and Global Impact of U.S. Inflation 1870-2023

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August 20, 2024

Abstract

This paper addresses the dearth of inflation models for the United States over an extensive historical window. The theoretical framework shows that there can not be ubiquitous drivers of inflation, not even money or labor market conditions, and not universal functional forms for a model. The analysis focuses either on the U.S. price level or the inflation rate with models of varying structures and explanatory variables. The selection depends on the prevailing monetary regime. From the gold standard to just before World War 2, the price level was predominantly determined by international conditions, with transient money supply effects. From 1940 to 1983, the inflation rate was driven by money growth and, less than before, by the global inflation component. From 1984 to 2019, money lost its direct influence, yet the international inflation component persisted. It reveals that, apart from the impact of energy prices, the global inflation-disinflation arc throughout the pandemic primarily originated in the U.S. before spreading to other economies. The surge and decline of pandemic-induced inflation depended on the evolution of supply chain backlogs, market labor conditions, and increased demand for durable goods fueled by fiscal stimulus measures. Nevertheless, the global component remained significant. Examining the United States' neighboring countries and the euro area reveals an evident influence of U.S. trends on their post-pandemic inflation patterns. All models presented in this article suggest that paying attention only to traditional domestic factors might not be best in understanding inflation.

Keywords: Inflation, monetary supply, Phillips curve, gold standard, Covid-19.

JEL classifications: O2, O4, F1, F6

*Banco de México. I thank Rafael Gómez Tagle his useful comments. Usual disclaimers apply.

1 Introduction

> "The exact determinants of inflation remain somewhat of a mystery to everyone, including economists."
>
> Tootell (2011)

Identifying the causes of inflation in modern economies tends to be challenging, with few exceptions. Nonetheless, when inflation peaks occur some causes can be plausibly identified. However, the causes behind the pandemic-related inflation in many countries have been subject to debate.

The controversy around the causes of the pandemic inflation-disinflation in the U.S. and other developed economies underscored the limitations of economic theories in comprehensively explaining or predicting inflationary processes. Despite robust theoretical frameworks, their application during the pandemic denouement and decades prior has yielded limited success.

In particular, the literature about the causes of inflation for the United States, likely one of the most popular topics in all of Economics, has a peculiar characteristic: there are no empirical papers that explain the behavior of inflation conditional on its drivers that covers its whole history. This might have two reasons. It is a common textbook proposition that in the long run only money matters as a determinant (see Romer, 2011). Because of this, it is assumed that it only necessary to show that either money velocity is more or less constant (stationary or mean-reverting) or a stable function of the interest rate. Therefore, according to this approach, it is enough to show that there is a long-run correlation, or spectral coherence, equal to 1 one between the price level and a monetary aggregate (see Benati, 2021). Another alternative, or complementary, approach is to consider that there is a trade-off between unused economic capacity and inflation. This was started by Samuelson and Solow (a960) and it has become the dominant modern approach.

However, despite the high quality data available for the United States to study inflation over the long run, to the best of the author's knowledge, there is not a single paper that tries to use it to study with either approach. The long-run correlation is not really a conclusive result because it does not prove causation. As Lorenzoni and Werning (2023), inflation can occur without a monetary cause. A way to conciliate the tight long-run correlation between money and the price level is the role of money as a unit of account. A long-run stable money demand (as in Benati et al., 20) cannot be a proof because there is the issue of invertibility, as pointed out by Hendry and Ericsson (1991).

The paper begins by proposing a plausible explanation for why the dominant theories on inflation often falter. This elucidation centers around a specific concept of monetary regimes, which delineates the monetary authority's role in setting the trajectory for nominal variables —whether determining the price level or the inflation rate during the policy horizon. This distinction is not novel but is crucial and often under-discussed. It fundamentally dictates the permanency or transience of monetary shocks on price levels, intricately woven into the challenge of identifying inflation causes.

The definition of a monetary regime also requires identifying the policy instrument employed, revealing another critical distinction. A well-known example is Friedman (1968), who objected to the equivalence of interest rate pegging with monetary policy based on controlling a monetary aggregate. He argued that they have different outcomes. Other instruments, such as the exchange rate, might yield different results.

Thus, in this paper, a monetary regime is the framework adopted by a monetary authority that dictates whether it will determine either the path of the price level or the inflation rate over a policy horizon through an instrument of its choice. This definition and the econometric restrictions it imposes will be detailed in a full section later.

This definition enables the paper to tracking down the monetary regimes adopted by the U.S. and other economies throughout their histories. In turn, this tracing aids in discerning the causes of inflation for a given period. For example, during the gold standard until before World War 2 (WW2), the U.S. was in a price level determination regime mostly driven by international monetary. Subsequently, it followed inflation rate determination regimes, albeit with alternate policy instruments.

The presence of one type of regime or another has several implications for econometric models of inflation. The first one is that a sole model for the whole sample, thus ignoring the existence of monetary regimes, would be wrong. This, by the way, should explain no such model exists for the United States. However, there is a one equation model for England for a long sample (Hendry, 2001), that is compared later with this paper's approach.

The second is that each type of regime has a different type of equation to represent inflation dynamics. For price level determination, the model is an error correction mechanism around the cointegration of the price level with a given nonstationary driver. For inflation rate determination, the model is an equation only stationary variables on the right-hand side. However, identifying inflation drivers becomes arduous in an inflation rate determination regimes as all shocks perpetuate within the price level and few seem to have a systematic and dependable role.

On this respect, the Phillips curve model, since it arrived to the U.S. in the 1960s, has been lauded with optimism as the potential dominant systematic inflationary mechanism. This contraption, whenever valid, would facilitate monetary policy implementation. However, that buoyancy has yet to be matched with equivalent success, at least in recent episodes. Notably, models derived from the Phillips curve exhibited unreliable forecasting properties past the Great Financial Crisis and the post-pandemic phase.

Despite its past failures, the Phillips curve is still the most popular framework for explaining the pandemic inflation and providing policy recommendations. The Federal Reserve did not apply interest rate adjustments as large as those implied by Phillips curves models and, instead of a sharp deceleration, it could set the path of a soft landing, at least to the beginning of 2024.

Similarly, analyses of the pandemic inflation based on the quantitative theory of money did not fare better. The first impressions of a comeback of money as the main inflationary factor soon fizzled. The simultaneous surge in monetary aggregates and inflation proved to be an isolated occurrence rather than a revival of the monetarist tenet.

Another important development was that, after the worst sanitary aspects of the pandemic had passed, the ramping inflation not seen in decades ravaged the United States spread abroad, particularly to its Western trading partners. This pattern had already been seen throughout history with its neighbors and many European countries.

Canada's inflation closely followed that of the United States for more than a century, so its quick increase during the pandemic was no surprise. However, Mexico's case is more nuanced. During some episodes shown later, its inflation closely followed that of the United States, similar to Canada's. In other episodes, from 1934 to 2000, the relationship between inflation in Mexico and the U.S. was masked by more volatile variables (see Garcés Díaz, 2017). In contrast, before the pandemic (2009-2019), Mexico's inflationary process appeared to have no correlation to that of the U.S., even after controlling for other variables.

Also, unlike most countries, Mexico did not apply much monetary or fiscal stimulus while the price of energy changed little due to increased government subsidies. Furthermore, its economic activity experienced one of the sharpest contractions in its history. Nonetheless, inflation in Mexico surged at a similar pace than that of the U.S. This suggests an international factor in play but also, simultaneously or alternatively, that a relationship between the price levels of both countries not seen in nearly a century had revived.

The contagion went outside the North American region. The euro area also had its highest inflation rates in decades, exacerbated by the conflict in Ukraine in the form of supply cuts and soaring energy prices. However, the behavior of its price level mirrored that of the United States, as had happened with such country's neighbors. Although the increase in the euro area's inflation rate to around 10 percent was not surprising given the global circumstances, the strong connection with that of the United States was still remarkable. All this suggests that inflation does not always follow a direct domestic factor, such as increased marginal costs or excess money.

Thus, it might be useful to attempt to understand the pandemic inflation by looking back in time so many decades. Many monetary circumstances and policies have changed over many decades. However, the strong connection in the inflation rates of countries not under fiscal dominance or in different institutional circumstances calls one's attention. Also, as has happened before and currently, the leading economy can have an outsized role in global inflation. Considering it explicitly, together with domestic factors, can lead to a better understanding of inflationary processes.

The rest of the article includes the following sections. Section 2 describes a monetary regime as understood in this article. Section 3 makes the definition of monetary regime more formal through pricing equations with rational expectations. Section 4 describes the data sources. Section 5 studies the determination of the price level of the United States and its neighbors. Section 6 analyzes the drivers of inflation in the United States from 1940 to 1983. Section 7 studies the inflation process for the U.S. during the period 1984 to 2023. Section 8 proposes econometric models to show the connection between the inflation processes of the United States, Canada, Mexico and the euro area. Section 9 concludes.

2 Monetary Policy Regimes and Their Tools

The expression "monetary regime" has several possible connotations that might refer to different things. Some examples of the use of such an expression are the following. Sims and Zha (2006) statistically characterize regime changes that follow a Markov process. Borio et al. (2023) define monetary regimes according to the level of inflation (high vs. low). Benati (2021) considers regimes with either a metallic standard or fiat money in addition to the modern regime of inflation targeting. Thus, it is necessary to provide a precise definition of what such a concept is within this article. Most of the following considerations are well-known, but put together will be helpful in the development of this article based on shifts between monetary regimes. It should be apparent from the outset that these shifts are not similar to those used by Sims and Zha (2006), where a statistical process describes them. The regime changes are identified here using events, policy statements, or both. Statistical identification procedures of regimes such as Markov switching or threshold autoregressions are not obvious and, perhaps, unfeasible. First, the article discusses the general idea, then a theoretical framework based on pricing equations is developed.

2.1 Monetary Policy Choices: Price Level Determination Versus Inflation Rate Determination

The first consideration is that the monetary authority must define its purpose, which is not always price stability. For example, a country might want to achieve low inflation. Yet, it cannot get it because it has large fiscal deficits without any other way to finance them than with the primary emission of currency.

A second choice is the type of target to pursue. The monetary authority might wish to achieve: 1) either the determination of a price level or 2) the determination of an inflation rate for a given period regardless of whether the target was reached in past periods ("bygones are bygones"). This difference between the two choices is crucial and gives room to very different inflation dynamics, as represented by econometric models, as seen below.

It is important to emphasize that modern inflation targeting, as currently followed by the Federal Reserve or the European Central Bank, is only a particular case of the inflation rate determination regime defined here. For example, there can be an inflation target, but with the growth rate of money as the policy instrument instead of the interest rate. These two choices are not equivalent; as explained below, this difference is also crucial.

The frequently discussed "price level targeting," where the central bank corrects past misses in the planned trajectory of the price level, is also only a particular case of price level determination as understood here. Modern "price level targeting" has been the subject of several studies comparing its performance to contemporary "inflation targeting." Nevertheless, there is no known empirical example of its application. For example, Svensson (1999) compares the pros and cons of both regimes. They share some features. One is the assumption of a Phillips curve where inflation mostly depends on the deviations from the optimal level of employment or other measures of idle resources. Another shared feature is that the central bank has perfect control over its target. The concepts of price level and inflation rate determination presented here are more general in that they might have a different driver than changes in the use of productive resources. This allows to cover even cases of hyperinflation where the Phillips curve is not as valuable a framework.

It is said that Sweden in the 1930s followed a price level targeting regime (see, for example, Svensson, 1999), but that country's price level at that time was tied to that of the United Kingdom, as happened with those of other nations. For example, the U.S. was also in a similar situation, as shown below, even though it was not targeting a price level. Thus, there are cases where there is price level determination without being one where the monetary authority sets its target in the way the above-mentioned theoretical framework implies. Several examples of this will be studied below, including some during the pandemic.

These two alternative policy choices, price level versus inflation rate determination, only lead to the same outcome in unlikely instances such as when the point inflation target is met in every policy horizon. That is why inflationary shocks have a different effect in each of these regimes at the end of the policy horizon. In price level determination, only one kind of shock has a permanent effect. On the contrary, all effects from inflationary shocks remaining beyond the policy horizon become permanent in inflation rate determination. This characteristic occurs because the monetary authority is not committed to correcting any failures in achieving its target once the policy horizon has passed.

A third decision involves the means or instruments to achieve the target. Traditional policy instruments have been a monetary aggregate, the exchange, and interest rates. They need not be equivalent in their outcomes except in particular situations. A common mistake is to consider that the use of the money supply and an interest rate as policy instruments are always equivalent, which then would let unexplained why one replaced the other in the first place and, more importantly, that the second instrument leads to multiple equilibria, as shown by Sargent and Wallace (1975), among others. This distinction was famously discussed by Friedman (1968), in the same address where he lays out key tenants of modern monetary policy and the role of expectations.

2.2 Drivers of Inflation

Despite the widely-known claim that inflation is always a monetary phenomenon, a comparison shows that the causes of inflation can vary sharply from one case to another. For example, in the last decades, countries like Argentina, Venezuela, and Zimbabwe have had high inflation, and the evident cause has been the use of monetary financing.[1] That was also the case in Germany in the early 1920s. The situation in other countries with less extreme inflation rates sharply differs in that the causes of inflation are factors such as spare productive capacity, believed to be more critical than money growth. In these contrasting cases, one can ignore the less relevant factor to concentrate on the most important one. There are also less extreme examples in the past and present where it is essential to differentiate, as will be seen.

2.3 Systematic and Nonsystematic Causes of Inflation and Their Impact on the Price Level

It is usually easier to see when an inflation driver such as money has a consistent role in causing inflation, as in high-inflation countries. However, it is harder to see a role for that variable in low-inflation economies, and it is often relegated to be the main factor only in the long run.[2] For these economies, it is usually presumed that spare capacity has a systematic role, although it is less clear that is the case than in money-driven inflation. Also, there can be situations where a variable has an evident but only temporary effect. This situation occurs, for example, with an oil shock or a sudden tax increase. These transitory shocks can be relevant for some periods but not others. The effect of these shocks on the price level depends, in turn, on the monetary regime's target.

