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Examining Price-Wage Dynamics in a Small Open Economy: The Case of Uruguay

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ABSTRACT: The recent increase of inflation globally has led to a renewed interest in understanding the link between inflation and wages. In Uruguay, the presence of centralized wage bargaining and indexation practices raises the question as to what extent wage growth dynamics can make the response of inflation to shocks more persistent. We use a medium-scale DSGE model which incorporates indexation in the wage setting equation to analyze the interactions between wage setting behavior and other macroeconomic variables, as well as the role of monetary policy. The analysis suggests that wage indexation increases the persistence of the response of inflation to domestic and foreign shocks, it also affects the monetary policy transmission mechanism and the severity of the trade-offs faced by the central bank.

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WORKING PAPERS

Examining Price-Wage Dynamics in a Small Open Economy: The Case of Uruguay

Prepared by Pau Rabanal and M. Belén Sbrancia [1]

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Contents

I. Introduction

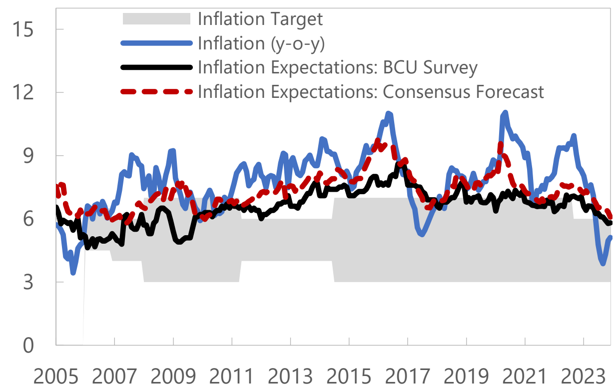
The relationship between wage setting and CPI inflation is closely monitored by central banks, as it is key to their success in achieving macroeconomic stabilization in an inflation targeting regime. Following an inflationary shock, such as an increase in oil prices or a large exchange rate depreciation, workers will demand higher wages to avoid losing purchasing power. The increase in wages will affect firms' production costs, putting upward pressure on prices, which will in turn trigger higher wage demands in the future. The strength of this channel, typically referred to as "second round effects" in central bank talk, is an important determinant of inflation persistence and the speed at which it will converge back to target after a shock, as well as the trade-offs faced by the central bank.

A recent example of this mechanism was the inflation shock of 2021-2022, when inflation increased globally due to a succession of supply (post-Covid supply chain constraints and the war in Ukraine) and demand shocks (fiscal and monetary expansions in advanced economies). As discussed by Lorenzoni and Werning (2023) for the United States, the initial CPI inflation increase, which went from below 2 percent in early 2021 to 9 percent in mid-2022, was followed by a delayed pick-up in the employment costs index, with the concern that high wage growth would further complicate the return of inflation to target or even set-off a price-wage spiral. Similar discussions took place in other advanced and emerging market economies (see IMF WEO, October 2022). More generally, in addition to Lorenzoni and Werning (2023) the feedback effects between price and wage setting, including the effects of real wage rigidities, have been studied by Blanchard and Galí (2007) and Gagliardone and Gertler (2023).

In this context, this paper examines how wage setting affects the response of CPI inflation to shocks in Uruguay. The case of Uruguay is interesting for a variety of reasons. First, it is a small open economy subject to multiple domestic and external shocks that can affect the inflationary process. Second, an important feature of Uruguay's labor market is the high degree of centralization of the wage setting process and the prevalence of indexation practices. Third, despite the recent improvements in the conduct of monetary policy since 2020, the central bank of Uruguay enjoyed low credibility in the past due to the persistent, one-sided deviations of the inflation rate from target. As a result, inflation expectations have generally remained outside the target range (see Figure 1).

The paper makes a contribution by quantitatively analyzing how all these features increase the persistence of inflation in Uruguay. The first part of the paper describes the wage bargaining process in Uruguay and presents reduced-form estimates of a standard wage Phillips Curve, based on the model developed in Galí (2011). The main finding from that section is that nominal wage growth is related to its own lag, a price inflation indexing variable, and the level in the unemployment rate. Specifications where labor productivity growth replaces the unemployment rate suggest that this variable is also a driving force for nominal wage growth. Based on this reduced form evidence, the second part of the paper studies the interaction of price and wage inflation, and the role of monetary policy credibility in general equilibrium. It presents a medium-scale open economy New Keynesian DSGE model as in Adrian et al. (2021), that is modified to include the relevant wage rigidities and indexation and is estimated using Bayesian methods on Uruguayan data.

Figure 1. Inflation in Uruguay



Source: Uruguayan authorities, IMF staff estimates

The DSGE model parameter estimates confirm the role of partial nominal wage adjustment and lagged indexation to annual CPI inflation in the wage formation process. The parameter estimates also suggest that the domestic price inflation Phillips Curve exhibits a significant degree of backward-looking behavior, which is symptomatic of low credibility by the central bank. As a result of these features, inflation displays high persistence in response to shocks. In a counterfactual exercise, wages are assumed to be sticky but indexed to the central bank inflation target. By muting price-wage feedback effects, CPI inflation exhibits less persistence, and the central bank faces a more favorable trade-off with respect to stabilizing inflation and the output gap.

Wage indexation practices are typically a response to the lack of credibility of the central bank. The central bank needs to deliver low and stable inflation for workers to agree to lower the degree of backward indexation for their wages. Further, lowering the degree of inertia in the price inflation Phillips Curve (which is also related to an increase in central bank credibility) to the EM average also helps in further decreasing inflation persistence, although this channel is quantitatively less important. Addressing these issues would lower inflation persistence to shocks and the output costs of bringing inflation back to target in Uruguay.

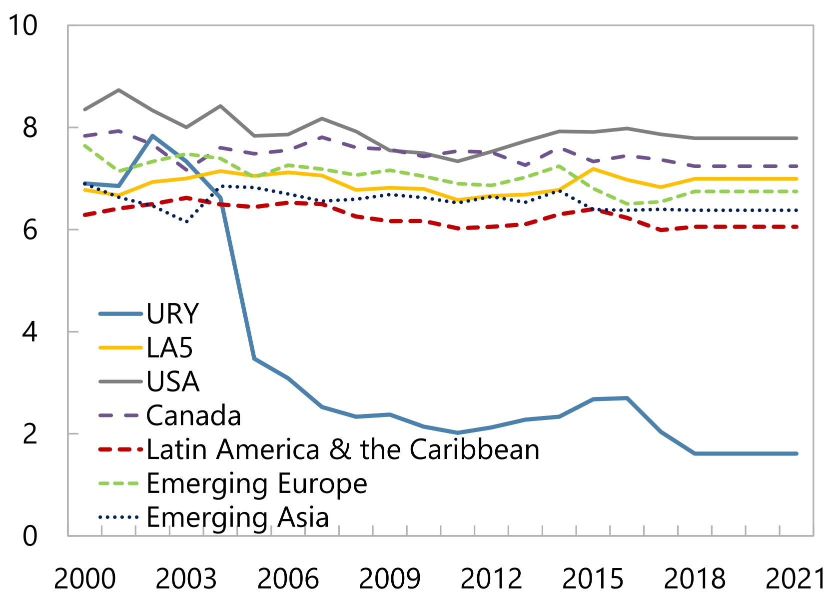
While not central to the results of the paper, the Adrian et al. (2021) model also allows for examining the role of foreign exchange interventions (FXI) as a stabilization tool that can complement conventional monetary policy decisions. The model includes financial frictions on the side of financiers that intermediate bonds in domestic and foreign currency, as in Gabaix and Maggiori (2015). This friction implies that the uncovered interest rate parity condition no longer holds in the model, and that the central bank can to some extent influence the exchange rate by purchasing or selling reserves. Given the estimated parameters of the model, the main result is that there are no significant benefits from using FXI as an additional policy tool in Uruguay.

The paper is organized as follows. Section II describes how wage bargaining takes place in Uruguay, and how it has evolved over time. Section III estimates a reduced form equation for nominal wage growth in Uruguay. Section IV presents and estimates the DSGE model for Uruguay. Section V discusses counterfactual exercises under alternative wage and price indexation rules. Section VI presents the estimated effect of interest rate and FXI, while Section VII concludes.

II. Wage Barganing in Uruguay

Collective bargaining has a long history in Uruguay. It was first introduced in 1943 with Law 10.449 which created wage councils, with an initial objective to set minimum wages, and did not include all economic sectors. The law was applied albeit with some interruption before the return of democracy in 1985. However, between 1992-2004 the government did not convene negotiations, even if the law was still in place. In 2005, negotiations were once again convened and extended to cover virtually all sectors of economic activity. Since 2009, collective bargaining is governed by Law 18.566 which, among other changes, extended the setting of wages to all workers. When compared to other economies, Uruguay's wage bargaining structure is seen as highly centralized. As an illustrative example, the "Flexible Wage Determination" index of the Frasier Institute highlights this characteristic (see Figure 2, where a lower value denotes more centralized wage bargaining).

Figure 2. Degree of Collective Wage Bargaining



Sources: Economic Freedom of the World dataset, 2022

Notes: "Flexible Wage Determination" series from the Economic Freedom of the World dataset. Wages in your country are set by a centralized bargaining process (= 1) or up to each individual company (= 7)

Wage negotiations are tripartite, including labor unions, employers and the government, with agreements negotiated at the sectoral level. The Tripartite Superior Council (TSC) is the body in charge of the coordination and governance of labor relations. It is constituted by nine members of the government, six representing workers and six representing employers, and an equal number of substitutes. One of its competencies includes the revision of the sectors for the negotiations. There are currently 24 sectors, with numerous subdivisions. Since 2005, there have been ten rounds of negotiations.

The government plays an important role in the different stages of the process. Each round of negotiation is initiated when the Executive Power convenes the TSC following its own initiative or the request of one of the parties. The government also issues guidelines ("pautas") on the suggested increase in wages as well as other relevant aspects of its wage policy. When an agreement is reached, the government has to ratify the agreement and issue a decree. In the event that there is no agreement between workers and employers, the government submits to vote an alternative proposal.

