INFLATION REGIMES IN LATIN AMERICA, 2020-2022: PERSISTENCE, DETERMINANTS, AND DYNAMICS

Gabriel Sánchez Hernández

June | 2023

INFLATION REGIMES IN LATIN AMERICA, 2020-2022: PERSISTENCE, DETERMINANTS, AND DYNAMICS

Gabriel Sánchez Hernández*

Abstract

Inflation shifts are in the spotlight in Latin America. This paper employs a Hidden Markov Model to uncover and test the persistence of inflationary regimes in six Latin American countries: Argentina, Brazil, Chile, Colombia, Costa Rica, and Mexico. It also uses an influence method based on the Mahalanobis distance to measure how a series of economic factors affect the path of inflation throughout the 2020-2022 period. Subsequently, I elaborate on a comparative dynamics analysis. The results show that monetary and international factors are the most important for the region and that the determinants of inflation are heterogeneous between countries. Specifically, US inflation shifts are crucial in defining the path of inflation in Latin American countries, representing the most relevant factor in Argentina. In addition, the study finds that Costa Rica is mainly affected by policy-related interest rates; demand-pull factors are central in Chile and Mexico, and cost-push elements strongly drive shifts in Brazil and Colombia. Inflation determinants are also time-varying and generally influence in different ways in consecutive periods. Finally, almost all countries display regime persistence, except for Argentina.

Palabras clave: : Inflation Determinants, Inflationary Regimes, Inflation Dynamics; Latin America

* Estudiante y Asistente académico, Escuela de Economía, Universidad de Costa Rica (UCR) Email: gabriel.sanchezhernandez@ucr.ac.cr.

Contents

1. Introducción 4

2. Inflationary Regimes and Persistence 4
   2.1. Inflation shifts 5
   2.2. Hidden Markov Model 5

3. The Determinants of Inflation 8
   3.1. What leads to inflation? 8
   3.2. Influence method 10

4. Results 12
   4.1. Latin America: A heterogeneous region 12
   4.2. Time-varying determinants 14

5. Conclusión 16

6. Appendix 17
   6.1. Hidden Markov Model 17
   6.2. Time-varying determinants 19

References 21

1. Introduction

Inflation is one of the most critical topics of economic theory. The relevance of this phenomenon relies not only on the thousands of researchers that study its determinants, but on the social impact behind it, for it must be widely recognized as *the most regressive tax that exists*[1], affecting directly those who have less. Over the years, great thinkers have developed arguments on the causes of inflation, but it remains an open discussion. Moreover, it represents a challenge for policymakers who try to lessen its impact on people from all regions of the world.

In the last three years, there has been an increasing public interest in the determinants and repercussions of the latter and unexpected inflationary events. In February 2023, for the eleventh consecutive month, it is the number one problem of the world, with 43% of people declaring it as one of the main problems they defy. Moreover, inflation holds the first place in 15 countries, including Argentina and Colombia, as the most considerable worry[2].

The central purpose of this study is to analyze the determinants of inflation shifts in Latin American countries over the period 2020-2022. There are three objectives: 1. To define inflationary regimes and measure their persistence; 2. To examine the relative influence of a selected group of variables on inflationary processes; and 3. To identify differences over time between countries. The set of variables includes those traditionally in the discussion of the subject, which allows for comparison between the most common theories about inflation. The countries covered are Argentina, Brazil, Chile, Colombia, Costa Rica, and Mexico.

The paper proceeds as follows. Section 2 defines inflation shifts and employs a Hidden Markov Model to deduce inflationary regimes and their persistence in Latin America; Section 3 summarises the most relevant inflation theories and methodologies employed to measure their influence. Finally, the determinants of inflation and comparative dynamics analysis are provided in Section 4.

2. Inflationary Regimes and Persistence

In this section, I define what an inflation shift is and use a categorical Hidden Markov Model (HMM) to identify regimes of inflation and test their persistence in Latin America. I implement the method developed by Kinlaw *et al.* 2022, who used it to identify those shifts for the United States.

1 In a figurative way.

2 According to What Worries the World, by IPSOS.

2.1. Inflation shifts

I identify an inflation shift from the *acceleration* of inflation; that is, the difference of the year-over-year rates, allowing to find abnormal moves up and down in inflation that could have occurred during the period. Let $\phi_{c,t}$ denote the inflation shift of country *c* at time *t*:

$$\phi_{c,t} = \frac{CPI_{c,t}}{CPI_{c,t-12}} - \left(\frac{CPI_{c,t}}{CPI_{c,t-36}}\right)^{\frac{1}{3}} \quad (1)$$

Equation *(1)* gives a positive number if the one-year rate of inflation is greater than the three- year rate, and vice versa. Also, a larger number (positive or negative) indicates a larger difference in the mentioned rates. The corresponding period has been strongly atypical worldwide in terms of inflation, and Latin America is not an exception. During this period, most of the countries in the region have faced their uppermost rate in recent years. Figure 1 provides evidence of this phenomenon using monthly data from the Latin American Reserve Fund's Economic Information System (SIE), and confirms not only important differences with the preceding years' rates but mostly positive changes; that is, generally, countries have experimented higher inflation rates in comparison to previous years.

2.2. Hidden Markov Model

Given the time series utilised to measure inflation, it is valuable to introduce two relevant ideas: stochastic process and *time series*. The first one refers to a temporal sequence of random variables, whereas the second to a singular realisation of a stochastic process[3], i.e. we have access to just one of the possible outcomes of each of these random variables, as in equation *(2)*:

$$\{X_t\}_{t=-\infty}^{\infty} = \{\ldots, x_{-1}, \overbrace{x_0, x_1, x_2, \ldots, x_T}^{Observations,\ X}, x_{T1}, x_{T2}, \ldots\} \quad (2)$$