[1] See Ocampo, 2021

[2] See, for example, Romer (2011).

This makes it essential to describe what might happen to inflation in each type of these economies. Nonetheless, in most modern economies, the target tends to be the inflation rate rather than the price level. Thus, the shocks seen during the pandemic inflation will tend to be permanent. In the case of those few countries that keep a price level determination (an example would be Bolivia), the pandemic inflationary shocks will probably also be permanent if the policy instrument is the exchange rate and the country to which currency the peg takes place was an inflation targeter.

3 Theoretical Framework

This section formalizes the above comments through present-value pricing models with rational expectations. One well-known example of such pricing models is the forward-looking Phillips curve; another is the quantitative theory model. In the first case, the dependent variable is the inflation rate, while the second is the price level.

The following two general equations, where the expectations are rational, can summarize many possible monetary regimes.

$$p_t = \gamma_x E_t[p_{t+1}] + h_z x_t \tag{1}$$

$$\Delta p_t = \gamma_z E_t[\Delta p_{t+1}] + h_z(z_t - z_t^*) \tag{2}$$

Equation (1) defines regimes with price level determination with $0 < \gamma_x < 1$ and x_t as the driver of the price level. This driver contains a nominal stochastic trend. The coefficient h_x often enters into the pricing equation with a value of 1, as in, for example, the quantitative equation or purchasing power parity. Two examples of such a unitary restriction are estimated in Garcés-Díaz (2017) and others in this paper. One where the coefficient h_x is different from one is estimated also below. The identity of the driver x_t, which can vary across time and countries, completes the definition of a monetary regime. Some cases with empirical examples are below. This type of regime includes hyperinflation or a dominant long-run role for money, but there can be others.

Equation (2) describes a regime with inflation rate determination where z_t can be a single stationary forcing variable or, differently from the case of price level determination, a vector of them. These might include the deviation of a variable from its "natural" value z_t^*, for example, the output or the unemployment gaps, the rate of growth of money, or the depreciation rate. This regime is prevalent in most modern economies, with the exceptions of countries such as Argentina and Venezuela, where there is still price level determination (see Garcés Díaz, 2016). The discussion of these two types of regimes follows next.

3.1 Regimes with Price Level Determination

Equation (1) can be solved forward through substitution and the law of iterated expectations:

$$p_t = \frac{1}{1+\gamma_x} \sum_{\tau=0}^{T} \left(\frac{\gamma_x}{1+\gamma_x} \right)^{\tau} E_t x_{t+\tau} + \left(\frac{\gamma_x}{1+\gamma_x} \right)^{T+1} E_t x_{t+T+1} \tag{3}$$

To rule out an explosive (speculative bubble) solution, a transversality condition must hold:

$$\lim_{T \to \infty} \left(\frac{\gamma_x}{1+\gamma_x} \right)^{T+1} E_t x_{t+T+1} = 0 \tag{4}$$

From this, a present value relationship results:

$$p_t = \frac{1}{1+\gamma_x} \sum_{\tau=0}^{\infty} \left(\frac{\gamma_x}{1+\gamma_x} \right)^{\tau} E_t x_{t+\tau} \tag{5}$$

In other words, the current price level is equal to the sum of the discounted future values of the fundamentals. As in MacDonald and Taylor (1993), one can subtract x_t from both sides of the equation to obtain:

$$p_t - x_t = \frac{1}{1+\gamma_x} \sum_{\tau=0}^{\infty} \left(\frac{\gamma_x}{1+\gamma_x} \right)^{\tau} E_t \Delta x_{t+\tau} \tag{6}$$

If expectations are rational, the forecasting errors of the right-hand side are stationary. Thus, the left-hand side is also stationary. Therefore p_t and x_t are cointegrated. Naming the right-hand side as η_t^x, one can obtain several well-known relationships, such as the quantitative equation of money and the purchasing power parity condition, as shown later. Several empirical examples of this type of regime mentioned below come from Garcés Díaz (2016). Still, this paper shows another kind in a subsample for the United States and other countries.

Some theoretical cases with corresponding empirical examples are the following:

3.1.1. When the forcing variable is the inflationary component of the money supply, $x_t = (m - y)_t$, one obtains:

$$p_t = (m - y)_t + \eta_t^m \tag{7}$$

The notation $(m - y)_t$ means that the term inside the parentheses is always defined as the logarithm of the ratio of the ratio of the two variables. It is preferred to the alternative $m_t - y_t$ because they are never separated in the empirical estimation so a test for having coefficients (1,-1) is not necessary.

Thus, when the monetary authority determines a price level through the money supply, the quantitative equation of money is a cointegration relationship. The long-run deviation η_t^m, represents the velocity of money v_t. The quantitative equation of money is not tautological if the money velocity is mean-reverting. Examples of this regime are Argentina (1960-2013), Brazil (1960-1980), and Mexico (1932-1982).

3.1.2. For $x_t = (e + p^f)_t$, the forcing variable is the foreign price level in local currency, $(e + p^f)_t$, the purchasing power parity is a long-run equilibrium condition:

$$p_t = (e + p^f)_t + \eta_t^{epf} \tag{8}$$

The residual η^{epf} is the real exchange rate rer_t, which in this case is stationary. Examples of this regime are Brazil (1981-1998) and Mexico (2002-2000).

3.1.3. When $x_t = e_t$, there is no strict PPP condition at work, so the nominal exchange rate drives the domestic price level. These cases include the German hyperinflation of the early 1920s and Chile from 1960 to 1992, as shown in Garcés Díaz (2018).

$$p_t = e_t + \eta_t^e \tag{9}$$

3.1.4. When $x_t = p_t^f$, the foreign price level alone drives the domestic price level without a role for the nominal exchange rate. This case is discussed below and corresponds first to the United

States from 1870 to 1937, where the foreign price level was that of the United Kingdom, then the global financial and economic powerhouse. Other examples of this case include one for the euro area and Mexico during the pandemic.

$$p_t = p_t^f + \eta_t^{pf} \tag{10}$$

3.2 Regimes with Inflation Rate Determination

The results above contrast fundamentally with the cases derived from equation (2). In such a pricing equation, the dependent variable is the inflation rate, and the forcing variables are stationary. Notice that there can be more than one forcing variable when there is inflation rate determination, so z_t and its corresponding coefficient can be interpreted as vectors instead of scalars, if necessary. Equation (2) can also be solved forward to obtain:

$$\Delta p_t = h_z \sum_{\tau=0}^{\infty} \gamma_z^{\tau} E_t (z - z^*)_{t+\tau} \tag{11}$$

As happened before, one can find empirical examples of this type of pricing equations. However, these are just indicative because, as any shock is equally permanent in the price level, there is no assurance that the inflation rate's determinants will always be the same, as in the U.S. case shown below. That is why the Phillips curve has gained so much favor. Such a model includes a measure of spare capacity as the systematic cause of inflation. If that is the case, monetary policy is conducted through a policy interest rate. However, as has been the case since the Phillips curve became the most popular model of inflation, an empirical stable formulation has yet to be found, at least in the United States, which is the most studied case (see Ball et al., 2022). Although some cases are mentioned below for completeness, in a regime with inflation rate determination, a search for significant variables is unavoidable in the absence of a compulsory one. The models for the United States during the inflation rate determination regime followed such a search. The alternative is to stick to a solid theoretical framework that has not worked well empirically.

3.2.1. The most common case is when $(z - z^*)_t$ is the domestic output gap $(y - y^*)_t$. Thus, current inflation is equal to the discounted future streams of domestic output gaps. This corresponds to the standard New Keynesian Phillips curve. Some models take instead as the relevant slack measure the unemployment gap or even the global output gap, as discussed above but the solution needs to take this form:

$$\Delta p_t = h_y \sum_{\tau=0}^{\infty} \gamma_y^{\tau} E_t (y - y^*)_{t+\tau} \tag{12}$$

3.2.2. Another case is when the inflation rate driver is the growth rate of a monetary aggregate. This case should not be confused with the one discussed above with price level determination. In this case, the solution takes the form:

$$\Delta p_t = \overline{\Delta p_t} + h_{\Delta m} \sum_{\tau=0}^{\infty} \gamma_{\Delta m}^{\tau} E_t \Delta m_{t+\tau} \tag{13}$$

where $h_{\Delta m}$ and $0 < \gamma_{\Delta m} < 1$ are corresponding constants. An example of this is Argentina since at least the 1960s.

3.2.3. One more case is when the driver of the inflation rate is the exchange rate depreciation. This also should be distinct from that discussed above within price level determination. The solution takes the form:

$$\Delta p_t = h_{\Delta m} \sum_{\tau=0}^{\infty} \gamma_{\Delta e}^{\tau} E_t \Delta e_{t+\tau} \tag{14}$$

where $h_{\Delta e}$ and $0 < \gamma_{\Delta e} < 1$ are constants. An example of this was Venezuela from 1979 to 2013 and probably to the present.

3.2.4. Finally, there could be a combination of variables, as inflation determination does not constrain the number of factors that permanently affect the price level. This kind of model is developed later for the U.S. core inflation during the pandemic. Unfortunately, models based on the quantitative theory or the Phillips, as this is written, have not been very successful, so a fishing procedure seems to be the only alternative at the moment.

3.3 Difference in the Dynamics of Price Level and Inflation Rate Determination

The above pricing equations are applications of well-known dynamic systems with stationary and nonstationary variables. Even though the coming sections show concrete empirical cases, it is helpful to show all this in the following hypothetical graphs in Figure 1. The horizontal axis marks represent time units such as months, quarters, years, decades, or policy time horizons. The curves take particular shapes, depending on some parameters, but at least in some cases below, they look like these. Both cases assume a final effect of ten percentage points. This representation corresponds to a conditional error correction of the dynamics for the price level determination regime.

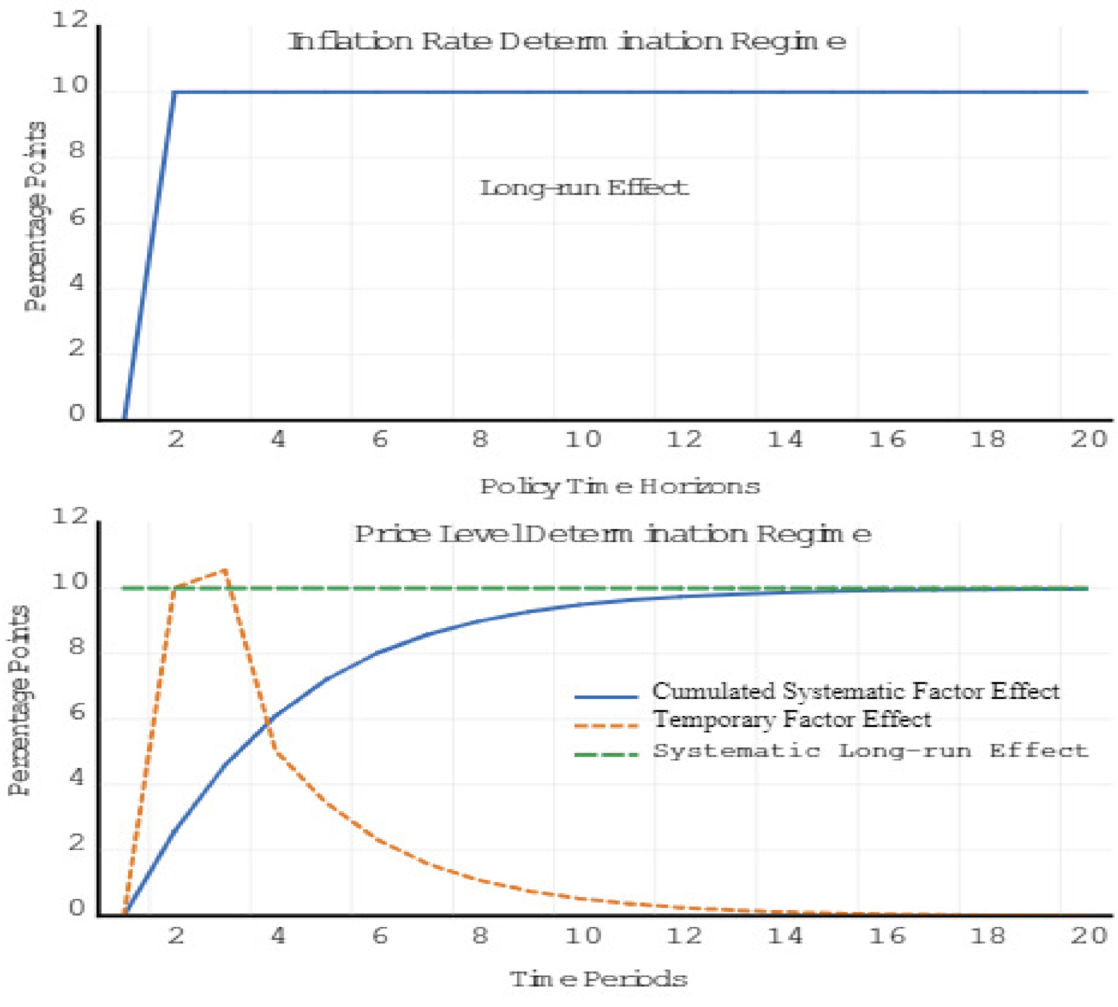

Figure 1: Impact of Inflationary Shocks of 10 Basis Points on the Price Level in Two Regimes. Source: Own elaboration.

The top panel represents a monetary regime with an inflation rate determination. The most simple example is contemporary inflation targeting, as the one followed by the Federal Reserve from 2012-2019. Before and after that period, that institution did not declare it was doing it, although it is often assumed it did. Many other central banks follow such a regime too.

At the end of the policy time horizon, say one year, all the impacts of shocks that were not dealt with within that horizon become permanent on the price level. This is probably the main reason why identifying the drivers of inflation is so difficult in this type of regime, as has happened since the end of the Great Moderation in many countries. In this case, a standard regression model with stationary variables can be used as long as one can find systematic factors. This is not an easy task even though a lot of models assume that a systematic factor is some measure of spare capacity.