The system allows in principle to negotiate company-specific conditions but this possibility is rarely triggered *de facto*. The law stipulates that the guidelines issued by the government constitute a minimum for any agreement but allows for agreements that improve the position of the workers. However, if a company or subsector is unable to meet the wage increase stipulated in the agreement, its only recourse is to apply for an exception ("descuelgue"). A recent report argued that the current system has three main weaknesses which are related to the fact that the negotiations do not allow for heterogeneity or sector/company-specific conditions to be reflected, a feature that is reflected in part in the low frequency of "descuelgues" in each round.[3]

The duration and scope of the agreements as well as the relevant parameters to adjust wages have changed over time[4]. Contracts typically have three components for adjustment: (i) expected inflation, (ii) "*correctivo*" to compensate when past actual inflation was higher than expected, and (iii) "*recuperación*", recovery or real growth which partially reflects improvements in aggregate productivity. Over time, the duration of the agreements has increased and is currently about two years for most agreements. Also, while there were some attempts in the third through fifth round to introduce wage adjustment based (partially) on productivity, most recent rounds have not included it. On the other hand, recent rounds have split the sectors in buckets (for example, most and least affected by the pandemic). The frequency of adjustment in wages is predominantly semi-annual, even if in some earlier rounds these tended to be annual.

Relevant to our analysis, the measure of inflation expectations used in the negotiations has changed over time. In the first rounds, the option to select among different measures of inflation was given, including past inflation or the inflation expected by private analysts. Over time, the agreements moved to using the central bank's measure of inflation expectation. However, in most recent rounds, expected inflation by the government as published in its fiscal reports to Congress (the "*Rendición de Cuentas*") has been used. Since the pandemic there have been some relevant changes to the bargaining process. In 2020, the government called on a "bridge" negotiation that would last for a year and would be carried at the core sector level to avoid numerous parallel negotiations from taking place. In 2021, when the ninth round started, the government proposed to split sectors among those more or less heavily affected by the

[3] The report was requested by the Ministry of Labor and prepared by CPA Ferrere: "Negociación Colectiva y Formación Laboral en Uruguay" (2023) https://dvz8qhbz2at1c.cloudfront.net/files/2023-10/informe-proyecto-de-modernizaci-n-de-la-negociaci-n-colectiva-en-uruguay.pdf.

[4] Cukerman et al (2017)

pandemic. The proposal also differentiated the adjustment based on the size of the company and the actual recovery in employment in the sector in June 2023.

Following a complaint by the Chamber of Industry and Chamber of Commerce and Services initially on the draft law and then on the 2009 law on collective bargaining, the International Labor Organization (ILO) issued a series of recommendations to align the Uruguayan legislation to International Labor Conventions in 2010. The recommendations referred mostly to two areas: occupation of workplace during strikes, and the free and voluntary nature that should govern collective bargaining. The recommendations by the ILO, most of which have already been addressed, were:

1. Employers' and workers' organizations should have recognized legal status, to ensure the appropriate exchange of confidential information and ensure that the organizations and not individuals are responsible in case of non-compliance.
2. The level of negotiation should be determined by workers and employers and not be subject to a tripartite vote.
3. The agreement should not need to be ratified (homologacion) by the government; its role should be circumscribed to communication.
4. The possibility that agreements remain valid after expiry (ultraactividad) should be eliminated.
5. If there is no union at the company level, the workers could designate a representative to negotiate with the company instead of the union of the sector the representative by default.
6. Minimum wages can be set in a tripartite setting but other conditions on labor relations should be set in a bipartite negotiation.
7. Equal representation in the TSC.

In May 2023, a law that addressed most of these observations was approved. Law 20.145 addresses points 1-5 in from the above, while the last one had already been addressed in 2012. A key change to the bargaining processes is that once a contract expires, its terms cease to apply unless a new agreement has been signed. Another relevant change is the requirement for both employers' and workers' associations to have recognized legal status. This implies that unless the workers' association formalize their registration, the companies cannot withhold the employee contribution to the union.

The tenth round was recently concluded and will cover the period July 2023- June 2025. The guidelines issued by the government in June 2023 aimed at recovering real wages to pre-pandemic levels in sectors where these had not been recovered. Following the announcement, inflation declined faster than expected in the second half of 2023 which implied that the inflation expected for the end-of-the-year was higher than the one that materialized. As a result, the government adjusted downwards the increase in public sector wages in January 2024 to reflect the decline in inflation expectations. This measure is unusual given the dynamics of inflation in Uruguay but also the *de facto* asymmetry in the adjustments by which if inflation is above expected inflation there is a positive adjustment, but the opposite does not hold.

III. Aggregate Wage Dynamics

Having described how wage bargaining works in Uruguay in the previous section, this section examines how wages behave at the macroeconomic level using a structural wage equation as the one derived by Galí (2011) for the United States. Under certain conditions, a Calvo-style restriction for wage-setting leads to the following relationship:

$$\pi_t^w = \alpha + \beta IND_t + \gamma u_t + \delta \Delta u_t + \varepsilon_t, \quad \text{(III.1)}$$

where quarterly wage inflation (π_t^w) is related to the unemployment rate (u_t), the change in the unemployment rate (Δu_t), and a reference price inflation variable to which wages are indexed to (IND_t). A more general specification also includes partial adjustment with a lagged nominal wage growth term:

$$\pi_t^w = \rho \pi_{t-1}^w + (1-\rho)(\alpha + \beta IND_t + \gamma u_t + \delta \Delta u_t) + \varepsilon_t \quad \text{(III.2)}$$

Equation (III.2) is estimated for Uruguay using the nominal wage index series (seasonally adjusted), the unemployment series, and either: (a) the lagged annual (year-on-year) CPI inflation rate, (b) the lagged quarterly (quarter-on-quarter) CPI inflation rate, and (c) CPI inflation expectations from Consensus Forecasts.[5] The equations are estimated via OLS, and to address possible endogeneity issues, with Generalized Method of Moments (GMM) with two lags of nominal wage growth, CPI inflation, and the unemployment rate as instruments. The sample period is 1999Q1 to 2022Q4, at quarterly frequency.

The results are included in Table 1. In all specifications, the (negative) relationship between the level of unemployment and wage growth is always significant. However, none of the specifications show a significant relationship between the *change* in the unemployment rate and nominal wage growth, even though this variable has the expected sign using alternative estimation methods. All specifications find that there is some degree of nominal wage growth inertia in the data, with an estimated effect of the lagged dependent variable of about 0.4 in all specifications. Regarding the indexation variable, the highest coefficients are obtained with the lagged annual CPI inflation rate, especially when the model is estimated with GMM. In that case, the estimated coefficient is the highest with a point estimate of 0.48

[5] When using annual inflation rates, these are rescaled so that they are consistent with the quarterly wage inflation dependent variable. Inflation expectations from the Central Bank of Uruguay survey were also used in the analysis, delivering similar results.

Table 1. Wage Inflation Estimates

Alpha	3.4***	3.48***	3.47***	3.2***	3.48***	3.45***
	(0.45)	(0.44)	(0.47)	(0.34)	(0.26)	(0.29)
Beta	0.29**	0.23**	0.3	0.48**	0.24***	0.36*
	(0.16)	(0.11)	(0.22)	(0.16)	(0.09)	(0.18)
Gamma	-0.18***	-0.18***	-0.19***	-0.19***	-0.18***	-0.2***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)
Delta	-0.04	-0.15	-0.13	-0.11	-0.62	-0.21
	(0.18)	(0.18)	(0.19)	(0.4)	(0.43)	(0.29)
Rho	0.41***	0.44***	0.45***	0.35***	0.38***	0.45***
	(0.1)	(0.09)	(0.1)	(0.13)	(0.15)	(0.09)
Adjusted R2	0.45	0.46	0.44	0.43	0.4	0.44
SE regression	0.73	0.73	0.74	0.75	0.77	0.74
Indexing variable	Annual	Quarterly	Expected	Annual	Quarterly	Expected
Estimation method	OLS	OLS	OLS	GMM	GMM	GMM

Source: IMF Staff estimates

The importance of lagged annual CPI inflation can be explained because of the following. In earlier rounds of wage negotiations, lagged inflation was the relevant indexing variable during wage negotiations. More recently, wages have been indexed to expected inflation by the Ministry of Economy and Finance (not the central bank target) but with a correction clause if actual inflation is higher than expected inflation which amounts to a *de facto* backward-looking indexation.

The October 2022 *World Economic Outlook* (WEO) Chapter 3 extended the Galí (2011) model to also include productivity growth (to avoid excessive volatility in this indicator, the average of the last 5 years is used for estimation). For the case of Uruguay, when the wage models are estimated with both unemployment and productivity growth, neither variable is significant. This result could be explained by the fact that the correlation between labor productivity growth and the unemployment rate in Uruguay is quite high and negative (-0.84), suggesting potential collinearity issues. When the model is estimated with productivity growth only (and excluding the level and first different of unemployment), this variable on its own is a significant driver of wage dynamics. Table 2 presents the estimates of the following regression:

$$\pi_t^w = \rho\pi_{t-1}^w + (1-\rho)(\alpha + \beta IND_t + \gamma PROD_t) + \varepsilon_t \qquad \text{(III.3)}$$

Moreover, the coefficient on lagged nominal wage growth is similar to the estimates obtain in Table 1. The indexing variables exhibit generally smaller coefficients and less significance than in the case of Table 1. The highest coefficient is obtained with the GMM regression using the lagged annual CPI inflation rate.

Table 2. Wage Inflation Estimates with Productivity

Alpha	1.5***	1.59***	1.66***	1.27***	1.79***	1.64***
	(0.35)	(0.28)	(0.45)	(0.46)	(0.29)	(0.38)
Beta	0.21	0.17	0.14	0.38*	0.16*	0.2
	(0.16)	(0.11)	(0.22)	(0.19)	(0.09)	(0.13)
Gamma	0.17***	0.17***	0.17***	0.17***	0.14***	0.16***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)
Rho	0.43***	0.46***	0.46***	0.43***	0.49***	0.49***
	(0.1)	(0.09)	(0.1)	(0.1)	(0.1)	(0.1)
Adjusted R2	0.45	0.45	0.44	0.43	0.44	0.43
SE regression	0.73	0.73	0.74	0.74	0.74	0.75
Indexing variable	Annual	Quarterly	Expected	Annual	Quarterly	Expected
Estimation method	OLS	OLS	OLS	GMM	GMM	GMM

Source: IMF Staff estimates

The main conclusion from this section is that, in the aggregate, wages in Uruguay react to labor market indicators. Specifically, they react to either the level of unemployment or medium-term productivity growth. They also exhibit partial indexation to lagged inflation and partial nominal wage adjustment. Amongst all the indexing variables, the evidence points to partial indexation to lagged annual CPI inflation.