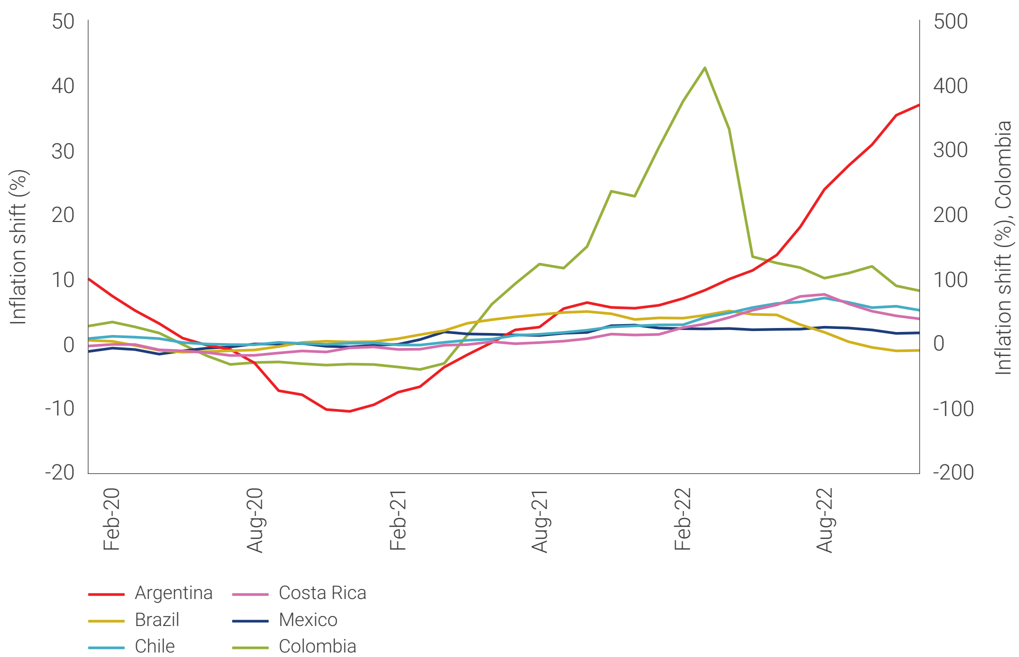
Next, I use a Hidden Markov Model (HMM) to test the persistence of inflation shifts. A Hidden Markov Model is a tool for representing probability distributions over sequences of observations (Ghahramani 2001), in which a sequence of observations *X* is generated by a sequence of internal

[3] See Romero-Aguilar 2020.

states Z that follow a stochastic process. Transitions between states *Z* are assumed to follow a Markov Model, where state Z_t at time t only depends on state Z_{t-1} at time *t-1*.

A Hidden Markov Model has two initial components. First, there are *observations*, that are the inflation shift time series for each country. Table 1 documents the selected characterization. In second place, there are hidden states that are addressed as *regimes* and follow the same categories as the observations: deceleration, normal shift, high acceleration and very high acceleration.

Figure 1. Inflation shifts (%) in Latin America, according to Equation (1)



Note: Left vertical axis plots inflation shifts for Argentina, Brazil, Chile, Costa Rica and Mexico. Right vertical axis plots inflation shifts for Colombia.

Table 1. Categorisation, inflation shifts of Equation (1)

Inflation shift	Category
$\phi_{c,t} < 0$	Deceleration
$0 \leq \phi_{c,t} < 2$	Normal shift
$2 \leq \phi_{c,t} < 4$	High acceleration
$\phi_{c,t} \geq 4$	Very high acceleration

The model requires three set parameters: first, a state transition model A that will assign a higher probability to regime persistence. This means that, for the initial model, it is more likely that after a certain regime in a specific month (let's say deceleration at time t), a country shows the same regime the next month (deceleration at time t+1). I set the probabilities this way according to the findings of Kinlaw *et al.* 2022 regarding the strong regime persistence for the United States.

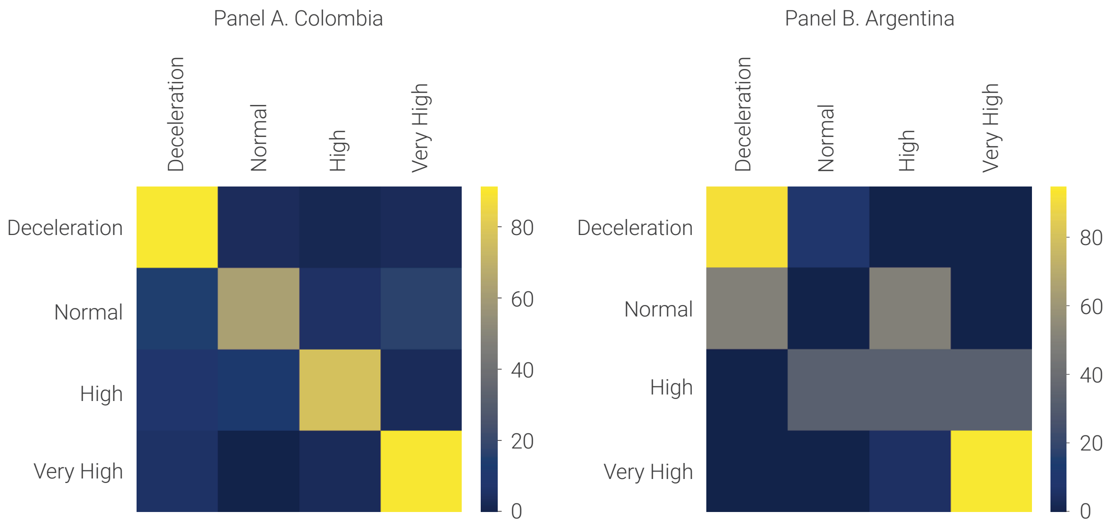
Next, we have an observation model B that is set to have stronger probabilities linked to same observation-regime relations. For example, if we have an observed value (let's say high inflation shift at time *t*), it would be very likely for the model to reflect the same category (high accelerated inflation regime at time $t + 1$). Both *A* and *B* are available in the appendix. Finally, we have an initial state distribution π that depends on the first observation for each country. Having specified the model $\lambda = A, B, \pi$ I run it for each country by using the *hmmlearn* python package[4]. In order to obtain the best score possible, this process repeats for a thousand iterations with help of a pseudo-random number generator's (PRNG) seed.

As a result, the stationary transition model shows the probabilities of staying or switching to different regimes, as depicted in Figure 2. The left panel 2A maps the situation for Colombia. Similarly to the other countries, the regimes present strong persistence; that is, if Colombia happens to be in a regime (let's say, with normal inflation at time t), it is very likely that it stays in such regime the next period (having a normal inflation state at time $t + 1$). Almost all analysed countries present strong persistence, as the elements in the diagonal of the transition matrix are substantially higher than the non-diagonal elements.