There are important provisos that will become relevant in the empirical section. The top panel of Figure 1 is rarely immutable. The shape of the adjustment curve might change. Less frequent is that the driving factors change, as some empirical examples in Garcés Díaz (2017). Even harder to spot is the possibility that the driven variable switches places with one of the drivers, as in the case of the United States below. When the last two types of features occur, some usual econometric estimation methods become invalid. As an example of this, the widely-used Johansen (1991) estimation VAR-based method cannot be used because the matrix of feedback, or adjustment, parameters is not constant (Kurita and Nielsen, 2009). In the context of inflation models, the intuition should be clear. If a nonstationary variable, such as money or the exchange rate, ceased to be the driving variable of the price level then a fixed feedback parameter makes little sense.

The lower panel shows a price level determination regime. In contrast with the one at the top, there are two types of effects. When the shock comes from the systematic factor, the pass-through to the price level is complete after some time that depends on the speed of adjustment (continuous smooth line). When the shock is from any other cause, it has a temporary impact on the price level that it is completely erased in the future (jagged line). In this example, the periods are months, similar to one of the empirical cases analyzed later, and the speed of adjustment is such that the pass-through is complete in about one year. The adjustment would take just one period with annual data, as in the case of the first empirical model presented below. This chart represents a conditional error correction model, which results from a cointegration relationship within a price level determination monetary regime.

Although some recent studies with cutting-edge econometrics have found that the proportionality of changes between excess money, ($m_t - y_t$, as shown above), or simply money, and inflation is nearly one-to-one, since the early eighties the connection "has vanished"[3], perhaps because of inflation targeting according to Benati (2021).

The periods for this chart would be years if the hypothesis that, in the long run, only money matters for the price level is accurate. In that case, the speed of adjustment would have to be extremely slow, as money is rarely considered to explain the dynamics of inflation in modern economies.

Although some economists saw the coincidence of surging inflation and fast money growth during the pandemic as a vindication of the quantitative theory of money, this was probably just a coincidence, and the disconnection between money growth and inflation remains, as seen below.

4 Data

The data of this paper was sourced from multiple sites and is not homogenous either in time length or frequency. Most data are annual; the frequency is monthly for the most recent years. Much of the annual data for the United States, Canada, and the United Kingdom, such as price indexes, monetary aggregates, and GDP that span from 1870 to 2016, was obtained from the historical database of Jordà et al. (2017). Some annual data from years after 2016 come from the International Monetary Fund WEO Database. For Mexico, the data from before 1980 comes from the book "Estadísticas Históricas de México" by INEGI and data since 1980 from that institution's website. The exchange rate data for Mexico is from Banco de México. The data for the euro areacomes from Eurostat. The backlog data for both the U.S. and the euro area are from Markit. The symbols for each variable are

5 Price Level Determination in North American Countries 1870-1939

The joint examination of the inflation dynamics of the three North American countries can reveal some aspects that can be useful to understand other experiences. Mexico has a very different level of economic development and a contrasting inflationary experience for most of its history. The comparison with the two other countries can yield a fresh perspective.

The analysis begins with a very long view of the relationship between the price levels of these

[3] Nicolini and Lucas (2015).

three countries before examining what happened during the pandemic inflation. Figures 2 and 3 contain the inflation rates from 1870 to 2023 for the U.S. and Canada. For Mexico, it starts from 1887, with missing data from 1914 to 1918. The next chart shows the logarithms of the price levels of the three countries from 1920 (taken as the base year) to 2022.

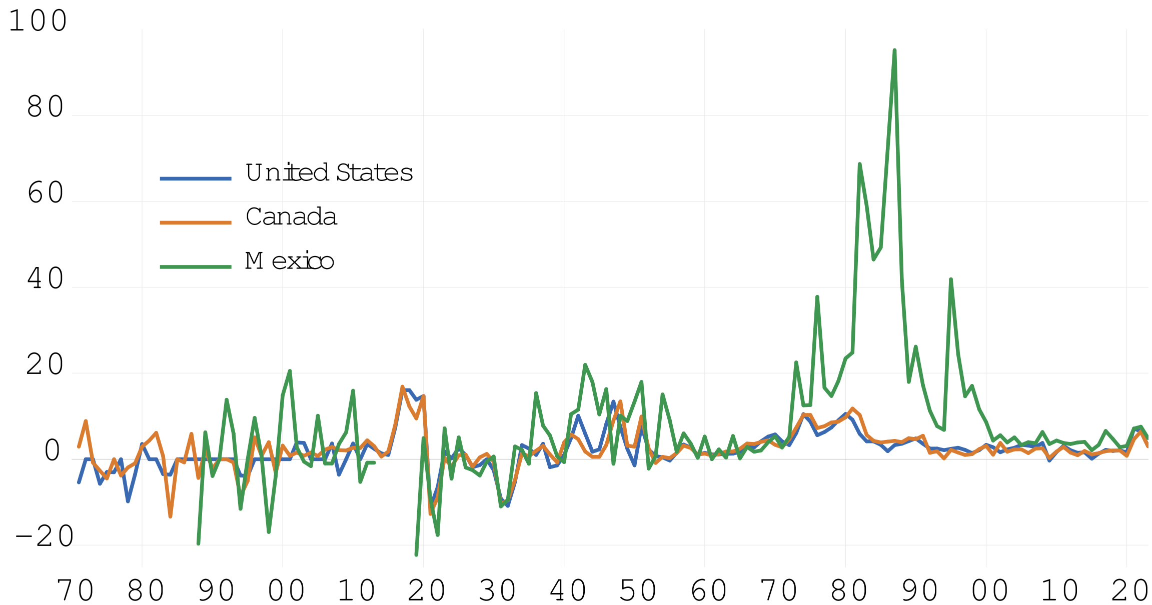

Figure 2: Inflation Rates of North American Countries 1870-2023. Source: Jordá et al. (2017), BLS, IMF, Inegi.

Both Figure 2 and 3 show that most of the time, the inflation dynamics of the U.S. and Canada have highly similar behavior to the point that they look almost the same. This behavior is not always the result of purchasing power parity in action, as the nominal exchange rate between the two countries is often nearly unrelated to their relative price levels. The relationships with Mexico's price level are more challenging to spot, except from 1920 to the mid-1930s, where a common trend suggests itself.

Such a relationship tends to vanish for the rest of the sample. Nevertheless, looking hard enough, one can spot some comovements from the mid-fifties to the beginning of the seventies and then again since 2020. A piece-wise analysis seems necessary to provide some insights into the determinants of inflation in general.

Mexico's nominal sector might look very different from the United States and Canada's, al-

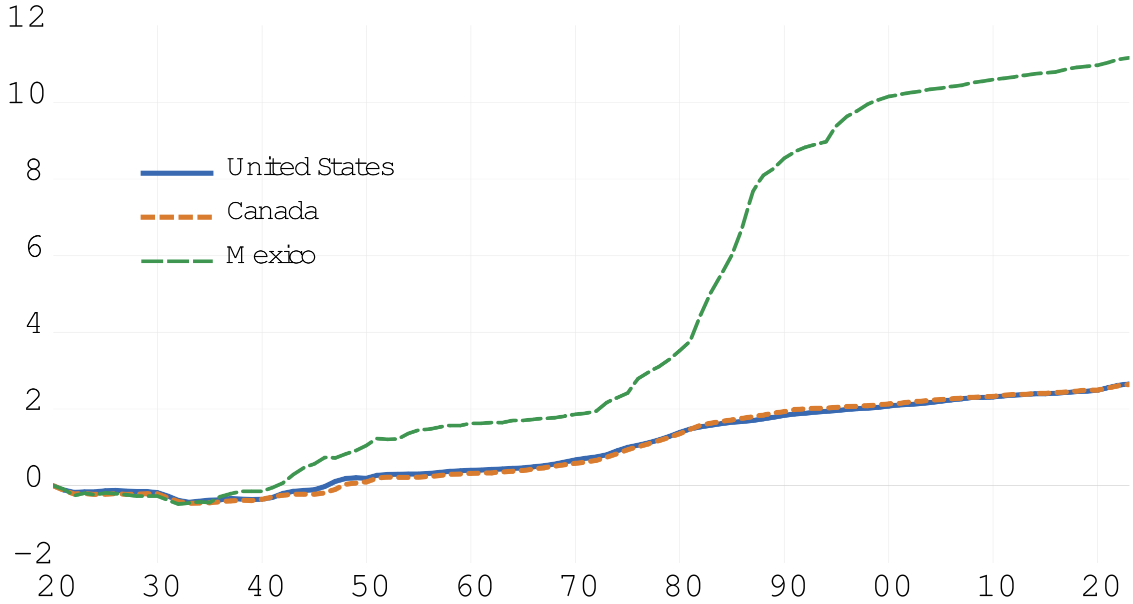

Figure 3: Log Price Levels of North American Countries 1920-2023 ($Index_{1920}$=1). Source: Jordá et al. (2017), BLS, IMF, Inegi.

though it has seldom been unrelated to those. This relationship arises because Mexico had a price level determination regime for most of the available sample. In such a regime, the key variable has been the U.S. price level, either with the nominal exchange rate (U.S. price level times the bilateral nominal exchange rate) or by itself. The exception of the last statement is the period starting with the adoption of inflation targeting in 2001 until 2019.

There is another paramount difference in the long-run behavior of price indexes between Mexico and its more developed partners. In the United States and Canada, most of the time, the price of goods relative to services has been declining, although during the pandemic inflation, that trend changed its direction. However, it reversed course again in 2022. Figure 4 shows the ratio of the CPIs of goods to services. It is set to 1 in 1982 for the three countries because that is where the shortest sample begins.

The only periods in the United States where the relative price of goods had sustained growth occurred around WW2 and its immediate aftermath. For Canada, the trend has been negative for most of its available sample, except during the pandemic. However, the decline is clearly less pronounced than in the United States during similar samples. For Mexico, the relative price of

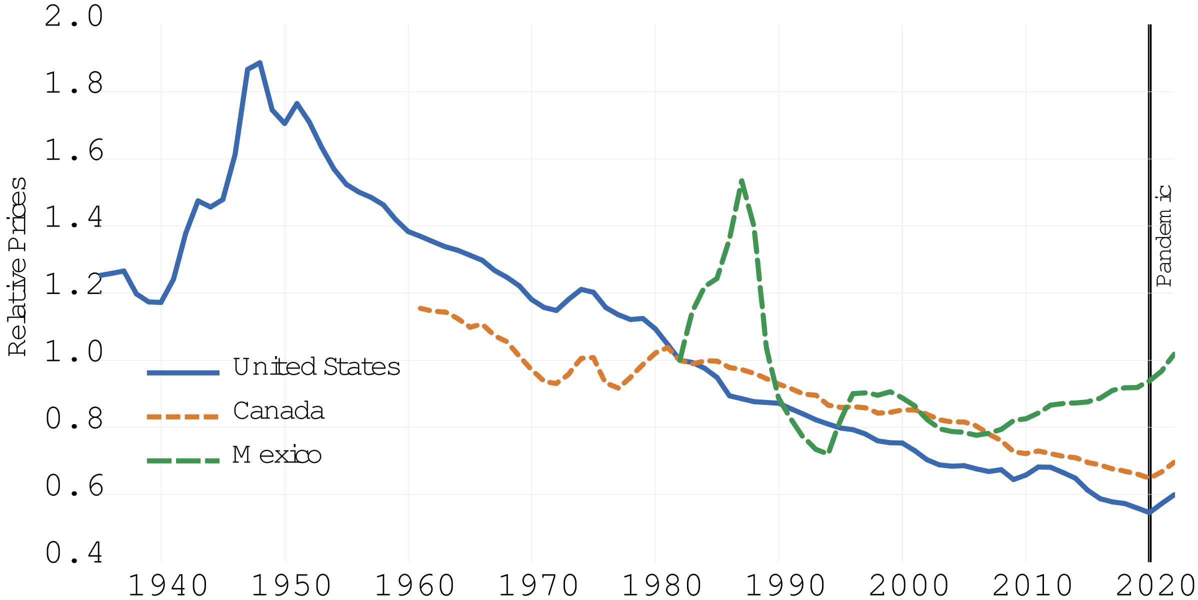

Figure 4: Price of Goods Relative to Services in North American Countries 1935-2022 ($Index_{1982}$=1). Source: BLS, Statcan and Inegi.

goods grew sharply during the large exchange rate devaluations of the eighties and 1995. It also increased since 2008, when there was another strong depreciation. The pandemic inflation did not change that trend but only made it steeper.

To analyze the relationship in the inflation processes in the three countries, one could start in 1870, although for Mexico, the data are not as dependable. Once the Mexican Civil War, the Great War and its posterior global inflationary period ended. From there, one can split the sample according to some important events related to what happened in the United States. The first subsample ended in 1939; the second went from 1940 to 1983; the third went from 1984 to 2019, and the fourth went from 2020 to 2024.

This period has striking yet expected, in a price level determination regime, features in the behavior of the price levels of the three countries. This behavior exemplifies well some aspects discussed about permanent and temporary shocks. One can also see how the correlations change when one of the countries moves from one monetary regime to another.

During most of this time, the three price levels were closely related, yet Mexico's began to drift apart since the mid-1930s, as Figure 5 shows. The lines would not show a correlation until the mid-fifties. Thus, three questions arise: why were they related? What was the permanent driving factor of the price levels? Why did Mexico's price level dissociate itself from the others?

The answer to the first question comes by noticing that the gold standard was still in place, and most countries had similar trajectories for their price levels (see Garcés Díaz, 2023). Inflation during the post-war period was global because of the fixed exchange rates imposed by the gold standard. It is important to emphasize that this differs significantly from what happened in other later episodes, for example, during the pandemic. In the latter episode, the exchange rates were floating, and there is no clear evidence that PPP was holding in these years. The big inflation episode following the First World War (WW1) was difficult to observe in Mexico as its civil armed conflict ended, and price data collection stopped for several years.

However, since 1920, the data show that the three price indexes followed similar paths, but only until 1934 did the Mexican one start rising much faster. The reason was the three countries' abandonment of the gold standard by 1933.[4] Mexico began since then a period of a periodically fixed exchange rate subject to several devaluations. Canada had periods when its exchange rate was devaluated, only to recover its previous level after some years.