Finally, wage dynamics in Uruguay do not appear to be significantly different from those in other similar countries. Chapter 3 in the October 2022 WEO provides estimates for a group of emerging markets. While the specifications are not strictly comparable because the WEO chapter uses panel data estimation techniques, the dependent variable is annual rather than quarterly wage growth, and there is no lagged wage growth term, some qualitative results are similar. For both the EM group and Uruguay, wage growth reacts to the level of unemployment and productivity growth. Moreover, there is evidence of partial indexation to lagged CPI inflation, and weak evidence of indexation to expected inflation. The main difference between the EM group and Uruguay is the importance of the change of the unemployment rate (significant for the EM group, not significant for Uruguay).

IV. An Estimated DSGE Model with Price and Wage Rigidities

To analyze the interactions between wage setting behavior and other macroeconomic variables, including CPI inflation, and the role of monetary policy, it is necessary to use a medium-scale DSGE model. This section presents an estimated version of the Adrian et al. (2021) model that was developed to implement the Integrated Policy Framework (IPF) at the IMF. This model has been estimated for a sample of advanced and emerging economies in Chen et al. (2023). In this section we explain how the model has been adapted to Uruguay, including by modifying the wage setting equation to incorporate indexation consistent with the reduced-form evidence of the previous section, and estimated using Bayesian methods. Moreover, the model in Chen et al. (2023) is extended by incorporating supply (productivity) shocks, including a permanent shock that introduces growth in the model.

The DSGE model follows a canonical setup for analyzing the role of policies in small open economies (Gali and Monacelli, 2005). In order to include the real effects of monetary policy, the model includes staggered price and wage setting. In addition to nominal rigidities, the model includes the following additional frictions: (1) incomplete international financial markets with frictions in domestic credit markets and foreign exchange markets that can lead to volatile real exchange rates; (2) local currency pricing (LCP) and incomplete exchange rate pass-through that can reduce the effects of exchange rate depreciation on trade; (3) indexation rules for price and wage setting that can amplify the effects of shocks on price and wage inflation; (4) discounting in the main supply and demand intertemporal relationships that realistically mutes the potency of future policies; and (5) micro-founded endogenous private and sovereign borrowing spreads that allow the effects of FXI on exchange rate to be quantified. The model has also a foreign block so that foreign monetary and real shocks can affect the small open economy.

Households in the model derive utility from consuming domestically produced and imported varieties of goods as well as leisure, subject to a budget constraint. They co-own firms and financial intermediaries and can trade bonds issued in local currency by the government and financiers. Labor is differentiated and wages are rigid and set in a staggered Calvo-style fashion. Following the evidence in the previous sections, wages are indexed to a convex combination of lagged nominal wage growth and annual CPI inflation when they are not optimally reset.

Firms producing differentiated intermediate goods are monopolistically competitive, while those producing final goods (for domestic consumption and exports) are perfectly competitive. Prices for intermediate goods are set in staggered Calvo-style contracts. Export prices are set in the currency of the destination market (i.e., local currency pricing or LCP), in this case in US dollars. Imports prices are also sticky in the domestic currency, which implies a gradual pass-through of exchange rate fluctuations to domestic inflation. Indexation in price setting proxies for less well-anchored inflation expectations.

The model incorporates financial market frictions that lead to deviations from the Uncovered Interest rate Parity (UIP) condition, following the contribution of Gabaix and Maggiori (2015). Financial intermediaries—partly domestic and partly foreign—comprise banks, portfolio investors, and financiers. Banks transfer funds between households and financiers; they are perfectly competitive and subject to a borrowing constraint. Portfolio investors take positions in home currency (LC) bonds, financed by issuing foreign currency (FC) bonds of the same value. Stochastic variation in these LC positions reflects changes in risk appetite for LC assets. Finally, and most importantly, financiers intermediate cross-border FX conversion. They take symmetric nominal positions in LC ad FC bonds to maximize profits in the presence of an agency friction, the degree of which is used to proxy “FX market depth”: a greater friction limits the capacity of financiers to insure against FX risks and so is equivalent to shallower FX markets.

The central bank follows a simple Taylor rule for the short-term interest rate and can also engage in sterilized FXIs. The carry-cost of reserves is assumed to be fully borne by the fiscal authorities. Changes in the government's net asset positions and spending are mainly financed using distortionary taxes on private consumption and labor income.

A. The Linearized Model

This subsection presents the main building blocks of the model in linearized form, which summarize the main economic relationships and transmission channels. A full derivation of the model is presented in Adrian et al. (2021). The model has the following five building blocks: (i) aggregate demand, (ii) aggregate supply, (iii) financial, (iv) central bank policies, and (v) the foreign country. In the model, growth is given by a permanent technology shock that has a unit root with drift parameter μ_Z. Real variables are scaled by the permanent shock to render them stationary and ensure that they grow at the same rate along the balanced growth path. Unless otherwise stated, variables in lower cases and with a hat are expressed as deviations from their steady-state and rescaled by the unit root productivity shock, to make them stationary.

Aggregate Demand

The aggregate demand block stipulates that domestic production is used for private consumption (endogenous), government spending (exogenous), and exports and imports (endogenous). Since the model abstracts from capital accumulation, the first equation below has the following interpretation: aggregate demand ($\hat{y}_t$) is determined by total private consumption ($\hat{c}_t$), government spending ($\hat{g}_t$), and trade balance (measured by the difference between total real exports, $\widehat{m}_t^*$, and imports, $\widehat{m}_t$).

$$\hat{y}_t = c_y \hat{c}_t + g_y \hat{g}_t + m_y(\widehat{m}_t^* - \widehat{m}_t), \tag{IV.1}$$

where the contribution of each variable is weighted by its steady-state share of output.

Consumption depends on real interest rates ($i_t - \pi_{c,t+1|t}$), a domestic risk premium shock (ψ_t), preference shocks ($\upsilon_{c,t}$), and growth shocks ($\mu_{z,t}$). The effect of interest rates on consumption is captured by the elasticity of intertemporal substitution (σ). The consumption equation also includes habit formation (captured by the parameter *h*) and discounting (captured by the parameter δ_c), to improve the empirical fit and realistically mute the effect of future policies on consumption:

$$\begin{aligned}\hat{c}_t = {} & \frac{\delta_c}{1+\delta_c\tilde{h}}\hat{c}_{t+1|t} + \frac{\tilde{h}}{1+\delta_c\tilde{h}}\hat{c}_{t-1} - \frac{\sigma(1-\tilde{h})}{1+\delta_c\tilde{h}}\left(i_t + \psi_t - \pi_{c,t+1|t}\right) \\ & + \frac{1}{1+\delta_c\tilde{h}}\left(\upsilon_{c,t} - \delta_c\upsilon_{c,t+1|t}\right) + \frac{1}{1+\delta_c\tilde{h}}\left(\delta_c\hat{\mu}_{z,t+1|t} - \tilde{h}\hat{\mu}_{z,t}\right),\end{aligned} \tag{IV.2}$$

where $\tilde{h} = h/\mu_Z$ is the habit formation parameter rescaled by the gross growth rate of the permanent technology shock.

All shocks are assumed to follow simple first-order autocorrelation (AR(1)) processes unless otherwise noted. Exports consist of both intermediate imported goods ($\widehat{m}^*_{m,t}$) and domestically produced goods ($\widehat{m}^*_{d,t}$) and depend on foreign demand $\hat{y}^*_t$ and relative prices.

$$\begin{aligned}\widehat{m}^*_{m,t} &= \hat{y}^*_t - \hat{\tilde{z}}_t - (1-\omega_x)\eta_x\left(p_{m,t}-p_t\right) - \eta_f\left(p_{x,t}-p^*_t\right) + \vartheta_{m^*,t} \\ \widehat{m}^*_{d,t} &= \hat{y}^*_t - \hat{\tilde{z}}_t + \eta_x\omega_x\left(p_{m,t}-p_t\right) - \eta_f\left(p_{x,t}-p^*_t\right) \\ \widehat{m}^*_t &= (1-\omega_x)\widehat{m}^*_{d,t} + \omega_x\widehat{m}^*_{m,t}\end{aligned} \tag{IV.3}$$

where both types of exports are detrended by the ratio of productivity differentials across countries ($\hat{\tilde{z}}_t$)

Imports are disaggregated into consumption and intermediate goods $m^*_{m,t}$ and influenced by domestic consumption and relative prices. The presence of imported intermediate imports that are reexported allows the model to explain the co-movement of imports and exports together with the preference shock $\vartheta_{m^*,t}$.

$$\widehat{m}_t = (1-\omega_x)\widehat{m}_{c,t} + \omega_x\widehat{m}^*_{m,t}$$

$$\widehat{m}_{c,t} = \hat{c}_t - (1-\omega_c)\eta_c\left(p_{m,t}-p_t\right) + \vartheta_{m,t} \tag{IV.4}$$

For all imports and exports demand equations in (IV.3) and (IV.4), ω coefficients reflect shares, and η coefficients reflect elasticities with respect to the relevant relative price.

Government spending g_t is for simplicity assumed to be spent on domestic goods only and follow an exogenous AR(1) process. While distortionary taxes are used to finance government spending in the steady state, the government balances its budget dynamically each period using lump-sum taxes. Therefore, the condition for Ricardian equivalence is met, and the conduct of fiscal policy is not a major hinderance to the central bank's macroeconomic stabilization effort.