Nevertheless, the analysis for Argentina produces a different result. As shown in Figure 2Bb, only in the limit regimes it appears to exist a high persistence (deceleration and very high acceleration). Moreover, it would be more likely to have decelerated or high accelerated inflation after being in a normal context. Furthermore, if Argentina is in a high accelerated inflation state, the expectation of staying in the same state is similar than those of shifting to a normal or very high one.

[4] Documentation available here.

Figure 2. Probability of switching from inflation regime A (vertical axis) to B (horizontal axis)



Note: Heat maps for Brazil, Chile, Costa Rica and Mexico are available in the appendix.

3. The Determinants of Inflation

The objective of this section is to evaluate how the most relevant economic factors influence the abnormal shifts in Latin America over the last three years, although I do not try to assert which economic theory is more *accurate*. Then, I review the methods I use to measure their influence and dynamics over the 2020-2022 period

3.1. What leads to inflation?

From *only money matters to rational expectations*, there exists a great variety of macroeconomic arguments[5] around the causes of inflation in both the short and long run. Table 2 provides a summary of the variables I used.

Modern economies have central banks that can directly set the quantity of currency in circulation. Moreover, it seems to be that money growth and the rate of increase in prices move together over long periods of time[6], being the excessive money growth over output growth one of the most

5 See Totonchi 2011.

6 Garín, Lester, and Sims 2020.

adopted thesis on the causes of inflation in the long run. The first monetary policy variable I use, which are denoted by MP in Table 2, is money supply in the form of a three-year change. In the same way, modern central banks raise the official (nominal) interest rate when high inflation affect the economy. In this manner, I assume a *Neo-Fisherianism* viewpoint, in which the real interest rate is independent of monetary factors, and so the nominal interest rates and inflation move in the same direction, and MPRs[7] are used as instruments to affect the price levels.

The second group of variables corresponds to international factors (IF), which take into account United States' inflation as well as nominal exchange rates. The first indicator is important due to the strong economic relationships between Latin American countries and the US, and because the 2020-2022 period was characterized by worldwide increases in prices. The national exchange rate to $1 is implemented based on pass-through theory, which argues that a country's rate of inflation is more robustly affected by exchange rate fluctuations when the country widely depends on imports.

Table 2. Theories and variables

Theory	Variable	Data	Measure
MP	Money Supply Interest Rates	M2 Policy-related interest rate	3y change 1y difference
IF	US Inflation Exchange Rates	Consumer Price Index Nominal Exchange Rate to $1	1y change 1y change
DP	Private Consumption	Household's Consumption Expenditure*	1y change
CP	Producer Prices	Producer Price Index**	1y change
IE	Inflation Expectations	Inflation Expectations***	1y difference

Monetary Policy variables come from monthly data from the Latin American Reserve Fund's (FLAR) Economic Information System (SIE). The United States Consumer Price Index for All Urban Consumers (CPIUSCL) was downloaded from the Federal Bank of St. Louis' FRED. Data for Exchange Rates, Private Consumption and Inflation Expectations were downloaded from OECD due to the time series frequency. The Producer Prices data for Chile, Colombia, Costa Rica and Mexico were downloaded from OECD; for Argentina from Bolsa de Comercio de Santa Fé (BCSF) and for Brazil from *Investing.com*.

* Household's Consumption Expenditure frequency is quarterly, hence I use interpolations to obtain monthly time series.

** Data for Colombia, Costa Rica and Mexico belongs to the domestic series, whereas *total market* for Argentina, Brazil and Mexico. Moreover, for Argentina and Brazil the available data were in *one-month change* units, hence conversion to indexes was needed in order to have the one-year change.

*** Inflation Expectations frequency is quarterly for Chile, Colombia, Costa Rica and Mexico, and yearly for Argentina and Brazil, hence I use interpolations to obtain monthly time series.

[7] Money policy rate, or *Tasa de política monetaria* in Spanish.

Private consumption is taken into account due to demand-pull theory (DP); that is, increases in aggregate demand that generate inflation pressures due to this being larger than the aggregate supply at full employment levels. In contrast, cost-push theory (CP) proposes that rises in the cost of production commodities impulse inflation rates, hence the Producer Price Index is included. Finally, inflation expectations (IE) fit in the analysis in behalf of the Rational Expectations revolution of 1970s, which recognises that economic agents generate expectations based on past *and* current information, and take into account these expectations when making their decisions.

3.2. Influence method

Subsequently, an attribution methodology based on the Mahalanobis distance will be used to examine the influence of the variables that were presented before. The Mahalanobis distance[8] is a measure of divergence between groups in terms of multiple characteristics[9]. Another way to introduce it is with variability: due to the positive or negative relation that multivariate data could show, the Mahalanobis approach assigns a larger distance to those observations that are not only further away from their means, as Euclidean distances would do, but to points from the sample that show a larger variability. The application used in this paper is based on Kinlaw *et al.* 2022, in which the authors compute this distance to analyse inflationary regimes in the United States. Let the Mahalanobis distance for country c at time t from regime r be denoted as $\delta_{c,t,r}$:

$$\delta_{c,t,r} = (x_{c,t} - \mu_{c,r})^T S_{c,r}^{-1} (x_{c,t} - \mu_{c,r}) \tag{3}$$

Where, for a specific country *c*, $x_{c,t}$ is a vector that contains the observations of the variables at time *t;* $\mu_{c,r}$ a vector that has the means of these variables for a certain regime *r;* and, $S_{c,r}^{-1}$ the inverse of the symmetric and positive semi-definite variance-covariance matrix of variables in regime *r*. The superscript *T* the transpose of a matrix, and the result is a scalar. Next, the distance of Equation *(3)* is converted into a statistical likelihood according to a normal distribution, as follows:

$$L_{c,t,r} = \frac{1}{\sqrt{det\,(2\pi\, S_{c,r})}}\; exp\left(\frac{-\delta_{c,t,r}}{2}\right) \tag{4}$$