Now, what was the cause of the shared deflation among these economies? It was part of the global phenomenon that followed the end of WW2, such as the military demobilization, the Spanish Flu of 1918-1920, the recession of 2020-2021, and the Great Depression from 1929 to the beginning of WW2. However, the region's connection with other parts of the world, particularly Europe, was evident.

There are two options here to analyze the impact of world inflation on the U.S. One is to use the U.K. price level as the reference, and the other is to use the first component of the rates of inflation of developed countries for that period. The exercise follows the first option for the following reasons.

The U.K. was one of the world's financial and economic centers, along with France and an emerging United States, and it was the gravitation center of the movements of the price level during the gold standard. The first principal components of a group of advanced economies, including or excluding the United States, are almost identical. Thus, it appears that anything that the U.S.

[4]Canada, as Great Britain, abandoned the gold standard at the beginning of WW1, adopted it again in 1926, and finally gave it up in 1929. However, it maintained a fixed exchange rate with the U.S. dollar. Mexico adopted the gold standard in 1905 and abandoned it in 1931. The United States did it in 1933.

price level contributed was already in those other countries' data.[5] The first component of that group of countries has the highest correlation (or, in technical jargon, loading) with U.K. inflation. So, the U.K. appears to have been the leading country in determining world inflation. Finally, the aforementioned first component does not have a trend, so the U.K. price level allows a more interesting analysis that will also be a reference for future episodes.

The sequence of causation in North America from 1870 to 1937 was: Great Britain's price level Granger-caused that of the United States, and this, in turn, Granger-caused the price level of both Canada and Mexico. This one-way causality might have changed during the years of the Great Depression as the economic turmoil started within the U.S.

The following three autoregressive distributed lags (ARDL) econometric models confirm each North American price level's direct driving force. Between 1870 and 1937, the U.S. price level depended on the U.K. price level; the U.S. price level explains the Canadian price level. These are cointegration relationships. For the Mexican price level, the sample with the comovements is too short (1920-1934), but a price level ARDL regression was still possible.

It is useful to remember that the long-run solution in a conditional error correction of an ARDL model form is obtained by dividing the levels of the lagged variables by the coefficient of the first lag of the level of the dependent variable. For example, in the equation below, the coefficients for p^{us}_{t-1} and p^{uk}_{t-1}, which are -0.12 and 0.12, respectively, are divided by -0.12, from which the normalized long-run coefficients are (1,-1). This pair of values is the cointegration vector.

The application of the ARDL bounds tests used below has some requirements. First, the right-hand side variable is weakly exogenous and has no feedback from the dependent variable. Second, the tests can handle relationships in levels with I(0) and I(1) variables,[6] which entail different statistical significance thresholds. However, this does not extend to the dependent variable in the conditional error correction representation, which must be I(0). Third, valid relationships must pass the F and t bounds tests together. Fourth, it is essential to be aware of the degenerate cases, for example, when the first lag of the level of the dependent variable does not appear in the right-hand side variables.

[5] These countries are Australia, Belgium, Canada, Switzerland, Finland, France, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

[6] A series is integrated to order d, or I(d), if it must be differenced d times before an I(0) series results (Davidson and MacKinnon, 2004).

5.1 An Econometric Model for the U.S. 1870-1939

The quantitative theory of money is the dominant framework for interpreting U.S. inflation before WW2, as evidenced by the seminal works of Friedman and Schwartz (1964) and Cagan (1965). Within such a theoretical approach, money in excess of economic activity is regarded as the cause of inflation, and a stable money demand is the way to determine the price level. The latter author, however, leaves open the possibility of a causality from prices to money or bidirectional.[7]

Price Level Determination for the U.S. 1871-1939.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (i)

$$\Delta p_t^{us} = -0.12 p_{t-1}^{us} + 0.12 p_{t-1}^{uk} + 0.22 \Delta p_{t-1}^{us} + 0.40 \Delta p_t^{uk} + 0.28 \Delta bm_t^{us} - 0.10 d_{1921}$$

s.e. (0.04) (0.32) (0.08) (0.08) (0.06) (0.03)

JarqueB = 2.16 FB-Stat. = 8.16^{**} tB-Stat. = -3.06^{*}

$\hat{R}^2 = 0.81$ F-Autoc. = 1.83 BPG-Het. = 1.19

Source: Own elaboration with data from Jordà et al. (2017).

Variables in logs. Superscript "us" means United States and "uk" United Kingdom.

s.e. = standard errors. F.B. = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc.= ARCH(2) L.M. test. BPG-Het. = Breusch et al. heteroskedasticity test.

* and ** indicate significant at 10% and 5%, respectively, for I(1) variables.

While the equation presented above will be addressed in more detail later, it's crucial to emphasize that it doesn't aim to refute existing approaches. Instead, it should be viewed as a simplified representation of the U.S. price level, primarily as a foundation for analyzing the transmission of nominal shocks across diverse countries and monetary regimes throughout history. While it may not achieve perfect accuracy for the entire subsample, as we will discuss later, it provides a valuable framework for comprehending these complex dynamics.

[7] "The higher correlation between money and prices might be consistent with the opposite direction of influence, from prices to money, if prices affected most of the determinants in a positive direction. The higher correlation between money and prices might then reflect a combination of the price effects on each determinant.," p.238

The equation includes an impulse dummy variable for 1921 to make the residuals normally distributed. Notice first that there was a one-to-one relationship in levels between the U.S. and the U.K. price levels. As the causality was running from the second to the first with coefficients (1,-1), as a Wald test does not reject such restriction, there was no room for another permanent inflationary shock, not even from the money supply.

The rate of change of broad money was included as another regressor and was statistically significant. However, as it is a rate of change, it cannot be a permanent inflationary shock; it is only a temporary one, as explained before. The effect of a money shock would be erased after some time, remaining only the shock represented by the U.K. price level, which most likely reflected a global factor. Although the U.S. had a substantial weight in the global economy by then, if U.S. domestic factors, such as the money supply, were determining domestic inflation, then they alone would have been determining inflation for every other advanced economy, which seems unlikely. More on this below.

The output gap, the cyclical component of the logarithm of GDP obtained by a Hodrick-Prescott filter, both contemporary and lagged, was also tried as a stationary regressor, but it was nonsignificant. The same occurred with the rate of growth of real GDP.

Unfortunately, the equation did not survive beyond a few years after 1939 as domestic factors were becoming more relevant than global ones for the U.S. economy. However, as shown in Garcés Díaz (2023), the connection of the inflation rates among advanced economies has been long-lasting, and this was also at play during the pandemic inflation. After WW2, as the U.S. economy seems to have transitioned to a regime of inflation rate determination, obtaining a satisfactory stable model becomes quite challenging, as will be seen later.

5.2 An econometric Model for Canada 1870-1939

The next equation explains Canada's price level as a function of the U.S. price level. Contrary to the one for the U.S. price level depending on the U.K. price level, this relationship survives across many decades up to 2023, although with some changes, as could be expected from Figure 3. The equation is even simpler and does not support Canadian money shocks even as a temporary inflation factor.

Price Level Determination for Canada 1871-1939.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (ii)

$$\Delta p_t^{ca} = 0.01 - 0.17\, p_{t-1}^{ca} + 0.16\, p_{t-1}^{us} + 0.97 \Delta\, p_t^{us}$$

s.e. (0.03) (0.04) (0.05) (0.08)

JarqueB $= 4.53$ FB-Stat. $= 7.71^{**}$ tB-Stat. $= -3.7^{**}$

$\hat{R}^2 = 0.72$ F-Autoc. $= 0.25$ BPG-Het. $= 2.00$

Source: Own elaboration with data from Jordà et al. (2017).

Variables in logs. Superscript "us" means United States and "ca" Canada.

s.e. = standard errors. F.B. = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc.= ARCH(2) L.M. test. BPG-Het. = Breusch et al. heteroskedasticity test.

* and ** indicate significant at 10% and 5%, respectively, for I(1) variables.

The F and t bounds tests cannot reject the existence of a price level relationship between the price levels of Canada and the United States, with the latter being the weakly exogenous variable. An equation with switched places does not work. The coefficients for the lagged price levels are close to the form of the vector (1,-1), leaving no room for other variables with permanent effects. The transmission of shocks is high-speed, as seen from the impact of contemporary U.S. inflation (coefficient of 0.97).

5.3 An econometric Model for Mexico 1920-1934

For Mexico, the absence of data for the years 1914-1917 and the faster growth of its price level since 1935 prevents the estimation of an equation of the same sample size as the ones for the U.S. and Canada. Still, the speed of adjustment is fast enough to allow the validity of the regression. The result seems compelling.

Price Level Determination for Mexico 1920-1934.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (iii)

$$\Delta p_t^{mx} = -5.14 - 0.63\, p_{t-1}^{mx} + 0.39\, p_{t-1}^{us} + 0.83\Delta\, p_t^{us} + 0.34\Delta\, p_{t-1}^{us}$$

s.e. (1.77) (0.19) (0.22) (0.18) (0.20)

JarqueB = 2.36 FB-Stat. = 7.08** tB-Stat. = −3.29**

$\hat{R}^2 = 0.80$ F-Autoc. = 1.47 $BPG - Het. = 0.16$

Source: Own elaboration with data from Jordà et al. (2017) and Inegi.

Variables in logs. Superscript "us" means United States and "mx" Mexico.

s.e. = standard errors. F.B. = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc.= ARCH(2) L.M. test. BPG-Het. = Breusch et al. heteroskedasticity test.

* and ** indicate significant at 10% and 5%, respectively, for I(1) variables.

These equations show a price level target regime where only one permanent type of shock is present. Also, notice that money, contrary to what a monetarist view would sustain, has only a temporary effect on inflation in the United States and no impact in Canada. This type of equation will reappear later in more modern settings, particularly in the euro area and Mexico during the pandemic, although with a fundamental difference discussed later.

Finally, notice that Mexico's price level began drifting away from the other two countries', mostly because of a monetary expansion used to finance some reforms. This characteristic would become a recurrent inflationary factor for several decades to come.

Thus, for about the first third of the XX century, the price levels of the three North American Countries followed the same trend, but this would not last after the demonetization of gold, the Great Depression, and the beginning of WW2. However, unexpectedly, that relationship would come back many decades later under unusual circumstances.

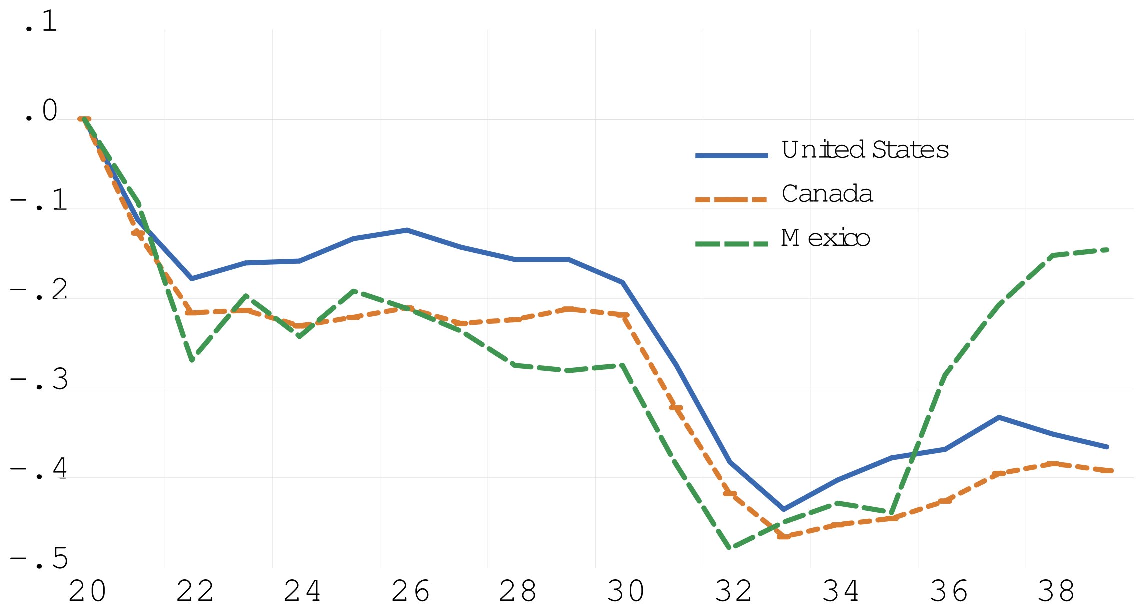

Figure 5: Log Price Levels of North American Countries 1920-1939 ($Index_{1920}$=1). Source: Jordá et al. (2017) and Inegi.

5.4 The End of Price Level Determination

Now, it becomes useful to look at the three countries' inflation history within the framework of monetary regimes in Section 2. However, the case of Mexico is very complex and requires a lot of space to present it. The reader is therefore referred to Garcés Díaz (2017) where the analysis of Mexico's inflationary process through different regimes goes from 1932 to 2013. From 2014 to 2019, there were changes in the regime; the only part missing in that article is the pandemic episode covered in this document. Canada's inflation behavior is just too similar to that of the U.S., as shown above, so most of the paper will be about the U.S. until before the pandemic.

The United States, like the rest of the developed economies, abandoned price level determination through the gold standard in 1940 and began to determine its inflation rate in the sense that there was one-to-one growth with any particular driver. Nonetheless, it still had monetary regime modifications involving a change in the monetary policy instrument. Thus, the period is, in turn, split into three parts: 1940-1983, 1984-2019, and 2020 to 2023.

6 Inflation Rate Determination in the United States After WW2 1940-1983

Despite the good econometric properties of Model (i), this might not be entirely correct because, after WW1, the U.S. became the world's leading economy and probably became less dependent on world monetary conditions, although not completely independent. The dependence on money in the U.S. on international conditions until the aftermath of WW1 was stressed by Friedman and Schwartz (1964). They also pointed out that, from 1919 to 1933, the money supply was also influenced by the Federal Reserve's monetary management (Bordo, 2003). Since 1934, gold became a commodity whose price was fixed through an official support program. These changes in U.S. monetary policy are reflected in the dynamics of the relationship between the price levels of the U.S. and the U.K. that must be considered.