Aggregate Supply

The aggregate supply block specifies how prices and wages are determined, assuming the presence of Calvo-type rigidities and indexation. Moreover, price setting for firms faces a Kimball-type demand aggregator that allows for possible asymmetric effects of inflation and Phillips curves slopes that better fit the data, see Adrian et al. (2021) and Smets and Wouters (2007) for a discussion. Domestic price inflation π_t follows a Phillips curve with slope κ_p. Export ($\pi_{x,t}$) and import ($\pi_{m,t}$) pricing allow for a gradual and inherently persistent pass-through of nominal exchange rate movements (Δs_t). Indexation in price setting, captured by the ι coefficients in all Phillips curves, proxies for less well-anchored inflation expectations. Consumer Price Index (CPI) inflation is the weighted average of domestic price inflation π_t. and import price inflation $\pi_{m,t}$.

$$\pi_t - \iota_p\pi_{t-1} = \beta\delta_c\left(\pi_{t+1|t} - \iota_p\pi_t\right) + \kappa_p mc_t + \varepsilon_{\pi,t}$$

$$\pi_{m,t} - \iota_m\pi_{m,t-1} = \beta\delta_c\left(\pi_{m,t+1|t} - \iota_m\pi_{m,t}\right) + \kappa_m mc_{m,t} + \varepsilon_{\pi_m,t} \tag{IV.5}$$

$$\pi_{x,t} - \iota_x \pi_{x,t-1} = \beta\delta_c\left(\pi_{x,t+1|t} - \iota_m \pi_{x,t}\right) + \kappa_x mc_{x,t}$$

$$\pi_{c,t} = (1-\omega_c)\pi_t + \omega_c \pi_{m,t}$$

where the price Phillips curve slope in each sector is given by $\kappa_j = (1-\xi_j)(1-\beta\xi_j)/[\xi_j + (1-\epsilon\phi)]$, ξ_j is the Calvo probability (of not resetting prices optimally in each period), ϵ is the curvature of the Kimball aggregator, and ϕ is the steady-state price mark-up.

Wage setting follows Erceg, Henderson and Levin (2000) and depends on the expected wage growth and the labor wedge, i.e., the difference between the marginal rate of substitution and the consumption based real wage $\left(mrs_t - \zeta_{c,t}\right)$. In addition, it is assumed that when not reoptimized, wages are indexed to a combination of lagged nominal wage growth and annual CPI inflation, consistent with the reduced-form estimations of Section [III]. This channel has the capacity to generate persistent responses of price and wage inflation to shocks, requiring a more aggressive interest rate response to re-anchor inflation expectations and bring inflation back to target.

$$\begin{gathered}
\pi_{w,t} - \tilde{\pi}_{w,t-1} = \beta\delta_c(\pi_{w,t+1|\mathrm{t}} - \tilde{\pi}_{w,t}) + \kappa_w(mrs_t - \zeta_{c,t}) + \varepsilon_{w,t} \\
\tilde{\pi}_{w,t} = \iota_w \pi_{w,t} + (1-\iota_w)\bar{\pi}_{c,t-1} \\
\bar{\pi}_{c,t} = (\pi_{c,t} + \pi_{c,t-1} + \pi_{c,t-2} + \pi_{c,t-3})/4 \\
\zeta_t = \omega_c\left(p_{m,t} - p_t\right) + \zeta_{c,t} \\
\zeta_t = \zeta_{t-1} + \pi_{w,t} - \pi_t - \hat{\mu}_{z,t},
\end{gathered} \tag{IV.6}$$

where all price and wage cost-push shocks $\varepsilon_{\pi,t}$, $\varepsilon_{\pi_m,t}$ and $\varepsilon_{w,t}$ are white noise. The slope of the wage Phillips curve is given by $\kappa_w = (1-\xi_w)(1-\beta\xi_w)\theta_w/\xi_w[(1+\theta_w)\chi + \theta_w]$ where ξ_w is the Calvo lottery for wage setting, θ_w is the average wage mark-up, and χ is the Frisch elasticity of labor supply

The production function is given by a standard Cobb-Douglas specification with a fixed cost of production and labor elasticity $(1-\alpha)$. In log-linear terms, it becomes:

$$\hat{y}_t = (1+\phi)\left(\tilde{\epsilon}_t - \alpha\hat{\mu}_{z,t} + (1-\alpha)n_t\right) \tag{IV.7}$$

where ϕ is the gross price mark-up, $\tilde{\epsilon}_t$ is the temporary productivity shock, $\hat{\mu}_{z,t}$ is the permanent growth productivity shock, and n_t is the labor input.

Financial Block

The financial block includes banks that engage in lending and financiers who trade currencies. It focuses on two types of financial frictions: the so-called Gabaix and Maggiori (2015) wedge or the "agency friction" due to financiers' limited risk-bearing capacity. Together with discounting, they give rise to a modified UIP condition for the product real exchange rate $q_{p,t} = s_t + p_t^* - p_t$. When the "agency friction" Γ is high, which can be interpreted as FX markets being shallow, credible FX interventions may be effective. The second equation relates the net foreign assets with the stock positions of the private sector and the central bank. It also includes an exogenous capital outflow shock $(\tilde{b}_{P,t})$ that leads to an exchange rate depreciation in the model. The third equation of the financial block is the log linearized equation for net foreign assets b_t, which shows the accumulation of NFA due to net exports nx_t, revaluation, interest rate spreads and carry costs. Finally, the last equation defines a 10-year nominal rate, which is needed to identify the domestic risk-premium shock ψ_t, which in the linearized model is assumed to be exogenous.

$$q_{p,t} = \delta_c q_{p,t+1|t} + \left(i_t^* - \pi_{t+1|t}^*\right) - \frac{1+r}{1+r^*}\left(i_t - \pi_{t+1|t}\right) + \frac{1+r}{1+r^*}\Gamma\left[b_{F,t} + b_F\left(i_t - \pi_{t+1|t}\right)\right]$$

$$b_{F,t} = -b_t - \left(\frac{1}{\Gamma}\right)\tilde{b}_{P,t} + b_{M,t} \tag{IV.8}$$

$$b_t = \frac{\tilde{I}}{\Pi_y}b_{t-1} + \frac{b}{\Pi_y}\left[(1-\omega)Ii_{t-1} + \omega I^*\Delta_S(i_{t-1}^* + \Delta s_t) - \tilde{I}\left(\pi_t + \hat{\mu}_{z,t}\right)\right] - \frac{1-\omega}{\Pi_y}b_M\left[Ii_{t-1} - I^*\Delta_S(i_{t-1}^* + \Delta s_t)\right]$$
$$- \frac{(1-\omega)(I - I^*\Delta_S)}{\Pi_y}\left(b_{M,t-1} - b_M\left(\pi_t + \hat{\mu}_{z,t}\right)\right) + nx_t.$$

$$i_{L,t} = \frac{1}{40}\sum_{k=0}^{40}\left(i_{t+k} + \psi_{t+k}\right)$$

Monetary Policy

The central bank policy block assumes an interest rate policy reaction function, which is a standard simple forward-looking rule responding to inflation forecasts and featuring interest rate smoothing. Higher ρ means a higher degree of smoothing, while higher γ_π implies stronger policy reaction to expected inflation 4 quarters ahead (and hence more aggressive monetary policy). The central bank also reacts to the output gap, and the rule is subject to white noise monetary policy shocks.

$$i_t = \rho i_{t-1} + (1-\rho)\left[(1+\gamma_\pi)\bar{\pi}_{c,t+4|t} + \gamma_y\hat{y}_t\right] + \varepsilon_t^i \tag{IV.9}$$

In addition, the central bank can also use FXI, measured by changes in FX reserves in log-linear form ($fx_t = b_{M,t}$ - $bB_{M,t-1}$). While the Central Bank of Uruguay does not intervene in the FX market currently, it is important to account for previous FX intervention policies during the sample period used for estimation.[6] It is assumed that FXI is endogenous and reacts to changes in the exchange rate with smoothing. The formulation of this rule is primarily driven by empirical considerations.

$$fx_t = \rho_{fx,1}fx_{t-1} - \rho_{fx,2}b_{M,t-1} - \left(1-\rho_{fx,1}\right)\frac{\gamma_{\Delta s}}{1-\gamma_{\Delta s}}\,\Delta s_t + \varepsilon_t^{fx} \tag{IV.10}$$

Foreign Block

Lastly, the foreign block is a closed economy formulation of the model above with equations for output, private consumption, price and wage inflation, and the policy rate. It includes seven shocks: government

[6] See Bucacos et al. (2019).

spending, consumption demand as well as permanent and transitory technology shocks, price and wage cost-push shocks, and monetary policy shocks (the last three are assumed to be white noise). Shocks in this large foreign economy can impact the small open economy, but shocks from the small open economy are assumed not have any effect on the foreign block.