8 Developed in Mahalanobis 1936.

9 See McLachlan 1999.

In Equation *(4)*, $S_{c,r}$ is the variance-covariance matrix of the variables of country *c* in regime *r*. Afterwards, the likelihood has to be rescaled to be interpreted as a probability. Let the probability of country *c* at time *t* to be in regime *r* be denoted as $\rho_{c,t,r}$:

$$\rho_{c,t,r} = \frac{L_{c,t,r}}{\sum_{all\ regimes r} L_{c,t,r}} \quad (5)$$

Next, in order to determine the importance of the variables I compute the derivative of the composite function[10] of Equation *(5)* with respect to the variables vector $x_{c,t}$. For a specific regime *i*, this derivative corresponds to:

$$\frac{\partial \rho_{c,t,i}}{\partial x_{c,t}} = \rho_{c,t,i} \left[\left(\sum_{all\ regimes\ r} \rho_{c,t,r} \frac{\partial d_{c,t,r}}{\partial x_{c,t}} \right) - \frac{\partial d_{c,t,i}}{\partial x_{c,t}} \right] \quad (6)$$

Equation *(6)* is a derivative with respect to the variables vector, meaning that the output is also a vector and it represents the sensitivity of regime *r* to the variables of the model. Having four regimes, and with the objective of obtaining the total sensitivity of the variables, I take an average[11] across regimes:

$$\zeta_{c,t} = \frac{1}{4} \sum_{all\ regimes\ r} \left| \frac{\partial \rho_{c,t,r}}{\partial x_{c,t}} \right| \quad (7)$$

In here, $\zeta_{c,t}$ denotes the total sensitivity vector of the variables of country *c* at a specific point in time *t*. Finally, rescaling equation (7) with the standard deviations of the full sample allows to obtain the relative importance vector of country *c* at a given point in time *t*:

$$\psi_{c,t} = \frac{\zeta_{c,t}\,\sigma_c}{\sum_{all\ variables\ v} \left| \zeta_{c,t}\,\sigma_c \right|} \quad (8)$$

[10] Using the chain rule: $\frac{\partial \rho_{c,t,r}}{\partial L_{c,t,r}} \frac{\partial L_{c,t,r}}{\partial \delta_{c,t,r}} \frac{\partial \delta_{c,t,r}}{\partial x_{c,t}}$

[11] Because of Equation *(5)*, the average will sum to one. Hence, the average of the absolute values is computed.

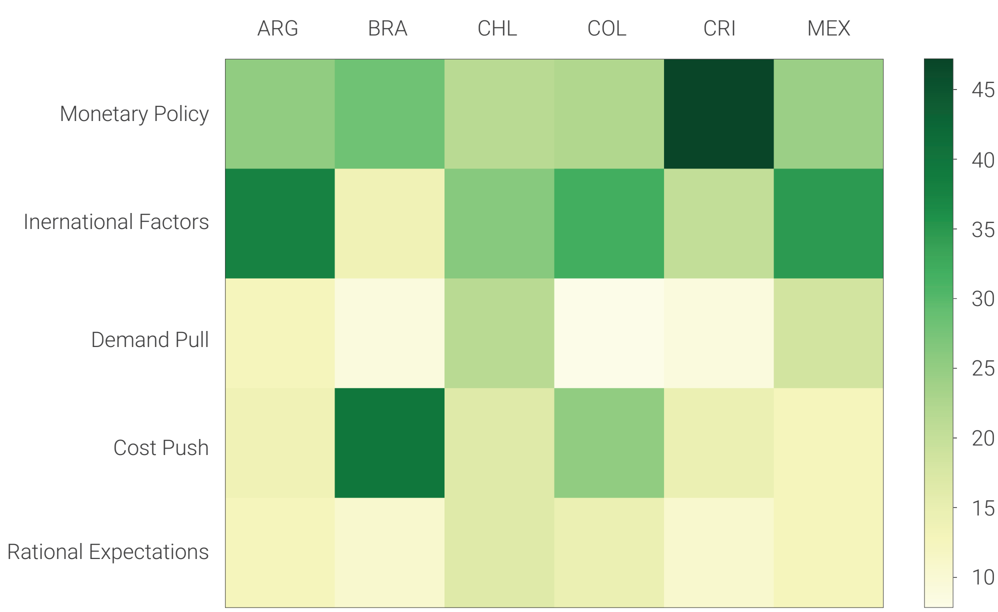
4. Results

In this section, I elaborate on the dynamics of inflation: how each variable influences the acceleration of increase in prices over time, and what differentiates between Latin American countries. I compute the relative importance of each variable in the inflationary process from Equation *(8)*. The tools show valuable information. However, it is important to notice that this measure is relative and not an absolute value.

4.1. Latin America: A heterogeneous region

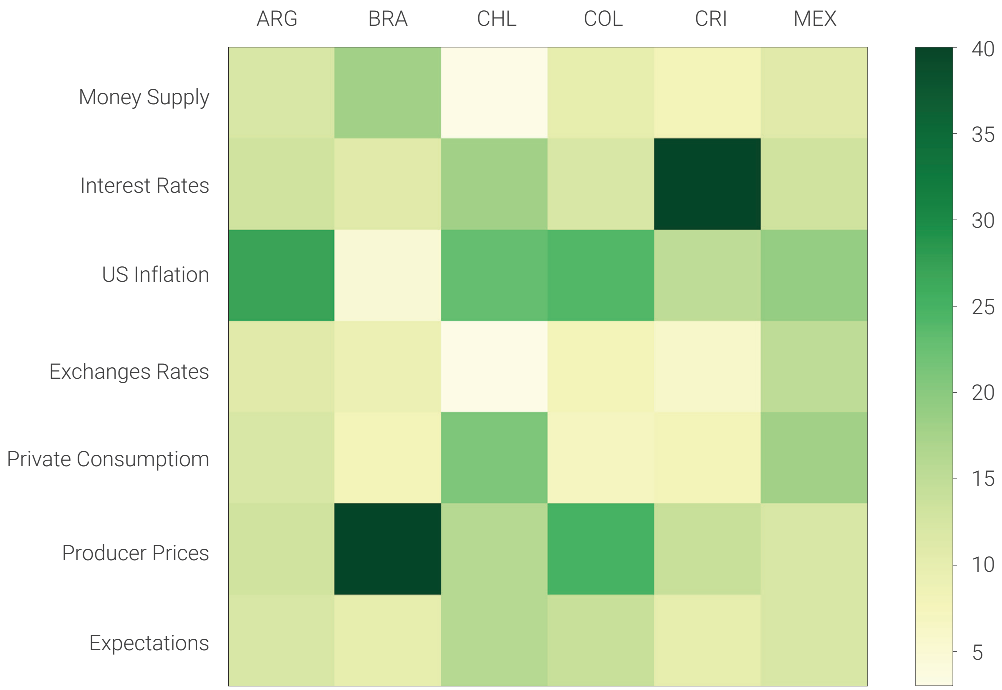
I first describe the general results. Figure 3 summarises the average importance of each possible explanation throughout the 2020-2022 period. It is evident that monetary and international factors are the most relevant. Some countries show a more noticeable tendency, such as Costa Rica with an average of 48% of its inflation shift driven by the monetary policy; or Argentina, with international factors representing 38% of its variations. In contrast, Brazil and Colombia are remarkably affected by cost-push schemes, which represent the third more relevant theory in terms of average effects. Lastly, demand-pull and rational expectations share the last place with approximately 12% of influence for all countries. Despite this, expectations seem to be more equally distributed in a range from 10% to 16%, while demand-pull's average is markedly determined by Chile and Mexico with 21% and 18%, respectively.