Table 1 shows the Toda and Yamamoto (1995) test of Granger causality for nonstationary variables. This method adds an extra lag for the order of integration of the variables and performs the usual Wald test for Granger causality using only the lags in the original specification. Most information criteria suggested two or three lags, so there is one test for each lag number. Several subperiods are tested. The first is 1870-1920, the second is 1870-1939, the third is 1940-1983, and the fourth is 1984-2022.

Table 1: Granger Causality Tests for U.K. and U.S. Price Levels by Subsample

Excluded	1870-1920		1870-1939		1940-1983		1984-2022	
Variable	2Lags	3Lags	2Lags	3Lags	2Lags	3Lags	2Lags	3Lags
U.K. CPI	0.34	0.06	0.03	0.02	0.13	0.03	0.88	0.97
U.S. CPI	0.00	0.00	0.00	0.00	0.13	0.13	0.69	0.33

Variables in natural logarithms.

p-values of Chi-square statistics.

Source: Own elaboration with data from Jordà et al. (2017) and IMF.

The Granger causality tests with two and three lags for 1870-1920 support the notion that causality ran from the U.K. to the U.S.. An ARDL for this period has a more robust inference to justify the relationship in levels between these two variables than Model (i). According to the tests, such a model might not be completely valid after 1920 because the Granger causality is bi-directional. However, an ARDL model with the U.K. price level as the dependent variable, not shown here, is firmly rejected, so Model (i) remains the best, albeit imperfect, option to represent that relationship. A VECM estimation alternative would be invalid as the feedback parameters are not constant, which is why a shifting long-run Granger causality exists. For the same reason, a standard VAR analysis with orthogonalized shocks that does not preserve the weak exogenity properties (i.e., long-run Granger causality) would also be invalid.[8]

For the period 1940-1983,[9] there is a contradiction between the two and three lags specifications as the first specification rejects causality in either direction. In contrast, the second indicates causality running from the U.S. price level to the U.K. price level, which would be consistent with the consolidation of the U.S. as the main economy in the world. The main point here is that for this period the U.K. price level does not seem to be Granger-causing that of the U.S. Finally, for the period 1984-2022, the tests strongly reject Granger causality in either direction.

Of course, the absence of clear Granger causality with annual data does not preclude the correlation of both the price levels and the inflation rates of both countries, as can be inferred from Figure 6.

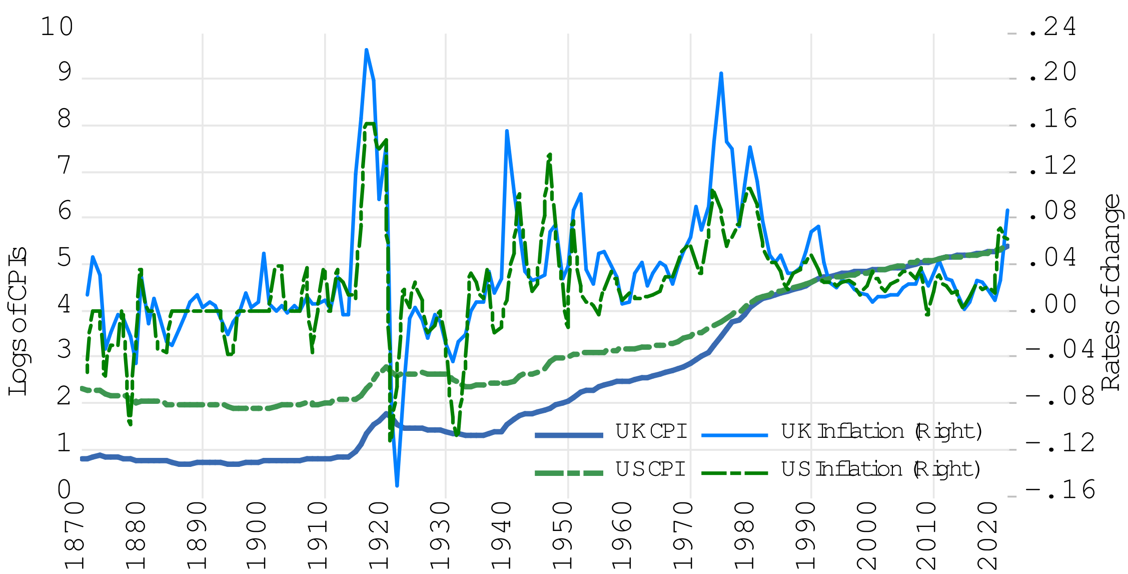

Figure 6: U.S. and U.K. Price Levels and Rates of Inflation. Source: Own elaboration with data from Jordà et al. (2017) and IMF.

[8]See Ericsson et al. (1998).

[9]1984 is taken as the beginning of the substitution of monetary aggregates for a policy interest rate as the conventional instrument of monetary policy in the U.S. It is also the beginning of the "Great Moderation" period.

Figure 6 conveys an important point. Despite the regime changes that could have occurred in both the U.K. and the U.S., there is a strong connection between their nominal sectors. This suggests that either the two economies face similar shocks or that domestic monetary policy cannot be the only determinant of the behavior of inflation in every country. Garcés Díaz (2023) finds a significant correlation between Western developed economies' inflation rates across many decades. Thus, given the similar economic conditions following both the Great Financial Crisis and the pandemic, it's unsurprising that developed economies experienced similar inflation rates.

As the U.S. became the undisputed leading economy in the world since 1940, there could be a possibility that its rate of inflation was determined solely by its monetary policy. It is also possible that it interacts with other economies in such a way that is not captured by typical monetarist or Phillips curve models that assume that U.S. inflation behaves as that to a near-closed economy.[10]

As mentioned before, obtaining a satisfactory model for an economy under inflation rate determination is hard. For example, it is well-known that there have been extended periods of much lower or much higher inflation from the seventies to the present than that projected by professional forecasters and the Federal Reserve. Although there must be much better models than the one following, it might be interesting to show which variables can at least help or not to beat simple univariate statistical models, which is the simplest and most used benchmark to evaluate a forecasting model.

For the period 1940-1983, another dynamic model for the price levels is not possible, [11] although nothing prevents the existence of a model in rates of change. As there might be many possible models when the monetary regime determines the inflation rate instead of the price level, the selection depends on the forecasting performance relative to an AR(4) model, the best univariate model for this period. This time, the equations for the models are omitted, and a more informative graphical display of the relative performance is shown instead.

The dynamic explanatory variables (i.e., those that are allowed to have lags in the ARDL model selection process) are the rate of change of "excess money," the logarithmic difference of the ratio M/GDP, $\Delta(m^{us} - gdp^{us})_t$, and the first principal component obtained from the correlation matrix

[10] "The U.S. is often analyzed as a closed economy" (Bullard, 2012).

[11] This is not to say that the price levels are not correlated, but then one would have to use the concept of spectral coherence as in Benati (2021). When the spectral coherence between two variables at the zero frequency equals one, cointegration and a model like those above can be obtained.

of the inflation rates of the group of countries listed in footnote 5 except Canada. Interestingly, the first principal component, including the U.S. and Canada, is almost identical, capturing a common factor among developed economies. The output gap, defined as the cyclical component from a Hodrick-Prescott filter, is the only fixed regressor tried with 0 and 1 lags. Also, broad money (M2) and narrow money (M1) were used alternatively as the monetary aggregate. M1 gave the best results for this period. The training sample was 1940-1975, and the out-of-sample evaluation period was 1976-1983.

Although oil prices were important in headline inflation during the seventies and early eighties, they were frozen during WW1 and with little movement before 1973, which is most of the training sample. Thus, they are omitted. Nonetheless, it might not matter much in any case for trend inflation because the importance of oil during this period is based on a strong correlation for about a decade from 1973 to 1983, which is regarded as "an anomaly" and its coefficients in regression equations, although statistically significant, "are not economically significant."[12]

The forecasts are dynamic and without re-estimation. In Figure 7, the variables for each forecast are listed in the labels between parenthesis, and the root mean square error (rmse) is shown next.

For this period, the AR(4) model does a poor job (Forecast "$AR(4)$" rmse = 8.4) in forecasting, as the surge of inflation was impossible to capture based only on its past behavior. The second forecast includes the lags and contemporary value of the rate of change of excess money (Forecast "$m - gdp$"). It strongly improves the forecasting performance, lowering the rmse to 4.7, making it a valid inflation factor for this period. However, the best specification also includes the first principal component described above. This forecast, "$m - gdp$, pc", has a much better rise of just 1.6, which shows how good the international inflationary factor is in explaining U.S. inflation. Finally, the first lag of the output gap was added (Forecast "$m - gdp$, pc, $outp.gap$"), hoping for a better forecast. This model, however, worsens the performance, increasing the rmse to 2.2 despite the output being statistically significant, although just barely. Other models have used alternative economic slack variables, for example, the unemployment gap, as in Gordon (2013).

Despite the good performance, there are caveats. First, although the international inflation first component convincingly helps predict U.S. inflation, there is a problem of "data leakage," in that such variable would have to be predicted, which is not easy. Nonetheless, the point of paying

[12]See Tootell (2011), p. 4.

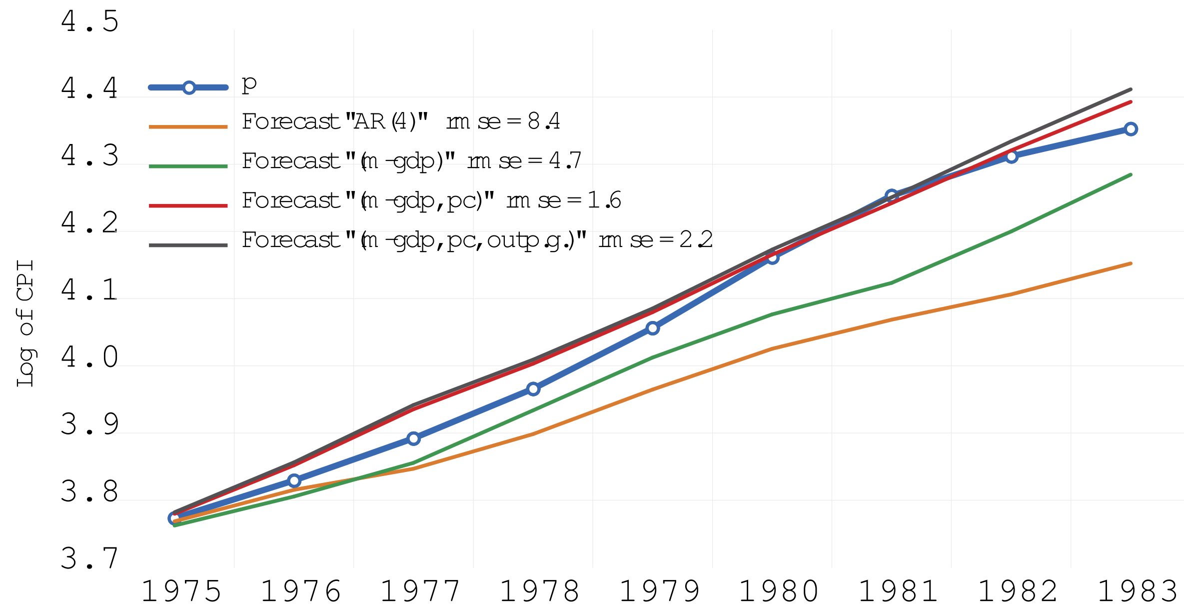

Figure 7: Out-of-sample Dynamic Forecast 1976-1983 for the U.S. Price level. Training Sample 1940-1975 Without Re-estimation ($m - gdp$= excess money, pc = first principal component, $rmse$ = root mean square error. Source: Own elaboration with data from Jordá et al. (2017).

attention to international factors in at least the same level as national ones is highlighted. Second, the forecasting performance is still not completely satisfactory as from 1976 to 1980 the forecasts is well above the actual price level and it does it again at the end. The model is no way a solution for the “Great Inflation.”

7 Inflation Rate Determination in the United States 1984-2019

Although the inflation rate determination regime continued after 1983, several authors detected some crucial changes in the monetary regime. First, money and inflation weakened their correlation (Lucas and Nicolini, 2015, and Benati, 2021). Also, money lost its role in the conduction of monetary policy (Bernanke, 2006), and the Great Moderation was starting (Bernanke, 2004). Other authors found that the Phillips curve became flat during this period, so they had to resort to very disaggregated data by states to capture a relatively small slope (Hazell et al., 2022). Thus, it became even more challenging to find a suitable inflation model for the United States. This paper contains no pretension of having found one. A remarkable acknowledgement is in Ball and Mazumder (2019) summarizes the situation:

> "Unfortunately, researchers have repeatedly needed to modify the Phillips curve to fit new data... Each modification helped explain past data, but, as Stock and Watson (2010) observe, the history of the Phillips curve "is one of apparently stable relationships falling apart upon publication." Ball and Mazumder (2011) is a poignant example...Nonetheless, because of the practical importance of the Phillips curve, researchers must continue to search for better specifications."

This paper does not attempt to pursue such an endeavor, which is not a trivial matter anywhere, even if it can ever be accomplished[13] One should ask if it is worth chasing it or trying something else. The paper uses historical evidence to identify the most likely reasons behind the pandemic inflation. It does this by first acknowledging that, within an inflation rate determination regime, finding systematic factors is hard. Then, it shows that the evidence for some presumed inflation factors from the past is sometimes based on a one-shot phenomenon. At the same time, it stresses the importance of a variable that, during the previous regimes, appears very useful for the statistical adequacy of the model and even out-of-sample forecasts.

The use of external drivers of inflation is widely spread in the design of inflation models,[14]. The first component, such as the one above, approximates foreign inflation.

The strategy is the same as in the previous section. Some models for the inflation rate are obtained using several possible factors of inflation. Although the preferred model is more parsimonious this time, the results will also be presented with a chart with the out-of-sample forecasting performance. The comparison base is with an AR(1) model, which is a low standard, but it is often a starting point.