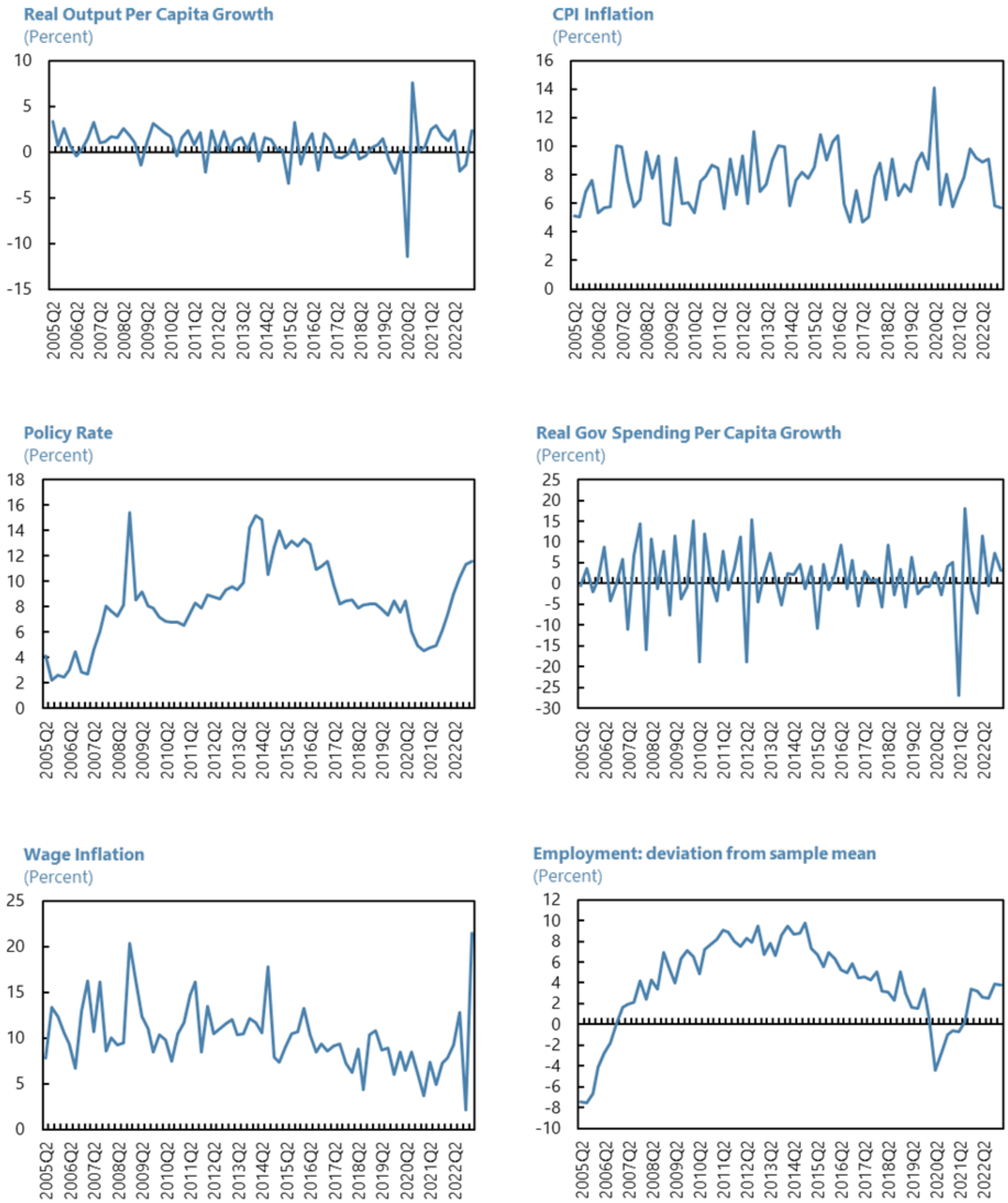
B. Estimation

The baseline DSGE model is estimated on quarterly data (2005:Q1–2023:Q1) for Uruguay with Bayesian likelihood methods. There are eleven domestic and six foreign macroeconomic variables (observables) used in model estimation. Domestic variables include real GDP growth, real imports and exports growth, real government spending growth, CPI inflation, nominal wage growth (seasonally adjusted), employment, the short-term (1 month) interest rate, long-term (10 year) government bond yields, the bilateral exchange rate with the USD, and foreign exchange intervention as percent of GDP (Figure 2). Foreign variables include real output growth, real government spending growth, CPI inflation, wage growth, employment, and the policy rate for the United States. Some of the variables are measured as deviations from their steady state, while others are expressed in levels or log levels. Real growth of national accounts components is normalized by population growth.

In practice, parameters pertaining to some structural parameters and shock processes are estimated using standard priors widely adopted in the DSGE literature. Parameters pertaining to steady-state ratios are calibrated using historical means. Other structural parameters such as some elasticities and shares are also calibrated, using information from Uruguay when available and a sample of EMs when not (see Table 3). For instance, the shares of each GDP component, the ratios of reserves and NFA to (quarterly GDP) are calibrated using Uruguay data, while the steady-state rate of inflation is assumed to be the upper band of the inflation target. Most macroeconomic and trade elasticities are calibrated at parameters that are conventional in the international macro literature (see Chen et al., 2023).

In the model, thirteen structural domestic shocks and seven foreign shocks were used to account for fluctuations in the main macroeconomic variables. These include technology, price markup, wage markup, government spending, private demand, risk premia, monetary policy and foreign exchange intervention shocks. Finally, the model estimation conditions on a pre-estimated US economy model (as a proxy for “foreign economy”) estimated separately. Even so, US variables are included as observables to assess the role of foreign and domestic shocks. Moreover, the US shocks and the subsequent dynamic responses of the US output, inflation, wages, and interest rate will be model based and consistent.

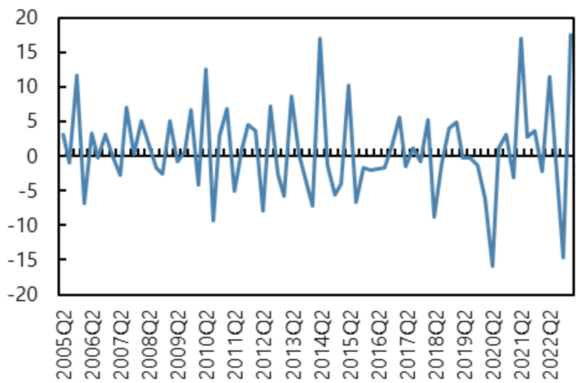
Figure 3. DSGE Model Observable Uruguay Domestic Variables



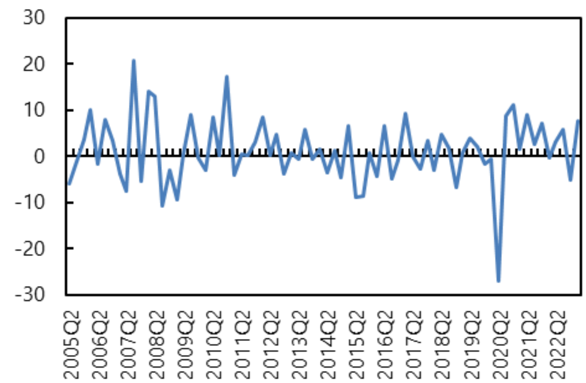
Notes: All growth, inflation and interest rate variables are shown in annualized terms.
Source: Uruguayan authorities and IMF staff calculations.

Figure 3. DSGE Model Observable Uruguay Domestic Variables (concluded)

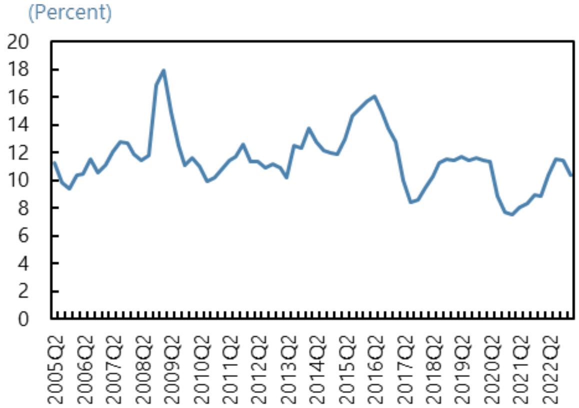
Real Export Per Capita Growth
(Percent)



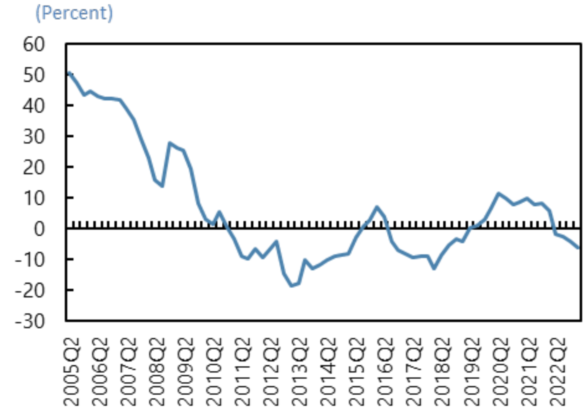
Real Import Per Capita Growth
(Percent)



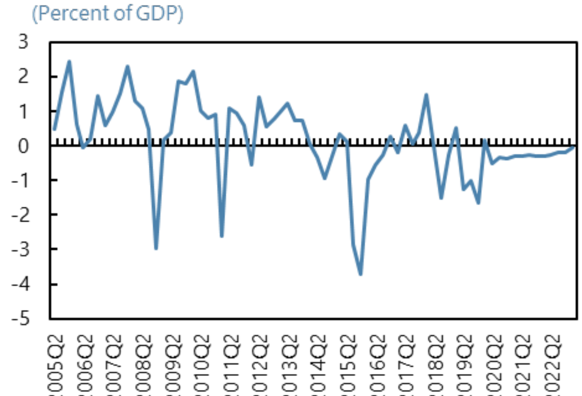
Long-term yield
(Percent)



Real Exchange Rate: Deviation from Mean
(Percent)



FXI
(Percent of GDP)



Notes: All growth, inflation and interest rate variables are shown in annualized terms.
Source: Uruguayan authorities, Adler et al. (2021) and IMF staff calculations

Table 3. Calibrated Parameters

Parameter	Description	
$\overline{b_M}$	Reserves relative to quarterly GDP	0.84
β	Household subjective discount factor	0.9999
$\bar{\pi}$	Steady-state inflation (APR)	6
$\bar{r}$	Steady-state real rate (APR)	2
g_y	Share of government expenditure in GDP	0.258
ω_x	Share of imports in exports	0.118
m_y	Share of exports and imports in GDP	0.297
ω_c	Share of import goods in consumption	0.353
$\overline{tp}$	Term premium (APR)	1.5
μ_z	Real growth rate (quarterly, in gross terms)	1.005
α	Capital elasticity in production function	0.3
χ	Frisch elasticity of substitution	2
η_c	Import price elasticity	0.8
η_x	Export price elasticity	0.8
$\chi/(1-\alpha)$	Marginal rate of consumption/leisure substitution	2.857143
σ	Coefficient of relative risk aversion	1
θ_w	Wage mark-up (net)	0.333333
ω	Ownership share of financial intermediaries/investors	0.8
$\bar{b}$	NFA relative to quarterly GDP	-1.012
ϕ	Price mark-up (net)	0.5
ϵ	Kimball curvature	12

Note: APR means Annualized Percentage Terms.
Source: IMF staff estimates.

Table 4 presents the estimated structural parameters of the model. For comparison, Table 4 also includes the estimated parameters of the model for a group of advanced economies and emerging economies estimated by Chen et al. (2023).[7] Generally, the estimated parameters for nominal rigidities (Calvo-type probabilities and indexation) are well-behaved and similar to what the literature has found for other emerging economies (see Chen et al., 2023) as well as for Uruguay (see Basal et al., 2016). Specifically, the Calvo parameters suggest that prices are reset optimally about once a year, but with substantial indexation, especially the domestic inflation Phillips Curve. This estimate could be reflecting the relatively lower credibility of the Central Bank of Uruguay that leads to more backward-looking behavior by price-setters when compared to other emerging economies.

Wages are reset optimally once every six quarters, and they are indexed more to lagged annual CPI inflation, with a coefficient of 0.67, than to lagged nominal wage growth, that has a coefficient of 0.33.[8] The estimated parameters for habit formation and discounting are also similar to what has been estimated for other economies. Finally, the posterior mean of the parameter that governs the frictions in

[7] Some parameters are not strictly comparable because some model specifications are different. The Chen et al. (2023) model specification excludes permanent and transitory technology shocks and transforms observable variables in a different way (filtering instead of log-first differencing).