Figure 3. Inflation theories, average importance (%), 2020-2022



The relative effects of each variable reflect a considerably heterogeneous background for Latin American countries. Figure 4 presents a disaggregation of monetary and international factors. Technically, the predominant determinant is Producer Price Index, but this is on average and clear that Brazil strongly affects the mean value, having the stat a standard deviation of 10.86 pp. Next, there is what seems to be a familiar bold determinant: the United States inflation rate, which is not surprising considering the strong macroeconomic relations that Latin American countries and the US share, and the 2020-2022 circumstances that have disturbed all regions worldwide.

Figure 4. Inflation determinants, average importance (%), 2020-2022



Furthermore, policy-related interest rates account for most of monetary policy effects (and with higher standard deviation), being almost all out of six countries relatively more driven by interest rates in contrast with money supply, except for Brazil. Moreover, Costa Rica and Chile are not only the two countries more greatly influenced by interest rates but also the less affected by M2. On the other hand, private consumption and inflation expectations show the same relative importance, and Chile leads both measurements. Consumption displays a higher standard deviation in contrast to expectations, as previously analysed. Finally, the least relevant variable throughout the period is the nominal exchange rate with an average relative influence of 9%.

4.2. Time-varying determinants

It is evident from the analysis that Latin America displays heterogeneity between countries in terms of the average effects. Then, an important question arises: Do countries individually follow a specific path throughout the period? The answer is no, as the tested variables display horizontal differences for each country; that is, there can be highly marked determinants of inflation on average, but they generally vary from one year to another, even between months.

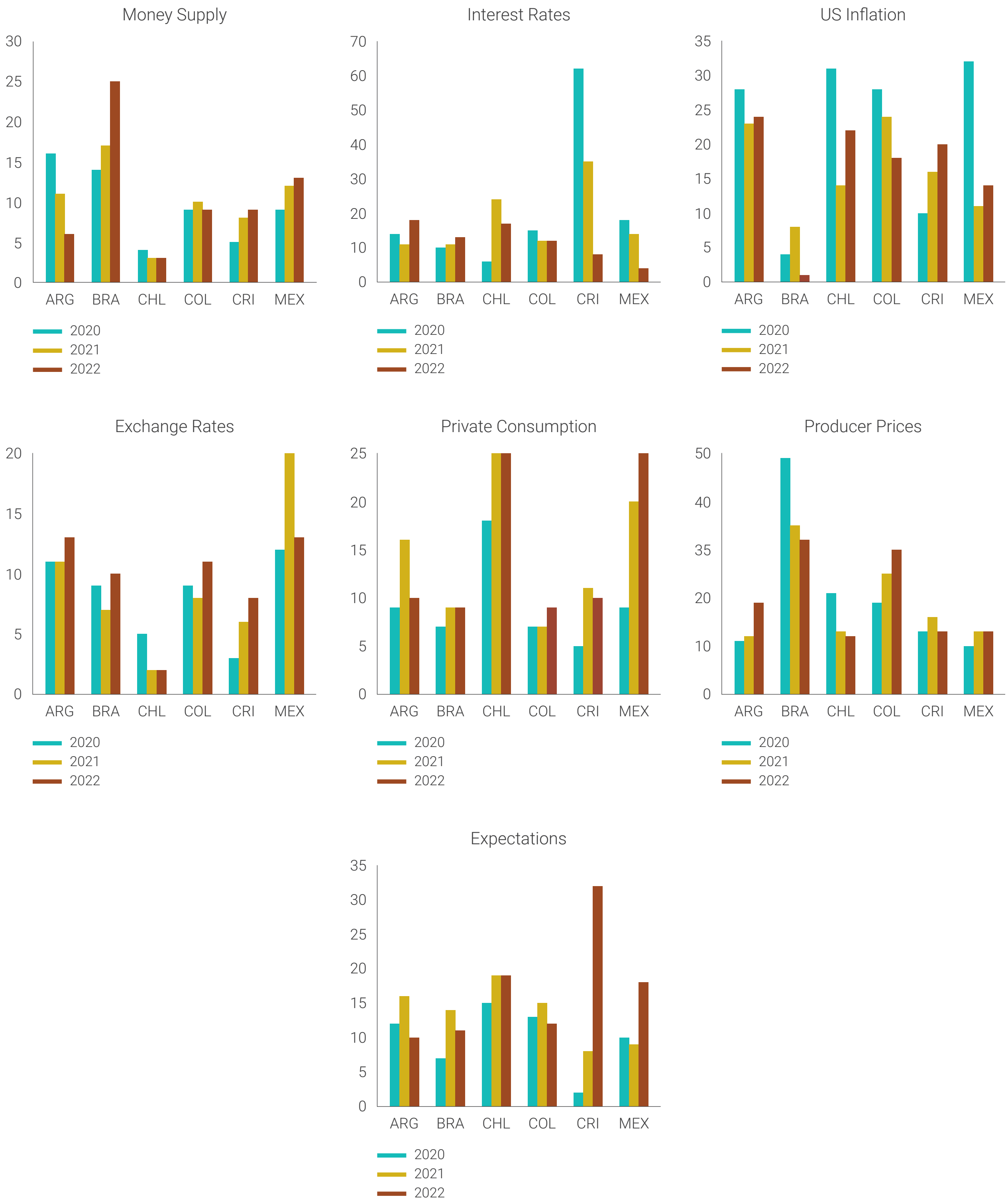
The determinants of inflation have a fluctuating context, and it is optimal to observe specific examples of this behavior. Figure 5 illustrates the average importance of each variable by year. As a result, the United States inflation rates highly influence Latin American countries. Throughout the period, this international factor showed an importance of at least 10% and values up to 32% in Costa Rica and Mexico, respectively, in 2020. Furthermore, Argentina exhibits the stronger relation between U.S. and local inflation, with a minimum influence of 23% in 2021. The previous analysis excludes Brazil because it displayed, on average, only 5% of inflation related to this factor during the whole period.