As in the previous section, the forecasts are dynamic and without re-estimation. Similarly, in Figure 8, the variables for each estimate are listed in the labels between parenthesis, and the root mean square error, rmse, is shown next. This time, the training sample is 1984-2015. The evaluation sample is 2016-2022. There are three models to compare. The starting model is an AR(1), the second is augmented by the principal component of advanced economies inflation rates. The third includes the cyclical component of the logarithm of GDP obtained with a Hodrick-Prescott filter.

[13]See, for instance, Bańbura and Bobeica (2020).

[14]Examples include exchange rates, international output gap, and foreign inflation.

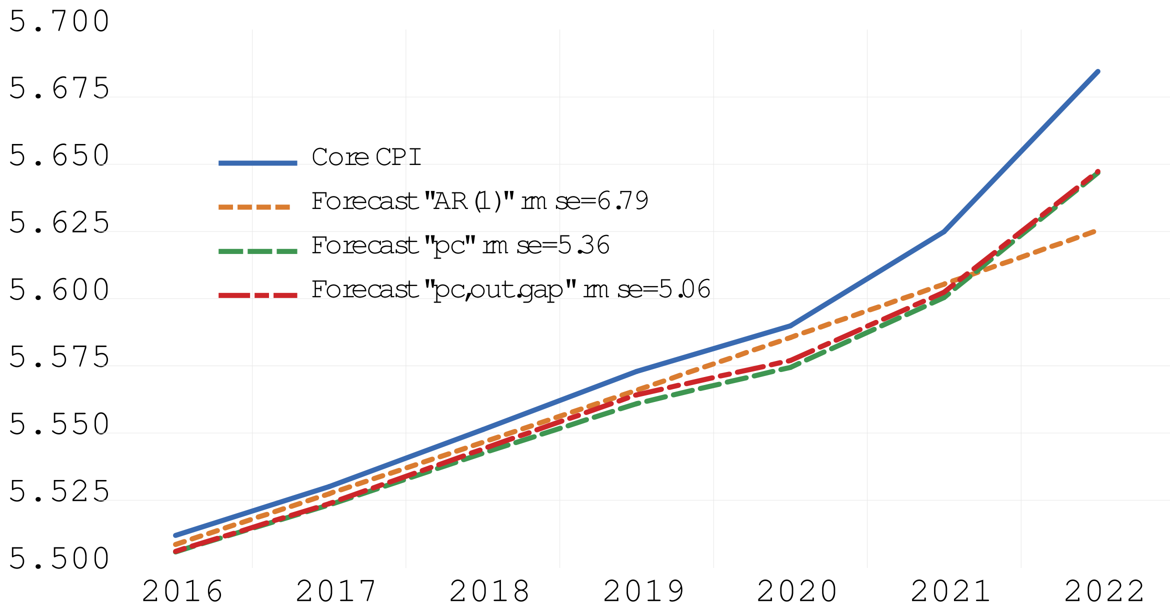

Figure 8: Out-of-sample Dynamic Forecast 2016-2022 for the U.S. Core CPI. Training Sample 1984-2015 Without Re-estimation (*pc* = first principal component, *out.gap* = output gap, *rmse* = root mean square error. Source: Own elaboration with data from Jordá et al. (2017), BEA and BLS.

After the Great Financial Crisis, the U.S. entered a period of stubbornly low core inflation despite an extended economic recovery and low unemployment rates. On the other hand, headline inflation had occasional bursts due to commodity prices that fizzled out quickly. Because of this, many models failed to forecast correctly.

Unlike the previous regime, the AR(1) model became competitive. Its forecast stays below but relatively close to the actual core CPI index. On the contrary, the model with the principal component forecasts much worse until 2019, but then it compensates since 2020, mimicking the core CPI's change of trend but still subestimating it. Adding the output gap improves the performance marginally, obtaining the best rmse.

Other variables tried in the models were the percentage changes of the wage tracker and the rate of change in fuel commodities' price index. None of these variables was significant.

For headline inflation, the number of significant explanatory variables with significant coefficients was more extensive, with all the variables mentioned in the previous paragraph being important. Nonetheless, the strongest regressor was again the first principal component.

8 The Pandemic Inflation-disinflation Period in the U.S. and Other Economies 2020-2023

The low inflation years in the U.S. and most advanced economies ended unexpectedly and were seen by many as a fluke. The return of high-one-digit inflation was initially taken by many observers, including the Federal Reserve, without much apprehension. That institution had recently changed its policy framework in favor of a not-so-clearly defined average inflation targeting regime. In such a novel approach to monetary policy, the central bank intended to compensate for the failures to reach the inflation target from below to promote higher levels of employment (Powell, 2020). This framework was the closest to adopting price level targeting a central bank has ever been. Yet, without a specific time horizon to calculate the average, it was hard to say how different it was. This posture was probably a reason for not responding swiftly to the inflation surge, as the Fed was compensating for a long period of undershooting its inflation target. Many economists, famously Paul Krugman, also considered inflation transitory as its causes were unclear.[15]

The bad performance of inflation models was already noticeable since the Great Financial Crisis, and, as the references above show, researchers were still coping with it when the new phenomenon struck. As the pandemic was ongoing, the speeding up of inflation since 2021 caught most people by surprise and led to heated debates about its origin. Among the proposed causes were the following:

- Increase in food and energy prices due to the war in Ukraine.
- Money supply expansion.
- Global supply chain disruptions.
- Fiscal expansion.
- Changes in demand patterns from services to merchandise.
- Low interest rates.
- Shortage of materials.
- Tight labor markets leading to rising wages.

[15] "I was Wrong About Inflation," The New York Times, July 21st, 2022.

- Changes in corporate pricing behavior (mocked as "greedflation").
- A combination of stimuli to aggregate demand while there was a supply contraction.
- Excessive fiscal stimuli that caused a large output gap.
- Drought in agriculture.
- Exchange rate depreciation.

These are reasonable factors, but that does not make them the explanation of the pandemic inflation. The experiences of previous episodes do not back some of them. There is no consensus on what happened during the pandemic inflation-disinflation, so the strategy here is to try some of these presumed factors.

This section focuses primarily on the original core component, the commonly used measure that excludes volatile food and energy prices. Several other alternative "core" definitions exist.[16] Some of the above causes, such as increases in commodity prices, are very likely certain for the noncore components. This effect on the noncore component is a phenomenon observed in the past and is not generally controversial. For example, gasoline prices follow very closely those of crude oil.[17] The only real question is, in any case, whether there was or not a spillover to the core component, which, at least in the United States, has been rare. See Conflitti and Lucianni (2017) for a literature review that concludes that the pass-through from oil prices into core inflation ranges from tiny to zero. Nonetheless, some authors claim that during the pandemic inflation, there was an impact from headline to core components.[18] Figure 9 shows the annual rate of variation of the CPI, core CPI, and the prices of Brent oil and regular gas.

Several things are worth noticing. One is the evident comovement of crude oil prices with the price of gasoline and headline CPI. Meanwhile, there is no such relationship with core CPI. The second is that since 2020, there has been a separation of the behavior of headline CPI and the price of crude oil. A third feature of this period is that core inflation reached higher levels than

[16] Some of these measures are reported in the Atlanta Fed page. The "weighted median inflation" was deemed a better measure of core inflation by Ball et al. (2022). Other measures are the "structural core" proposed by Morana (2023) and the "instantaneous inflation" by Eeckhout (2023).)

[17] From 1988 to 2023, The correlations of the annual growth rates of the price of a barrel of Brent oil with the price of a gallon of U.S. regular gas, the headline CPI, and the core CPI are 0.93, 0.61, and 0.02, respectively.

[18] As in Ball et al., 2022

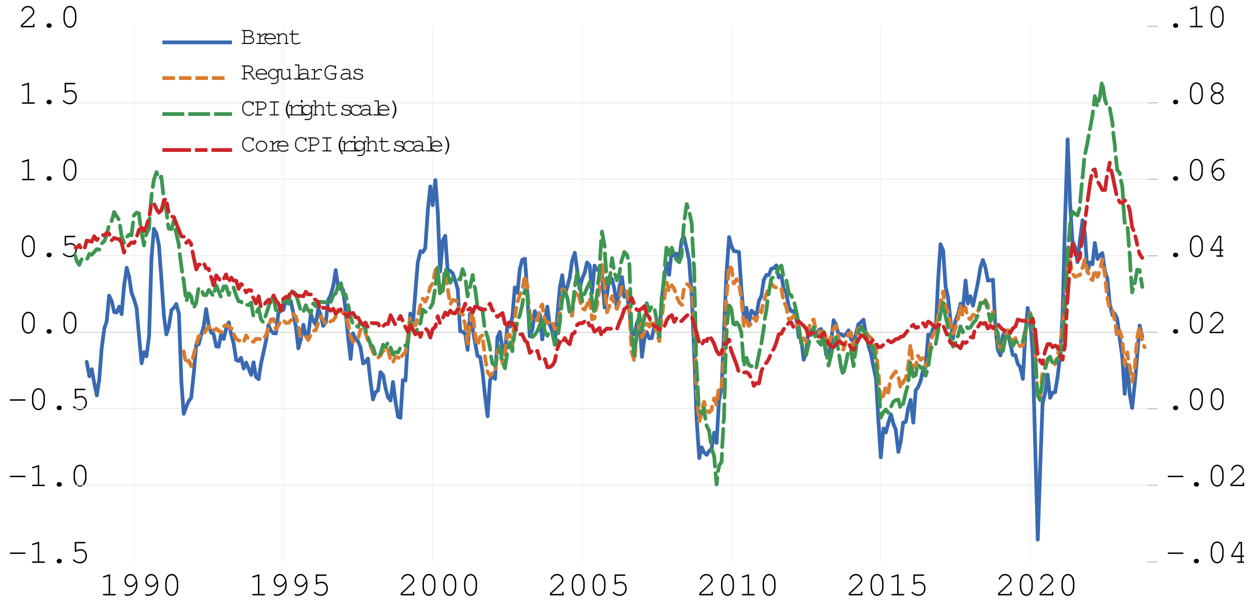

Figure 9: Annual Variations of Brent Crude Oil Price, Gasoline Price, Headline CPI and Core CPI. Source: Own elaboration with data from FRED and BLS.

the headline because some of its components had substantial and persistent increases. This fact led many economists to distrust the usual definition of core inflation as the best indicator of the medium-term trend of price increases.

The second factor in the list, money, was immediately greeted as one of the likeliest causes because of its hefty role in monetary theory. However, a previous section pointed out that money has not had a central role in the behavior of inflation since at least the early 1980s (Bernanke, 2006). Also, models of inflation based on monetary aggregates nowadays are rare compared to those based on the Phillips curve. In any case, it is worth exploring.

Money's presence as a cause of inflation could occur because there was regime change, giving this time a role to money as a systematic factor or as a one-time shock. Both seem unlikely within a quantitative theory framework unless more inflation to match the growth of M2 was in store for the U.S. economy. Borio et al. (2023) classify monetary regimes according to their level of inflation. There is a 1-to-1 relation in the high-inflation regime, but it is nil in the low-inflation regime. This idea is common, but it has several shortcomings as it invalidates the other argument in favor of the quantitative theory of money: that in the long run, there is a 1-to-1 relationship (Benati, 2021).

However, this does not preclude money from being one or "the one" driver of inflation during the pandemic, and that paper finds that it helps to predict inflation. The argument in favor is that there was a strong increase in money derived from the fiscal response to the pandemic a little earlier than inflation. Figure 10 shows the logarithms of the velocity of circulation for both M1 and M2, which would be an error correction term in an inflation model where the quantitative equation of money was stationary.[19]

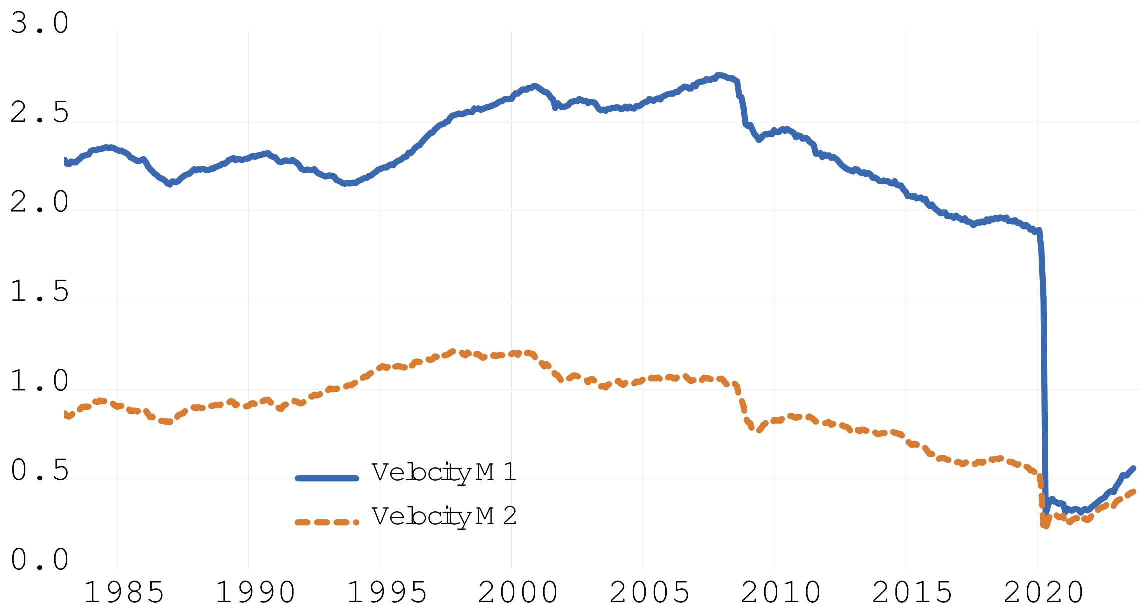

Figure 10: Velocity of Circulation of M1 and M2 (logs). Source: Own elaboration with data from FRED and BLS.

The chart shows a big jump downward in the velocity of either version of the money supply in May 2020 after the start of the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) of March 2020.[20] Much of this stimulus was in the form of cash to individuals and firms, which would be the definition of "helicopter money," that, in the quantitative theory, should cause inflation. Inflation began to increase steadily after the jump in the monetary aggregates, so it was natural to think that money was responsible for that. Moreover, the posterior smooth curve upward at the sample's end coincides with the inflation decline. However, different functions of monetary aggregates fail to be significant explanatory variables in any of the models tried. A possibility is

[19]See Garcés Díaz with a working empirical example of such an equation.
[20]This initiative allocated 2.2 trillion dollars as economic stimulus or about 10 percent of GDP.

that other variables reflected the fiscal stimulus in a better way.