[8] The wage indexation equation in the Chen et al. (2023) model includes indexation to nominal exchange rate depreciation instead to CPI inflation, so these parameter estimates are not comparable.

the FX market (Γ) takes a value of about 0.015. This is smaller than for most EMs and close to what has been estimated for AEs. As will be discussed below, the low estimated vale for this friction implies that FX intervention has a small macroeconomic effect in Uruguay.

Table 4. Estimated Parameters

Parameter		Prior distribution type	mean	std. dev.	Posterior distribution AEs	EMEs	URY (mean/90 percent C.I.)		
Calvo parameter for import prices	ξ_m	beta	0.66	0.05	0.85	0.77	0.79	0.74	0.83
Calvo parameter for domestic prices	ξ_p	beta	0.66	0.05	0.84	0.92	0.66	0.58	0.74
Calvo parameter for wages	ξ_w	beta	0.75	0.05	0.79	0.72	0.84	0.80	0.88
Calvo parameter for export prices	ξ_x	beta	0.66	0.05	0.89	0.85	0.70	0.61	0.79
Imported goods price indexation	ι_m	beta	0.7	0.2	0.73	0.74	0.62	0.35	0.91
Domestic price indexation	ι_p	beta	0.7	0.2	0.54	0.48	0.76	0.47	1.00
Exported goods price indexation	ι_x	beta	0.7	0.2	0.79	0.66	0.43	0.11	0.74
Wage indexation	ι_w	beta	0.5	0.15	0.36	0.57	0.33	0.18	0.49
Habit formation	h	beta	0.7	0.15	0.23	0.37	0.38	0.23	0.53
Discount factor	δ_d	norm	0.985	0.0075	0.97	0.97	0.97	0.95	0.98
FX market friction	Γ	beta	0.05	0.025	0.02	0.03	0.02	0.00	0.03
Domestic risk premium shock persistence	ρ_ψ	beta	0.85	0.05	0.83	0.75	0.84	0.78	0.90
Domestic demand shock persistence	ρ_{ε^c}	beta	0.85	0.05	0.94	0.91	0.93	0.89	0.97
Govt. expenditure shock persistence	ρ_{ε^g}	beta	0.85	0.05	0.92	0.85	0.86	0.80	0.92
Import demand shock persistence	$\rho_{\varepsilon^{\vartheta m}}$	beta	0.85	0.05	0.81	0.80	0.84	0.78	0.90
Export demand shock persistence	$\rho_{\varepsilon^{\vartheta m*}}$	beta	0.85	0.05	0.93	0.86	0.91	0.87	0.96
Exchange risk premium shock persistence	ρ_{ε^q}	beta	0.85	0.05	0.91	0.91	0.92	0.88	0.96
Temporary productivity shock persistence	ρ_ϵ	beta	0.85	0.05	-	-	0.84	0.74	0.93
Unit root productivity shock persistence	ρ_{μ^z}	beta	0.75	0.1	-	-	0.73	0.57	0.95
Convergence speed productivity	$\tilde{\rho}_{\mu^z}$	beta	0.05	0.025	-	-	0.01	0.00	0.02
Domestic demand shock	σ_{ε^c}	invg	0.5	2	2.50	3.55	5.93	4.49	7.28
Imported inflation shock	$\sigma_{\varepsilon^{\pi m}}$	invg	0.1	2	0.55	0.51	1.72	1.38	2.06
Domestic inflation shock	$\sigma_{\varepsilon^{\pi}}$	invg	0.1	2	0.42	0.51	0.08	0.02	0.15
Wage inflation shock	$\sigma_{\varepsilon^{\pi w}}$	invg	0.1	2	0.71	1.86	0.92	0.79	1.05
Domestic risk premium shock	$\sigma_{\varepsilon^{\psi}}$	invg	0.1	2	0.48	1.32	1.95	1.28	2.60
Govt. expenditure shock	σ_{ε^g}	invg	0.5	2	1.03	3.31	7.65	6.52	8.63
Import demand shock	$\sigma_{\varepsilon^{\vartheta m}}$	invg	1	2	3.23	4.95	5.21	4.53	5.90
Export demand shock	$\sigma_{\varepsilon^{\vartheta m*}}$	invg	1	2	17.06	30.03	6.19	5.35	6.99
Exchange risk premium shock	σ_{ε^q}	invg	1	2	0.78	0.82	0.70	0.50	0.89
Interest rate shock	σ_{ε^i}	invg	0.1	2	0.08	0.17	0.36	0.31	0.41
FXI shock	$\sigma_{\varepsilon^{\Delta R}}$	invg	0.5	1	2.01	6.00	0.74	0.64	0.84
Temporary productivity shock	σ_ϵ	invg	0.1	0.1	-	-	0.23	0.03	0.43
Unit root productivity shock	σ_{μ^z}	invg	0.5	1	-	-	1.71	1.46	1.97
Interest rate reaction to CPI inflation	γ_π	norm	0.5	0.25	1.10	0.62	0.68	0.32	1.07
Interest rate reaction to output gap	γ_y	beta	0.125	0.05	0.10	0.09	0.12	0.05	0.17
Interest rate smoothing	ρ	beta	0.75	0.05	0.85	0.82	0.69	0.62	0.75
FXI response to change in exchange rate	$\gamma_{\Delta S}$	beta	0.5	0.125	0.13	0.45	0.20	0.15	0.25
FXI persistence	$\rho_{\Delta R}$	beta	0.5	0.15	0.25	0.45	0.46	0.33	0.61
FXI rule error correction	ρ_R	beta	0.05	0.025	0.04	0.02	0.02	0.01	0.03

Source: IMF staff estimates.

The bottom block of Table 4 shows the estimated parameters for the interest rate rule as well as the historical FX rule. Regarding the Taylor rule, the estimated coefficients are quite similar to those estimated in the literature for other EMs and also for Uruguay: the response to inflation is quite high (about 0.7) but the response to the output gap is quantitatively small. However, the somewhat lower estimated degree of interest rate inertia in Uruguay (about 0.7, while it is above 0.8 for other EMs and AEs) could be related to the fact that during several periods in recent history (between 2002 and 2007, and again between 2013 and 2020), monetary policy was conducted by targeting monetary aggregates, implying that short-term rates were more volatile and less persistent during those periods. Regarding the

FX intervention rule, the estimated response to a change in the exchange rate is about 0.2 (close to the AE average than to the EM average) with higher degree of policy inertia (0.45) than in other economies. Finally, the Bayesian estimation procedure also provides a convenient model comparison device by focusing on the estimated Marginal Likelihood of different versions of the model, which allow the researcher to update its priors as to which model is more supported by the data (see Rabanal and Rubio-Ramírez, 2005; for a detailed explanation). Alternative models with different indexation mechanisms for the wage Phillips curve were estimated, assuming that wages were indexed to lagged quarterly CPI inflation or to the steady-state rate of inflation. Other versions assumed that indexation to lagged nominal wage growth did not play a role. The baseline model with wages indexed to a combination of lagged wage growth and annual CPI inflation ranked highest according to the Marginal Likelihood criterion, providing evidence that this specification delivers the best model fit.

Table 5. Model Comparison

Lagged wage growth	Indexing Variable	Marginal Likelihood
Yes	Lagged Annual	-2985.6
Yes	Lagged Quarterly	-2992.2
Yes	Steady State	-2992.8
No	Lagged Annual	-2992.8
No	Lagged Quarterly	-2990.9
No	Steady State	-2992.0

Source: IMF staff estimates.

V. Implications for Inflation Dynamics and Monetary Policy: Counterfactual Analysis

Having established the importance of lagged nominal wage inertia as well as annual CPI inflation in affecting the wage setting process in Uruguay, this section studies how it affects the persistence in the response of prices and wages to macroeconomic shocks. In addition, this section also studies how improvements in central bank credibility can also affect feedback effects between prices and wages. The dynamics of the estimated model are compared to a counterfactual economy where wages are only indexed to the steady-state rate of inflation (which coincides with the target of the central bank), and the degree of backward-looking behavior in the price Phillips Curve is equal to the average of a group of selected emerging economies.

Specifically, in our counterfactual, wages are set according to the following equation (in log-linear form):

$$\pi_{w,t} = \beta\delta_c\pi_{w,t+1|\mathrm{t}} + \kappa_w(mrs_t - \zeta_{c,t}) + \varepsilon_{w,t} \tag{V.1}$$

Under this specification, nominal wages are fully indexed to steady-state inflation when they are not reoptimized. As a result, they grow at the same rate as in the estimated model along the balanced growth path, implying that workers' real wages do not lose purchasing power on average. At the same time, for workers to agree to such a scheme, it is crucial that the central bank improves its credibility and its track record to deliver inflation close to target. It is also important to emphasize that if real wages were to grow persistently at a slower rate than the real economy, agents would be able to reset them at a higher rate whenever they are allowed to do so, in order to close the gap between the consumption real wage and the marginal rate of substitution $(mrs_t - \zeta_{c,t})$.

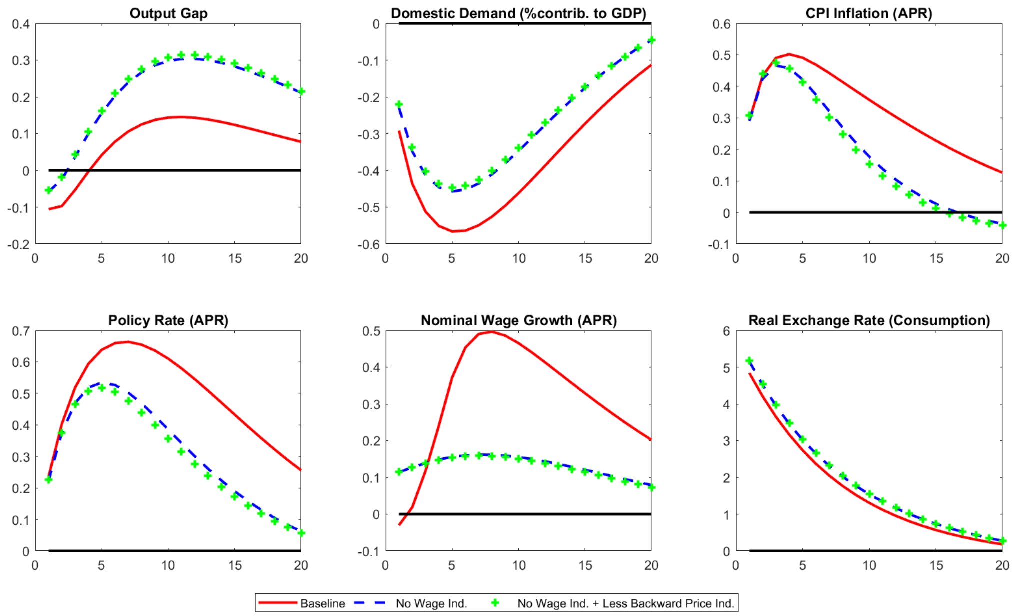
As discussed in the previous section, the estimated backward-looking coefficient in the domestic inflation Phillips Curve (ι_p) for Uruguay, 0.76, is larger than the average of advanced economies (0.54) and emerging markets (0.48). Higher inflation persistence has been related to lower central bank credibility (Erceg and Levin, 2003), but it can also be related to other factors such as such as informational rigidities (Mankiw and Reis, 2002). To simulate how an improvement of central bank credibility can affect how backward looking is the price Phillips curve, the counterfactual economy assumes that the value of ι_p is 0.48, the average in EMs.