The strongest effect of a single variable corresponds to policy-related rates in Costa Rica. On average, MPRs determined 62% and 35% of the country's inflation in 2020 and 2021, respectively. This variable also influenced almost a fifth of Chile's inflation. It is important to note that MPRs show significantly high standard deviations, with an approximated maximum value of 21pp in 2020. It also displays larger medians than means, which leads to think about heterogeneous effects.

Another relevant result comes from Chile and the role of private consumption, which not only determines on average more than a fifth of the country's inflation during the years but exhibits an increasing tendency. That is, Chile's inflation has been each year more dependent on demand-pull factors, reaching a relative influence of 25% in both 2021 and 2022. Similarly, Mexico presented an increasing path, and demand-pull drives a quarter of inflation in 2022. What's more interesting: it was the least relevant determinant for the North American country in 2020. In general, for all countries, indicators reveal that private consumption represented a higher impact on inflation in 2022, in contrast with 2020.

Cost-push factors strongly influenced the acceleration of the increase in prices in Brazil and Colombia but in different ways. Brazil reveals a decreasing tendency in producer prices importance, while Colombia was each year more influenced by this factor. However, it is vital to note that almost half of Brazil's inflation was determined by cost-push components in 2020 and by a still large share of 32% in 2022. Similarly, the results exhibit that Colombia had more *constant* shifts than Brazil, increasing each year by approximately 5pp, whereas Brazil displayed a decrease of 14pp between 2020 and 2021.

Figure 5. Inflation determinants, average importance (%) by year, 2020-2022



Money supply effects in Brazil widely excel the average importance by 8pp. Unlike cost-push factors, the influence of M2 on Brazil's inflation has increased throughout the period, causing almost a quarter of it in 2022. In contrast, the money supply became relatively less important in Argentina, with a 10pp decrease from 2020 to 2022.

Expectations effects in Costa Rica increased significantly, determining almost a third of the country's inflation in 2022. This indicator has similarly affected all countries throughout the period, having the minimum standard deviation across variables, with 2.34pp. Likewise, another factor with data clustered around the mean is the exchange rate. However, it is relevant to note that this was the least crucial variable with an average impact of 8.67%, and only Mexico experimented values higher than 15% of inflation driven by this determinant.

Even the principal determinant of inflation varies between years. In 2020, it is the United States inflation rate, whereas producer prices represent, on average, the leading determinant of inflation in 2021 and 2022. Overall, the varying nature of these variables extends to shorter periods, as pictured in Figure 7 in the appendix. Undoubtedly, inflation is not only a fluctuating phenomenon but one strongly responsive to current events.

5. Conclusion

Inflation is one of the most crucial topics of economic theory, and there are multiple arguments on its causes and effects. However, it remains as an open debate. What generates inflation? Is it a persistent phenomenon? How responsive is it to current events? Does it impact all countries the same way? In this paper, I analyse the persistence, determinants and dynamics of inflation regimes for 2020-2022 on six Latin American countries: Argentina, Brazil, Chile, Colombia, Costa Rica and Mexico.

I first define inflation shift time series and compute a Hidden Markov Model to uncover inflationary regimes and test their persistence. Then, I select a set of economic elements grouped into five main categories: monetary policy, international factors, demand-pull, cost-push and inflation expectations, and describe the methodology I use to test their influence. Finally, I analyse the determinants and dynamics of inflation for 2020-2022.

The results indicate that inflation determinants are highly heterogeneous and time-varying. Furthermore, inflationary regimes are strongly persistent; that is, if a country is in a specific regime, it is very likely that it stays in such way the next period. Nevertheless, Argentina generates a different result: only decelerating and high accelerating inflation regimes display persistence.

The monetary and international factors are the most relevant determinants of inflation for the period. Specifically, US inflation shifts have strong effects in Latin America, and are the main component in Argentina. It also shows that inflation determinants are markedly heterogeneous between countries: Costa Rica's inflation is highly influenced by policy-related interest rates, whereas private consumption is crucial in Chile and Mexico. On the other hand, increases in producer prices drive most shifts in Brazil and Colombia. There are also episodes in which the determinants display considerably higher values than average, such as exchange rate in Mexico in 2020 and money supply and inflation expectations in Brazil and Costa Rica, respectively, in 2022.

6. Appendix

6.1. Hidden Markov Model

Table 3. State transition model, A (%)