The fiscal stimulus that led to such monetary expansion was unprecedented, and it is hard to think that inflation would have been as rampant without it. It appears to have been used to pay debt, increase wealth, and finance the purchase of goods, whose supply was suffering the ravages of production bottlenecks. Thus, a possibility to capture this impact is the real price of cars, which sharply reversed its historical downward trend after the stimulus started. This variable is also used by Ball et al. (2022), from where it was inspired, although the interpretations might differ. It is noticeable that the behavior of the prices of cars was different in the euro area, where the real prices of cars remained without significant changes. At the same time, they skyrocketed in the U.S. (Figure 11). This contrast could be related to the different sizes of the fiscal stimulus and how they were applied in each economy. For example, in the U.S., there were direct cash transfers to individuals, while in the euro area, there were subsidies to preserve job positions.

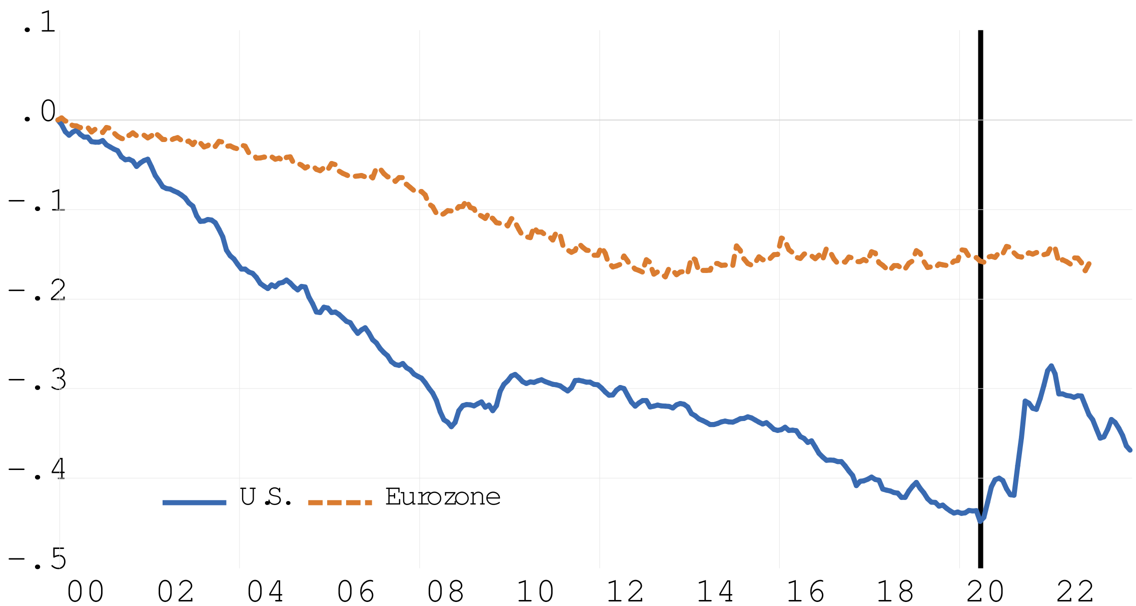

Figure 11: Real Price of Cars (logs) in the U.S. and the euro area($Index_{99:01} = 1$). Source: Own elaboration with data from FRED and BLS.

Even though many inflation models start with giving the central role as an explanatory variable to some measure of spare capacity, that approach has yet to solve stability problems.[21] Instead, in

[21]See Hazell et al. (2022), Ball et al. (2022), and Castle and Hendry (2023). The latter claim to have found the

the model here, several potential factors are tested as explanatory variables of core inflation. This time, however, one spare capacity variable, the ratio of unemployed workers to vacancies, is a valid driver of inflation.

Other variables included are the first principal component of inflation in the countries in the euro area as a measure of international inflationary pressures, also seen in previous regimes. Another was Markit's backlogs component, also suggested by the model in Ball et al. (2022). As for some of the explanatory variables, there is the possibility of a correlation with the error term; the estimation method is two-stage least squares. The variables potentially correlated with the error term are the Persistent and Common Component of Inflation (PCCI) of the euro areaCPIs of 12 countries, $\Delta ezpc_t$, as there is a strong comovement of such indexes with U.S. CPI. The other one is the rate of growth of the real price of cars, defined as the ratio of the consumer price index for cars divided by the headline CPI. Orthogonality tests on these variables did not reject them as valid instruments. The last variables included are the Markit backlog index, $bklg_t$, and the ratio of unemployed workers to open vacancies, $vm2_{t-1}$,

reason for that instability in the U.K., but there is no similar statement regarding the U.S.

Core Inflation Rate Determination in the U.S. 2020-2023.

Two Stage Least Squares estimation with instruments: $\Delta u2v_t$, $ezpc_{t-1}$, $\Delta ezpc_{t-2}$, $bklg_t$, $\Delta pcar_t$, $vm2_{t-1}$, $\Delta pcore^{us}_{t-1}$, $\Delta pcore^{us}_{t-2}$, C

Model (iv)

$$\Delta pcore^{us}_t = -0.64 + -0.09\,\Delta u2v_t + 0.15\;ezpc_t + 0.01\;bklg_t + 0.10\;\Delta pcar_t \ldots$$

s.e. (0.02) (0.22) (0.26) (0.26) (0.26)

$$+0.27\Delta pcore^{us}_{t-1} - 0.30 pcore^{us}_{t-2}$$

s.e. (0.02) (0.26)

JarqueB = 2.34 J-Stat = 0.69 P(J-Stat) = 0.70

$\hat{R}^2 = 0.86$ F-Autoc. = 0.81 BPG-Het. = 0.30

Source: Own elaboration with data from BLS, Eurostat and Markit.

Variables in logs. Superscript "us" means United States. *pcore* = core cpi; $u2v$ = unemployed to vacancies ratio; *ezpc* = first principal component of euro areaCPIs; *bklg*= Markit backlogs index; *pcar*=cars CPI to total CPI component; $vm2$=velocity of circulation of M2; C=constant.

s.e. = standard errors. J-Stat = Hansen J Statistic. P(J-Stat) = p-value of J Statistic. F-Autoc.= ARCH(2) LM test. BPG-Het. = Breusch et al. heteroskedasticity test.

The corresponding variables are seasonally adjusted. The signs of the estimated coefficients are the ones expected and highly significant. Some other variables tried as explanatory were nonsignificant and thus deleted. Two variables that did not show a statistically significant coefficient were the circulation velocity of M2 and the variation of nominal wages (measured by the wage tracker constructed by the Atlanta Fed).

The first thing to notice is that the coefficients of the autoregressive terms nearly cancel one another, so the long-run impact of the other explanatory variables is almost the same as the one displayed. The variable with the most significant coefficient is the Persistent and Common Component of Inflation (PCCI) for the euro area, $ezpc_t$, interpreted as a measure of international inflationary pressures. A percentage point increase in such variable raises by 0.15 percentage points raise U.S. core inflation. There was a concern about the endogenity of this variable as is constructed with the inflation rates of other countries that tend to follow that of the United States. Therefore, it was instrumented by two of its lags. Both the instrumental orthogonality C-test and the J-test for overidentifying restrictions did not reject the hypothesis this was a valid instrument.

Backlogs were a consequence of the production chain disruption triggered by the pandemic. The Markit index, $bklg_t$, represents these. An increase of one point increases core inflation by 0.01 percentage points.

The third variable to discuss is the change in the number of unemployed persons per job opening, $u2v_t$. This choice has become common as a measure of tightness in the job market instead of the unemployment gap. Ball et al. (2022) use a cubic polynomial of the ratio of vacancies to unemployed workers in their model, which ensures a good within-sample fit of the model. This approach risked a bad forecasting performance, as often happens with overfitting tactics in regressions.[22] The coefficient says that one unit increase in this ratio causes a decline of 0.09 percent points to core inflation.

The last significant explanatory is the growth rate of the real price of cars, $\Delta pcar_t$. This price is the ratio of the CPI for cars divided by the headline CPI. As the ratio of two price indexes, it is natural to suspect endogeneity. As discussed above, it seems a reasonable way to approximate the impact of the fiscal stimulus on the increased demand for goods, where it stood out, grabbing headlines for months. It was used instead of the real price of durables because these are a significant proportion of core components. Neither the C-test nor the J-test rejected its validity as an instrument. In any case, its immediate exclusion from the regression lowers the goodness of fit, but not by much. Thus, in any circumstance, it does not invalidate the coefficients of the other variables. An increase of one percent in the growth rate of the real price of cars raises core inflation by 0.1 percentage points.

The diagnostic tests for the model are satisfactory, not detecting signs of nonnormality, autocorrelation, or inhomogeneous variance for the error terms. The probability for the J-statistic was 0.70, very far from any reasonable level of significance, so the set of instruments is not rejected as valid.

[22]That paper suggests an increase in the unemployment rate higher than that expected by the Federal Reserve. In hindsight, the Fed seems to have been correct, as no surge in unemployment occurred before inflation went down to close its target.

The inflationary process started in the U.S. one year after the pandemic was a combination of domestic and global factors. Thus, inflation in other economies most likely had a similar origin. Lockdowns of work and public places and widely spread disruptions of production and transportation chains were the norm worldwide. Many governments applied domestic measures that compounded such pressures. However, the timing of events suggests a central role in what happened in the United States. Without discarding a different sequence of events, there were several examples of that. There was also at least contagion to another country without fiscal or monetary stimuli during the pandemic.

8.1 Euro Area

The inflation rates of advanced countries have historically followed related paths (see Garcés Díaz, 2023). In particular, it was seen above that the dominant economy at a given point strongly influences what happens to others. Before WW2, and especially before the 1920s, the U.K. had a powerful influence in the determination of the inflation rates of other countries. After WW2, that role had moved to the U.S. Thus, one would expect such influence to be present during the pandemic. Figure 12 shows how closely related the headline inflation rates of those economies are because energy prices strike them similarly.

A key observation in both pairs of series is that U.S. inflation precedes its counterparts in the euro area, both in its rise and fall. This sequential behavior suggests Granger causality, implying the former drives the latter. These tests are similar to those applied before to the U.K.-U.S. case. However, a more compelling demonstration of this transmission is achieved by obtaining an equation akin to Model (i), which explains the U.S. price level by the U.K. price level for some period. In this case, the U.S. headline price level dictates the euro area's. Attempts to reverse the causality lead to a clear rejection of the econometric model.

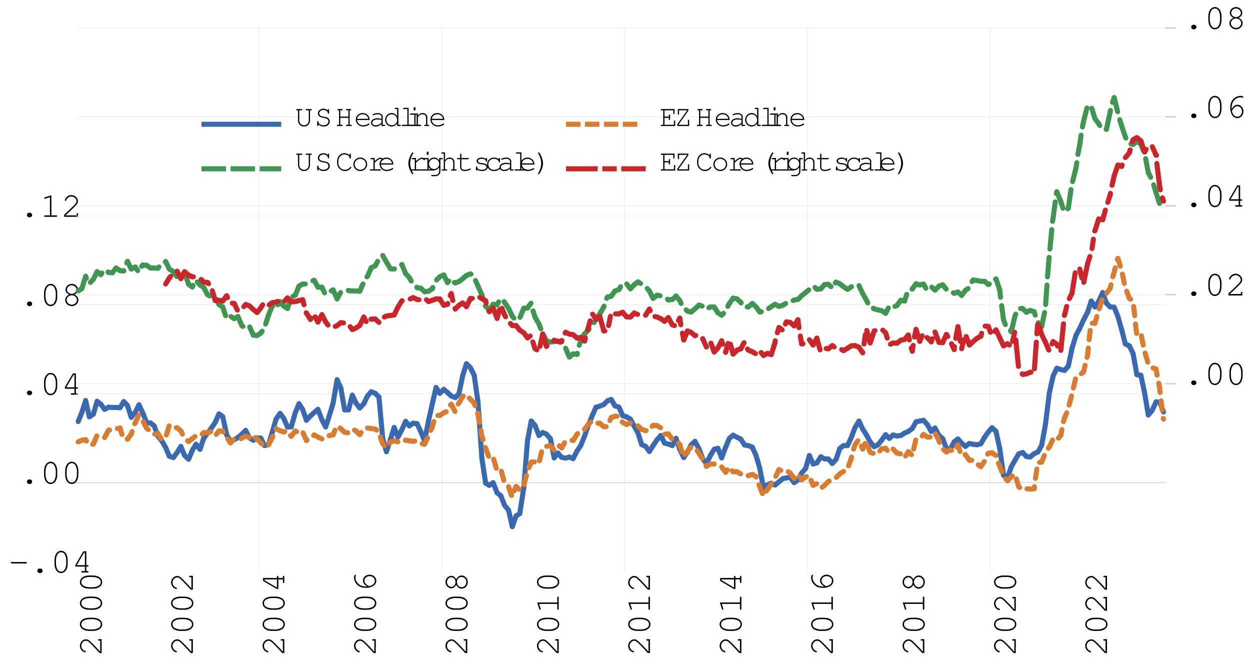

Figure 12: Real Price of Cars (logs) in the U.S. and the euro area($Index_{99:01} = 1$). Source: Own elaboration with data from FRED and BLS.

Price Level Determination for the euro area 2020-2023.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (v)

$$\Delta p_t^{ez} = -0.33 - 0.28\ p_{t-1}^{ez} + 0.30 p_{t-1}^{us} + 0.31 \Delta p_{t-1}^{ez} + 0.46 \Delta p_t^{us} - 0.81 \Delta p_{t-1}^{us}$$

s.e. (0.08) (0.06) (0.07) (0.12) (0.21) (0.25)

JarqueB = 3.08 FB-Stat. = 10.57*** tB-Stat. = −4.36***

$\hat{R}^2 = 0.51$ F-Autoc. = 2.42 BPG-Het. = 0.41

Source: Own elaboration with data from BLS and Eurostat.