Both in the baseline and in the counterfactual economy, and consistent with current BCU policy, it is assumed that FX intervention is not used as a policy tool, and the central bank only reacts by moving nominal interest rates according to the estimated Taylor rule. To switch off the FX Intervention response, in both the baseline and the counterfactual economy, the intervention parameter is set to $\gamma_{\Delta s} = 0$.

Impulse Response to a Global Risk Appetite Shock

The first shock we examine is a global risk or capital outflow shock, modeled as shock to the variable $\tilde{b}_{P,t}$ in the financial block equations (IV.8). Under the estimated model (solid red line), this shock triggers a real depreciation of the peso of about 5 percent, and an increase of CPI that peaks after 4 quarters at about 0.5 percent above target. Nominal wage growth is initially muted but as CPI inflation increases and the indexation effects kick in, it slowly increases and peaks about 8 quarters after the initial shock. After that, nominal wage growth returns slowly to its steady-state value. As a result, the central bank tightens the policy rate for a few quarters, and domestic demand declines. The output gap initially declines but then recovers as the depreciation improves the trade balance overtime.

Figure 4. Shock to Global Risk



Source: IMF staff estimates.

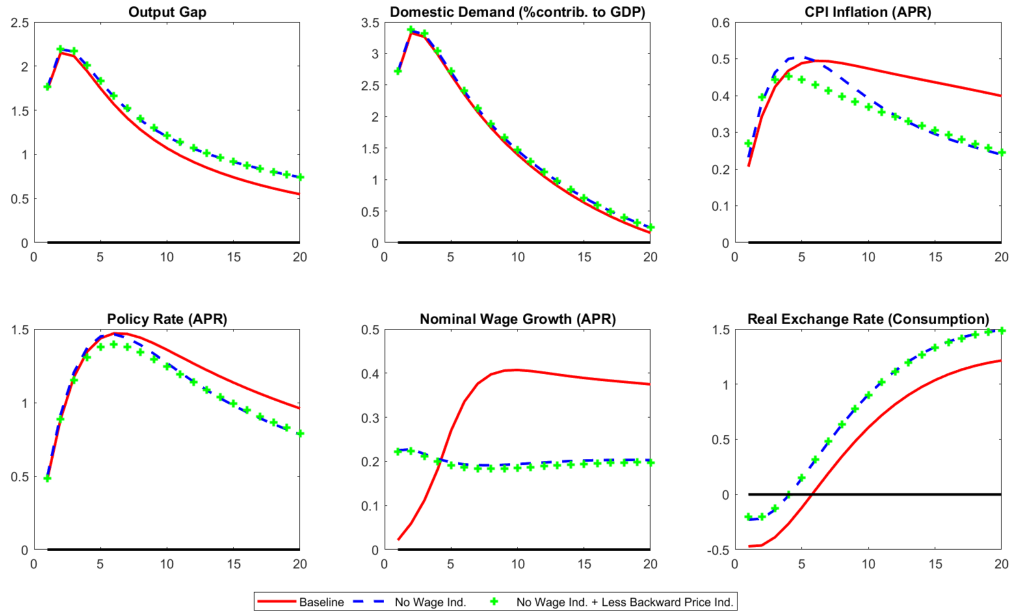
In the counterfactual experiment where wages are no longer indexed to past inflation and wage growth (dashed blue line), CPI inflation reacts initially by the same amount, due to the impact of the depreciation on imports prices, but due to the fact that wages are indexed to the central bank target rather than lagged annual CPI inflation, the response of wage inflation is also much more muted, which helps in facilitating a faster return of CPI inflation to the target.. As a result, the needed monetary tightening is smaller, and the output gap responds more positively all along, ameliorating the trade-off faced by the central bank. The dynamics of the main variables when the degree of backward-looking behavior in the price Phillips Curve is smaller(dotted green line) are slightly more favorable, but the improvement is quantitatively smaller than when wage backward-looking indexation structures are removed.

Impulse Response to a Demand Shock

Next, we examine the effects of a demand shock, modelled as a shock to preferences in the consumption equation (IV.2) that leads to more consumption for a given level of interest rates. The demand shock leads to a higher output gap, inflation, and a gradual pick up of wage growth that feeds back into a highly persistent response of CPI inflation. The central bank tightens the policy rate, and the exchange rate initially appreciates although it depreciates afterwards.

In the first counterfactual economy, the initial impact of the shock on inflation is quantitatively very similar, but the lack of backward-looking indexation in wages facilitates a more muted response of wage growth and a faster return of inflation to target. As a result, the central bank does not need to tighten rates so much, and the effect on the output gap is somewhat larger. In the second counterfactual economy, the improvement in central bank credibility reflected in lower backward-looking indexation in the price Phillips curve delivers an improved inflation profile between three and ten quarters, but the overall macroeconomic dynamics are generally unchanged.

Figure 5. Shock to Domestic Demand



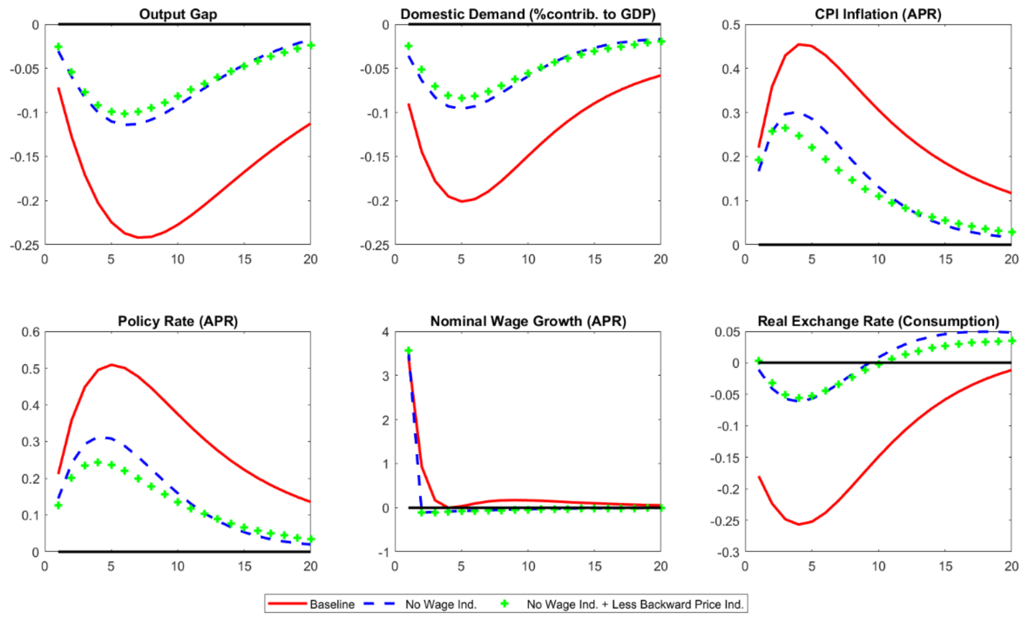
Source: IMF staff estimates.

Impulse Response to a Wage Mark-Up Shock

Finally, we examine the effects of a wage mark-up shock that takes the form of a (positive) shock to the wage equation in the aggregate supply block (IV.4). The wage mark-up shock affects domestic and CPI inflation through an increase in labor costs and the real marginal cost of production. As a result, the central bank tightens rates and the output gap declines, because both domestic demand (through interest rates) and the trade balance (through the exchange rate appreciation) contract. Again, because of the interplay between backward-looking wage indexation, and CPI inflation, the response of CPI inflation is hump-shaped and highly persistent.

In the counterfactual economies, we obtain a somewhat different result than with the two previous shocks: in this case, the response of CPI inflation is not only less persistent but is also on impact lower. It peaks at a lower value (about two thirds) than in the estimated economy, and it returns to the steady-state much faster. Because the response of inflation is lower and less persistent, the central bank does not need to tighten so aggressively, and the contraction in the output gap that is needed to bring inflation back to target is also much smaller. As in the previous case, the quantitative effects of an improvement in central bank credibility are modest.

Figure 6. Shock to the Wage Mark-up



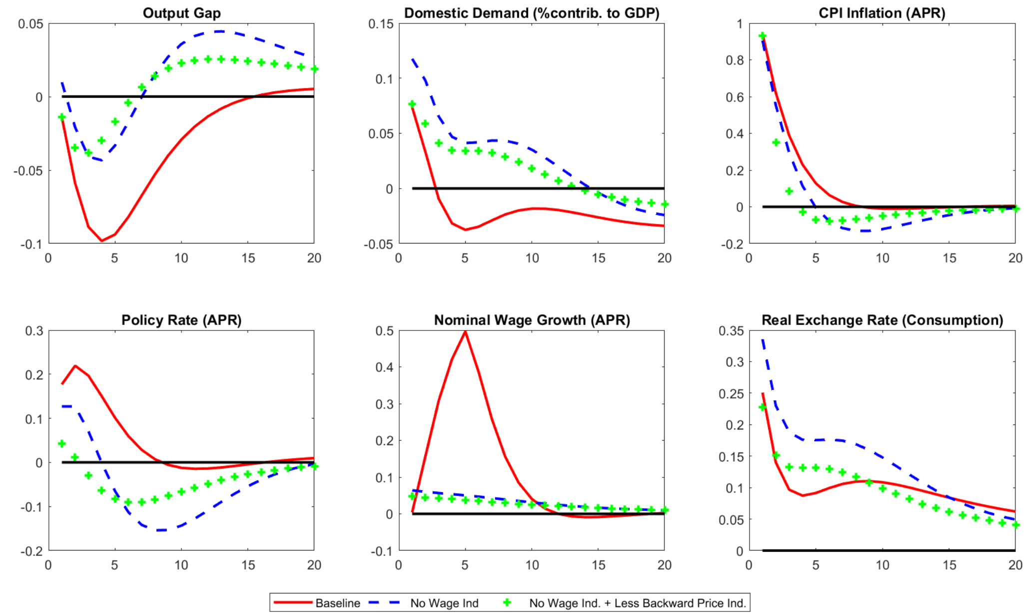
Source: IMF staff estimates.