	D	N	H	V
D	85	5	5	5
N	10	70	15	5
H	15	10	65	10
V	5	5	5	85

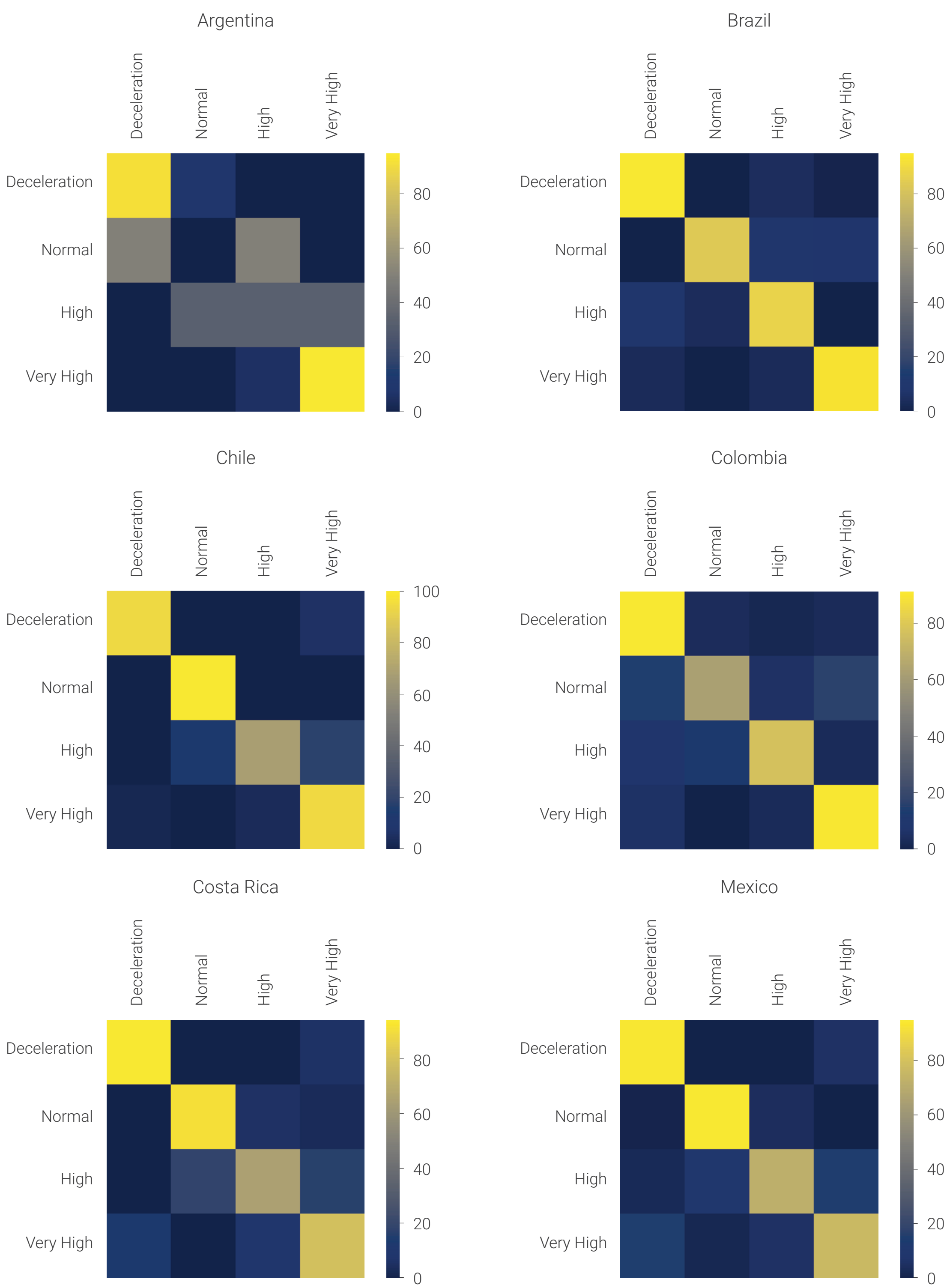
D = Deceleration
N = Normal shift
H = High acceleration
V = Very high acceleration

Table 4. Observation model, B (%)

	D	N	H	V
D	70	10	10	10
N	15	50	25	10
H	10	10	70	10
V	10	10	10	70

D = Deceleration
N = Normal shift
H = High acceleration
V = Very high acceleration

Figure 6. Probability of switching from inflation regime A (vertical axis) to B (horizontal axis)