Variables in logs. Superscript “ez” means euro area and “us” United States.

s.e. = standard errors. FB = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc.= ARCH(2) LM test. BPG-Het. = Breusch et al. heteroskedasticity test.

*** indicate significant at 1%, for I(1) variables.

As happened with the models during the gold standard, the price level of the euro area is determined by that of the United States. As before, the cointegration vector is close to (1,-1) without mediating the nominal exchange rate, as would be the case if relative purchasing power parity was active. The F and the t bounds statistics are each significant at the 1 percent level. There are no indications of nonnormality, autocorrelation, or heteroskedasticity. As in the case of the United States, the Markit backlogs for the euro area and the price of cars were tried as additional variables without success. Also, even though energy and other commodity prices got much blame for rising inflation in Europe,[23] The model says otherwise. The rates of growth of the IMF's indexes of total commodity prices and energy were tested alternatively as contemporary and lagged variables and were not close to statistical significance.

On the other hand, a model where the U.S. price level is the dependent variable and that for the euro area the independent results in a nonvalid relationship, with very small bound F and t test statistics. This result means the U.S. price level is the only weakly exogenous variable in the relationship.

This result is consistent with the idea that, even though the pandemic inflation was a global phenomenon, it was triggered and fueled by domestic developments in the United States and even a large partner as the euro area was affected not only by what was happening in the world as a whole but by the U.S. domestic drivers of inflation. The euro areawas not the only economy that experienced such an effect, as shown next.

8.2 Canada

During and after WW2, Models (i) to (iii) cease to work, according to their statistical properties. However, the close relationship between the price levels of the U.S. and Canada remained almost unchanged.

However, as seen before, Canada's price level continued closely following that of the United States. Despite this, it was not possible to obtain a statistically acceptable model for Canada similar to Model (ii). One possible yet vague explanation is that the United States began following a regime of inflation rate determination, and that affected Canada's price level properties too.

[23] See Guerrieri et al. (2023), they were not significant in the equation. They found that commodity prices had a central role in rising inflation in the euro area, where that kind of shock is more persistent than in the U.S.

Thus, a new ARDL model was obtained for Canada from 1940 to 2022 for the inflation rates of both countries.

The data peaks of inflation during and after WW2 made it necessary to include two pulse dummy variables for 1942 and 1948 to enforce normality in the residuals. Although a similar model can be obtained with monthly data instead of annual frequency, there are too many parameters involved to capture the intra-annual dynamics. Also, the monthly model requires many impulse dummies to obtain normality in the residuals. Nonetheless, the long-run solution for models with annual data for headline inflation from 1940 to 2022 and for core inflation from 1961 to 2022 yielded similar long-run solutions, which with I(1) variables are cointegration vectors, of (1,-1). Only the model for headline inflation is reported as the one for core inflation is very similar. The model is also displayed in conditional error correction form. Notice that the dependent variable is the double difference of the logarithm of the price level, $\Delta^2 p_t^{ca}$. The constant was nearly zero so it is not reported to save space.

Inflation Rate Determination for Canada 1940-2022.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (vi)

$$\Delta^2 p_t^{ca} = -0.44\,\Delta p_{t-1}^{ca} + 0.44\,\Delta p_{t-1}^{us} - 0.15\Delta^2\, p_t^{ca} + 0.84\Delta^2\, p_t^{us}$$

s.e. (0.08) (0.10) (0.07) (0.07)

$$-0.05 I_{1942} + 0.08 I_{1948}$$

s.e. (0.03) (0.04)

JarqueB = 2.58 FB-Stat. = 14.0^{**} tB-Stat. = -5.2^{**}

$\hat{R}^2 = 0.74$ F-Autoc. = 0.26 BPG-Het. = 2.11

Source: Own elaboration with data from Jordà et al. (2017).

Variables in logs. Superscript "us" means United States and "ca" Canada.

s.e. = standard errors. FB = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc.= ARCH(2) LM test. BPG-Het. = Breusch et al. heteroskedasticity test.

* and ** indicate significant at 10% and 5%, respectively, for I(1) variables.

8.3 Mexico

This time the variables involved are the core indexes, $pcore_t^{mx}$ as the dependent variable and the corresponding measure for the United States, $pcore_t^{us}$. Core indexes exclude volatile components which can vary from country to country but that typically include food and energy. As was discussed above, many economists doubted the usefulness of these measures, but in the case of the relationship between the price indexes of Mexico and the United States, it seems appropriate. The headline indexes are less related because in Mexico, energy prices changed little due to regulation policies through subsidies applied by the government. Thus, the relationship modeled below uses U.S. and Mexican core CPIs.

Core Price Level Determination for Mexico 2021-2023:09, monthly data.

ARDL model with no trend and unconstrained constant.

Conditional error correction form.

Model (vii)

$$\Delta pcore_t^{mx} = -0.47 - 0.19\, pcore_{t-1}^{mx} + 0.24\, pcore_t^{us} + 0.25\Delta\, pcore_{t-1}^{mx}$$

s.e. (0.12) $(0.05)^a$ (0.06) (0.14)

JarqueB = 3.21   FB-Stat. = 7.8^{**} tB-Stat. = -3.9^{**}

$\hat{R}^2 = 0.49$ $F - Autoc.(12) = 0.82$ BPG-Het. = 2.13

Source: Own elaboration with data from Jordà et al. (2017) and Inegi.

Variables in logs.

Superscript "us" means United States and "mx" Mexico.

^{a} Presence of $pcore_t^{us}$ implies that $pcore_{t-1}^{us}$ and $\Delta pcore_t^{us}$ have the same coefficient.

$pcecore_t^{us}$ is the PCE Index excluding food and energy.

s.e. = standard errors. FB = F Bounds Statistic. tB = t Bounds Statistic.

F-Autoc. = ARCH(2) LM test. BPG-Het. = Breusch et al. heteroskedasticity test.

* and ** indicate significant at 10% and 5%, respectively, for I(1) variables.

As the U.S. is the largest economy between the two, it is reasonable to think that the short and long-run causalities run from the U.S. to Mexico. Core inflation in Mexico is stationary: according to the ADF test at 5 percent of significance for the whole available sample 1982:02-2023:09: t-stat=–4.01<critical value 5%=-2.86, rejecting the hypothesis of a unit root. Other unit root tests provided similar results. Both the F and t bounds tests reject for model (vii) the null of an invalid level relationship even if every series is I(1). The rest of the diagnostic statistical tests have satisfactory properties.

9 Conclusions and Final Remarks

The debates surrounding inflation during the pandemic are the latest chapter in a longstanding struggle to make inflation theories work. This paper argues that part of the problem lies in the notion of “deep causes” of inflation, which are often assumed to be universal and immutable. The usual explanation for inflation in the long run and when it is very high is excessive money growth. In other circumstances, it is the degree of idle economic resources. However, aside from random infrequent shocks, the drivers of inflation depend on the choices made by the monetary authority and economic agents' reactions to them, as history proves. As a simple example, consider the cases of Canada and Mexico at the beginning of the XX century or during the pandemic, as shown above.

After defining the concept of monetary regime for this paper's purposes, the analysis shows that the choice of monetary regime plays the defining role in determining the permanence or transience of inflationary shocks. In inflation rate determination regimes, common in modern economies, all inflationary shocks become permanent beyond the policy horizon. This characteristic arises because the central bank is not committed to correcting past misses in its target. In contrast, price level determination regimes only allow permanent effects from shocks related to the systematic driver. The paper highlights the need to understand the implications for inflation dynamics of the monetary regime in place. This understanding also matters for designing effective monetary policy strategies.

Depending on each regime type and corresponding drivers, inflation dynamics models take a particular structure. Price level determination gives rise to an error-correction mechanism. In contrast, inflation rate determination has a less specific form, and one has to follow a hands-on search without taking any factor for granted.

The analysis applies the notion of different monetary regimes shifting over time to study the behavior of U.S. inflation from the gold standard era to the present. One can only speculate why there are no known, to the author, previous attempts to do that. Analyzing contemporary events is, understandably, a priority in economic research as it is the continuous search for more refined theoretical approaches. However, the past is the most immediate opportunity to take theory to the data. Regardless of the accuracy of the econometric models in this article, this makes the case for studying the inflationary history of the U.S. with explicit models that justify the beginning and end of the analyzed samples. In other words, it is crucial to consider explicitly evolving monetary regimes when modeling inflation.

It is worthwhile to comment more on this point. The sample used here for the United States, 1870-2023, is much longer than that used by Hendry (2001) to study U.K. inflation. However, the approaches are very different because the objectives are. Hendry (2001) was trying to show that there have been many other factors besides money that explain U.K. inflation from 1875 to 1991. This paper's approach tries to identify the relevant drivers at each historical stage. The difference in the structure of the econometric models is striking. Hendry's model for the U.K. consists of a single equation with many explanatory variables and dummies, as corresponds to the plan to prove there are many determinants for inflation. This paper's strategy consists of a different model for each alleged, by the author, monetary regime. The advantage of that is that each model is sparing, with very few explanatory variables in each one. The paper does not claim its approach is preferable; it only corresponds to the objective of explaining why some drivers might be active or not at a given time.

The paper shows that the U.S. price level during 1870-1939 has a cointegration relationship with the price level of the leading economy at the time, the U.K. The dynamics of U.S. inflation only allow for a transitory role for money. Canada and Mexico's price levels were, in turn, simultaneously a function of the United States price level with corresponding cointegration relationships. This structure in the relationship of the three countries' price levels would make a comeback about a century later.

Since the abandonment of price-level determination after WW2, U.S. inflation has become more challenging to explain, with debates about the drivers of various periods still unresolved. From 1940 to 1983, money was the primary monetary policy instrument. During this period, an econometric model for the inflation rate confirmed that it was a major driver. Notably, the U.K. inflation rate no longer significantly contributed to U.S. inflation ina direct way as that economy lost its hegemonic role. However, an international factor derived from the first principal component analysis of a sample of European economies maintained a high level of significance as an explanatory variable for U.S. inflation.

From 1984 to 2019, the Federal Reserve abandoned monetary aggregates in conducting monetary policy to use an interest rate instead. This shift coincided with a drop in the causality relationship and the correlation of monetary aggregates with U.S. inflation. For this period, advanced economies' principal component remained a significant inflation factor.

Inflation in the U.S. and other economies rose unexpectedly during the pandemic breakout. Many economists attributed this rise to transitory factors but became more persistent. However, those rejecting the notion of inflation being a transitory phenomenon changed its story, so it was unclear who was closer to the truth.[24]

Different sources named many potential direct causes. This plethora of explanations is natural in an inflation rate determination regime, as assigning a dependable role to any variable as a systematic factor is hard. For this episode, the paper models only U.S. core inflation, in the definition that excludes volatile food and energy prices, because the impact of energy prices on the noncore component is clear. The variables were found through a heuristic search as there is no dependable theoretical guide for these cases. The significant factors were: 1) the ratio of unemployed workers to vacancies (as a measure of job market pressures); 2) international inflationary pressures, measured by the first principal component of inflation in the euro area; 3) production bottlenecks, measured by the Markit backlogs index and; 4) the impact of the fiscal stimulus on the demand for durable goods, measured by the real price of cars.

The model thus corroborated the extended impression that the pandemic inflation in the U.S. was a combination of domestic and global factors. The fiscal stimulus significantly boosted demand, while global factors such as supply chain disruptions contributed to even higher prices. As an echo of the relationships present in the gold standard era, headline inflation in the euro area appears to have been driven by inflation in the U.S. A model shows that the euro area price level was determined by the U.S. price level, with no mediating role for the nominal exchange rate. Similar econometric models for Canada and Mexico are available.

As inflation returns to its pre-pandemic levels, a compelling question for monetary policy emerges: will the connection between the price levels of the U.S. and other countries persist? While confirming in advance is impossible, the link will likely continue without much change for Canada. However, the relationship in price levels with Mexico and the euro area may break, returning to a more typical correlation between inflation rates.

The findings in the paper suggest that inflation is a phenomenon that often erases borders and that domestic factors of one country can significantly impact inflation in others. The exception to this would be the inflation of countries under fiscal dominance where only domestic monetary and public budget factors matter.

[24] "Furthermore, what struck me in 2022 was that the arguments that leading pessimists were making for persistent high inflation had no logical connection to the arguments they had made for a surge in inflation back in 2021. They were predicting the same thing but for completely different reasons. There was nothing linking the inflationist views of 2022 to those of 2021 except a shared pessimistic vibe." P. Krugman, New York Times, Dec. 5, 2023.

There are, of course, limitations to the analysis that require further study. One crucial point of the article is that, besides their idiosyncratic factors, foreign inflation plays a vital role in individual countries. However, the paper does not discuss what drives the international inflation component. For example, during the gold standard era, one would have to find the determinants of the U.K. price level. In other regimes, one must explain what drives the principal component used as a regressor.

Borio and Filardo (2007) proposed the ”global output gap” hypothesis to address the limitations of the classical Phillips curve. However, a key issue with this hypothesis is its assumption that the global output gap is a recent phenomenon arising from ”globalization.” This paper demonstrates that international inflation has been crucial in shaping U.S. inflation since the gold standard era and has never truly gone away.

Another objection to that hypothesis is that the main central banks still need to find it compelling.[25] It could be a good idea, but it has yet to prove its usefulness and that it is really a systematic factor to explain inflation. Thus, a crucial question is: What are the determinants drivers of the international common inflation component? It might be that eventually could be the global output gap, but this is far from settled.

Representing the institutional environment for monetary policy as monetary regimes is customary and well-accepted. This paper proposes one definition that seems useful for its purposes. However, this is incomplete without an explicit model of how the economy transitions from one regime to another. Such research would require micro-foundations not to justify a dominant model as was done with the Phillips curve but to explain how drivers of inflation come and go. For this, it is necessary to abandon the quasi-religious belief that there has to be a Phillips curve in every inflationary process with low inflation or that money is the only factor that matters in the long run. Even if any of these two propositions one day prove accurate, they currently are of little practical use.

[25] See, Ihrig et al. (2007), Bullard (2012), and Calza (2008).

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