6.2. Time-varying determinants

Figure 7. Inflation determinants, monthly importance (%), 2020-2022

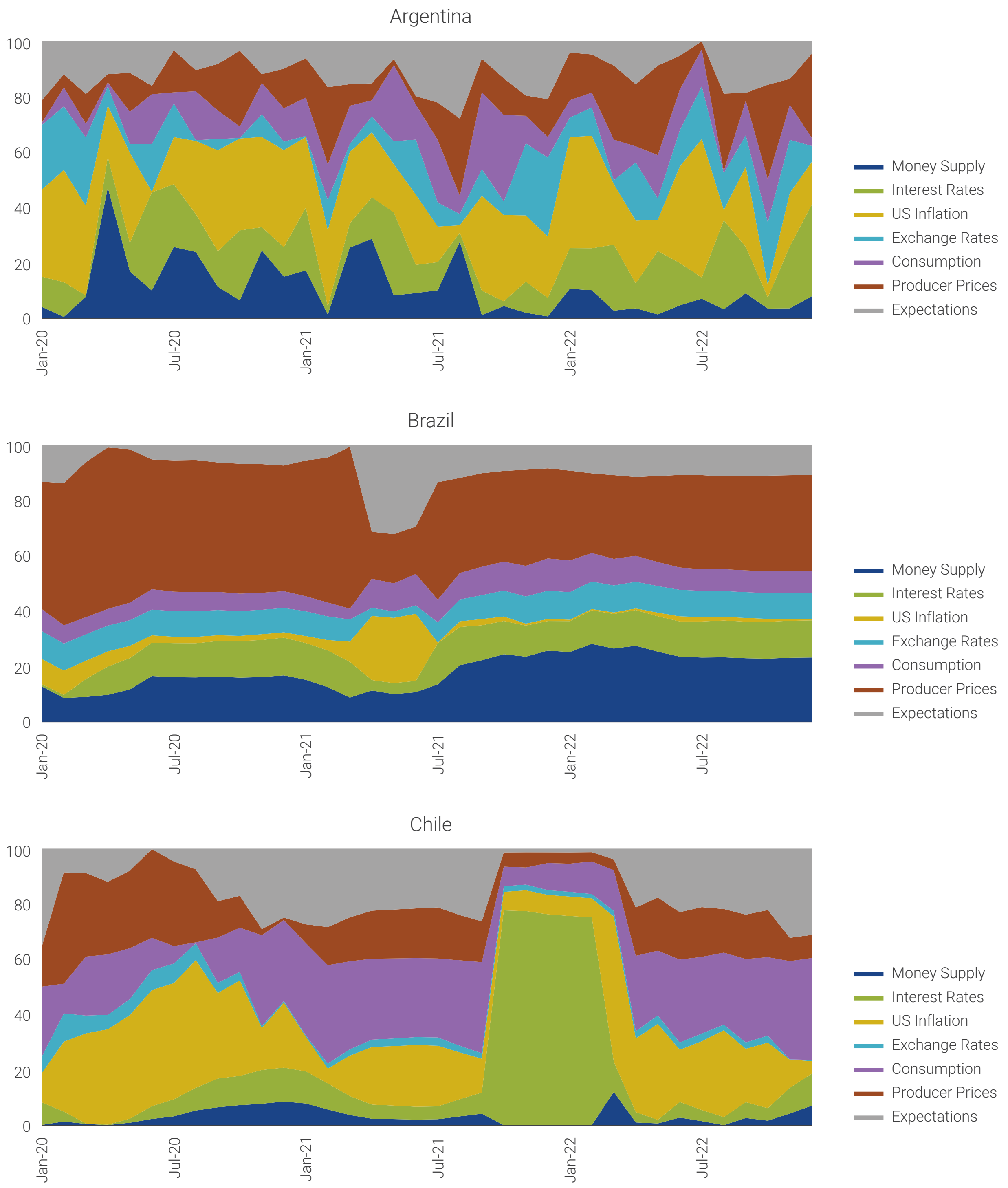
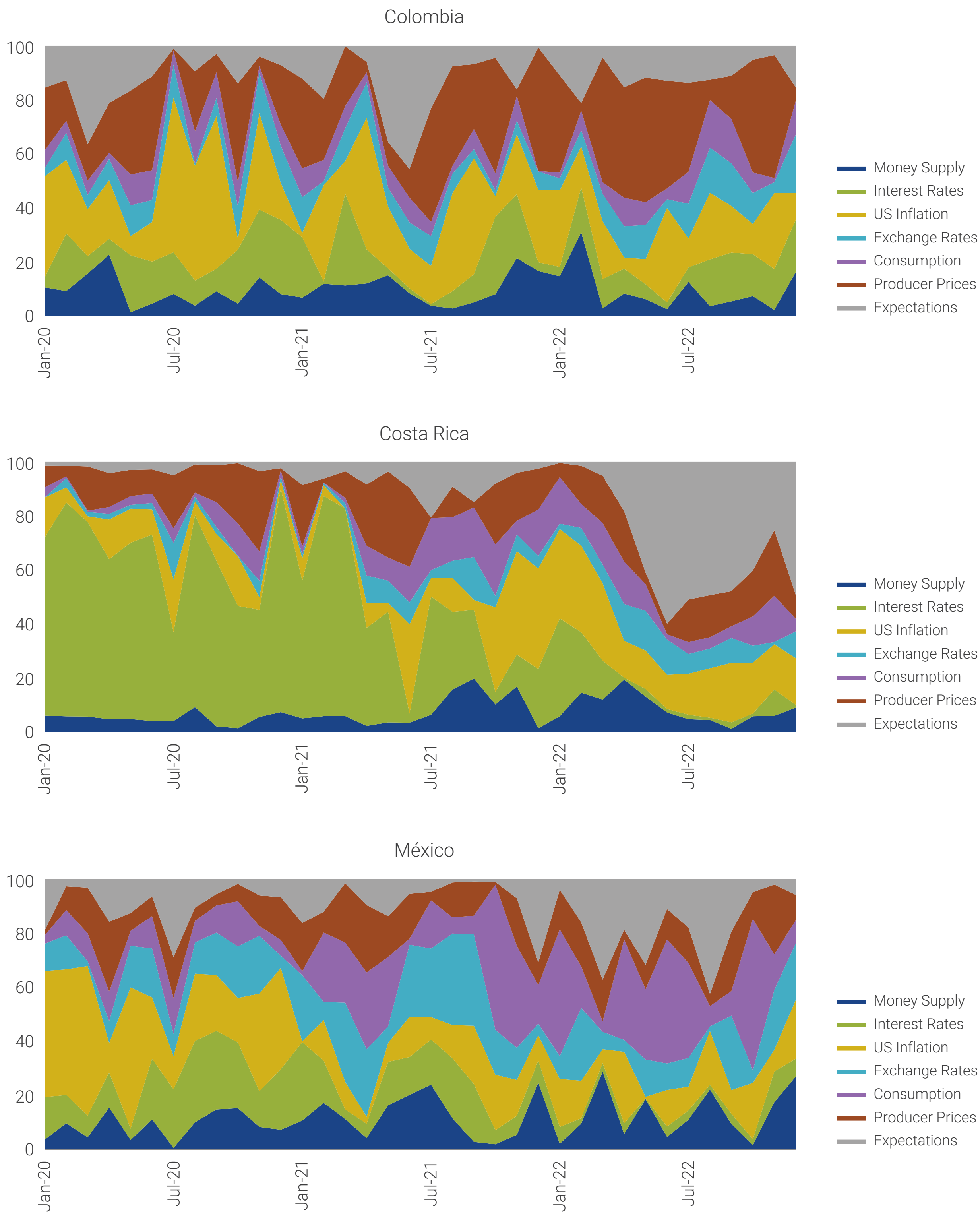


Figure 7. Inflation determinants, monthly importance (%), 2020-2022



References

Garín, J., R. Lester, and E. Sims. (2020). "Intermediate Macroeconomics."

Ghahramani, Z. (2001). "An Introduction to Hidden Markov Models and Bayesian Networks." *International Journal of Pattern Recognition and Artificial Intelligence* 15 (1): 9-42.

Kinlaw, W., M. Kritzman, M. Metcalfe, and D. Turkington (2022). "The Determinants of Inflation." *MIT Sloan Research Paper*, No. 6730, http://dx.doi.org/10.2139/ssrn.4137861.

Mahalanobis, P. C. (1936). "On the generalised distance in statistics." *Proceedings of the National Institute of Sciences of India 2* (1): 49-55.

McLachlan, G. J. (1999). "Mahalanobis Distance." Resonance, *Journal of Science Education* 4 (6): 20-26.

Romero-Aguilar, R. (2020). "Apuntes de Macroeconometría." *Escuela de Economía, Universidad de Costa Rica*.

Totonchi, J. (2011). "Macroeconomic Theories of Inflation." *International Proceedings of Economics Development and Research, IPEDR 4*.