Impulse Response to a Price Mark-Up Shock

Figure 6 presents the impulse response to a price mark-up shock that increases domestic prices. In the estimated economy, the increase in inflation triggers a delayed response in nominal wage growth which feeds back into CPI inflation, leading to an increase in the policy rate and a decline in the output gap. Under this shock, both the changes in the wage indexation and the improvement in central bank credibility lower inflation persistence, the need for the central bank to tighten policy, as well as the costs in terms of the output gap.

The key take-aways from the counterfactual exercises are as follows. The presence of indexation and partial nominal wage adjustment leads to persistent responses of CPI inflation to any shock, as wages react to the initial inflationary shock with lags and feed back to inflation through an increase of labor costs and real marginal costs. In a counterfactual economy where wages are indexed to the inflation target, CPI inflation persistence would decline by muting these wage-price feedback effects. In some cases, the initial inflationary response would also be lower. The analysis shows that the presence of wage indexation to lagged CPI inflation has important implications for the trade-offs faced by an inflation targeting central bank to stabilize output and inflation. Under higher backward-looking wage indexation, output costs are larger to offset inflationary shocks.

Figure 7. Shock to the Price Mark-up



Source: IMF staff estimates.

Second, the simulations also analyze the effect of an increase in central bank credibility by making the price Phillips Curve more forward looking, in line with the average estimates for emerging markets. For most shocks, the analysis shows that the additional decline in inflation persistence is quantitatively small. It is important to emphasize though, that the change in indexation practices (from backward looking to the inflation target) can only be achieved as long as the central bank improves its credibility. Wage indexation to past inflation emerges as an insurance to monetary shocks (see Gray, 1976), and this in turn makes inflation more persistent and worsens the central bank trade-offs.

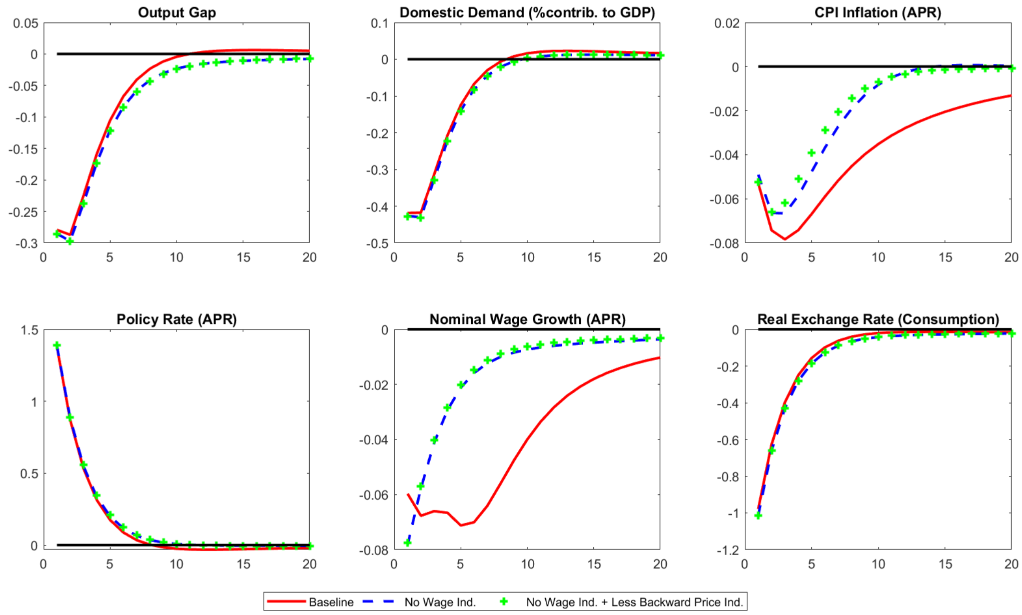
VI. The Effects of Monetary Policy and FX Interventions

The previous section has presented the estimated responses to several domestic and external shocks, together with counterfactuals with alternative wage and price indexation mechanisms. This section focuses on the effects of changes in interest rates and FX interventions.

Impulse Response to a Domestic Interest Rate Shock

Figure 7 presents the impulse response to a change in domestic interest rates. Following an increase of interest rates of about 130bps (the estimated standard deviation on an annualized basis), the output gap declines by about 0.3 percent, the exchange rate appreciates by about 1 percent, but the reaction of CPI inflation is more muted (it peaks at about 0.1 percent), due to the relatively large degree of nominal rigidities in prices and wages in the economy. These estimates are lower than those reported by Chen et al. (2023) for a sample of EMs for which the model was estimated and point to a relatively weak channel of monetary policy transmission in Uruguay. As was the case with other shocks, removing wage indexation to lagged inflation lowers the persistence in the response of inflation, while reducing the degree of backward-looking behavior in the domestic price Phillips Curve has a quantitatively smaller effect.

Figure 8. Interest Rate Shock



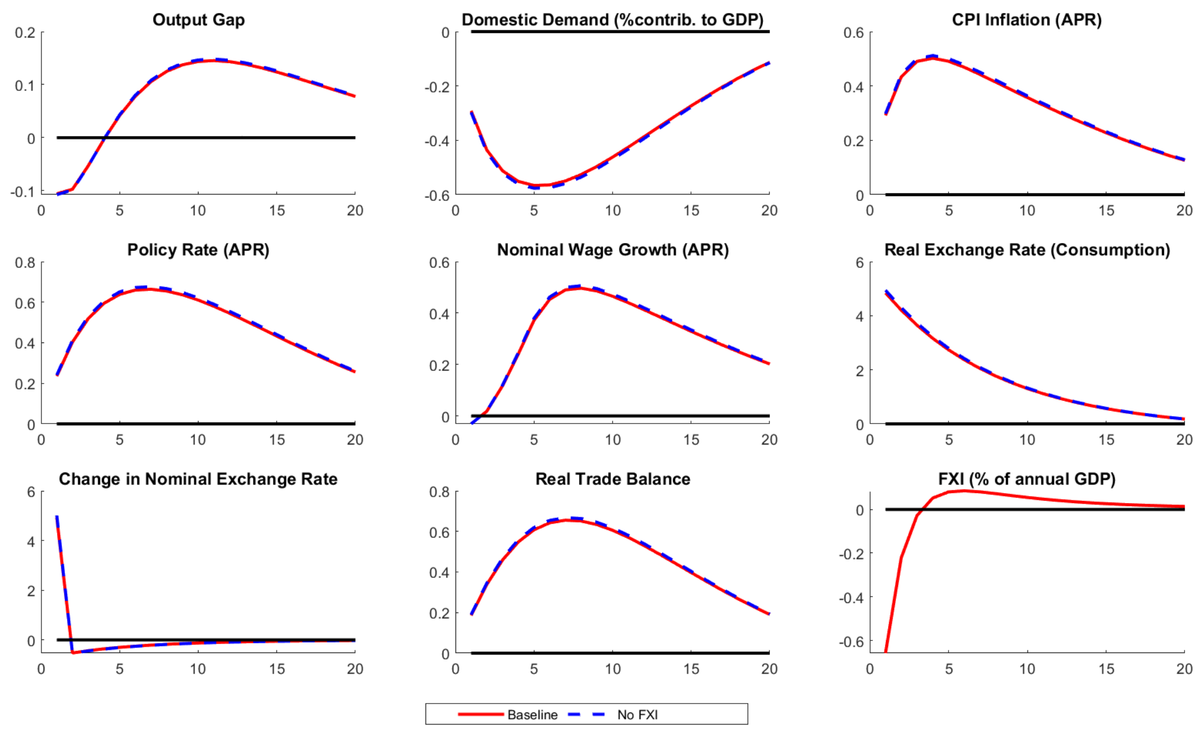
Source: IMF staff estimates.

The Effects of Foreign Exchange Interventions

The Adrian et. al (2021) model, developed for the Integrated Policy Framework (IPF) workstream, aims at modelling the role of foreign exchange interventions. In this subsection, we analyze the role of FXI for the model estimated with Uruguay data. For the purpose of this subsection, the parameters of the estimated model are utilized, as well as the assumptions for the wage equation in the aggregate supply block (IV.6). Figure 8 shows the impulse-response to the global risk shock when the central bank uses both interest rates and FX (estimated model), and when it only uses interest rates. In the estimated model, that captures the FX rule followed by the BCU until early 2020, the depreciation triggered by the global risk shock leads to a decline (selling) of FX reserves of about 0.7 percent of GDP to offset the depreciation. However, the effects on the exchange rate, inflation, output and interest rates are quantitatively very small and not too different from the responses when FXI is not used.

This is the case because the estimated friction in the FX markets, captured by the Γ parameter, takes a relatively small value of about 0.02, which seems more consistent with the values of advanced economies than emerging markets. As a result, there is not much power in FX interventions and their ability to affect the exchange rate in a sustained manner. An important caveat to this result is that the Γ parameter reflects the average of the sample period. It is quite possible that this parameter could be state-dependent, taking a small value during normal times but a much higher value in crisis times when FX markets may freeze, creating a role for FX intervention. Future research should aim at studying the state-dependence of this parameter and how it can be identified with a relatively small number of crisis observations over the estimation sample.

Figure 9. Shock to Global Risk. The Role of FXI



Source: IMF staff estimates.

Conclusions

The increase of inflation globally in recent years has led to a renewed interest in understanding the link between inflation and wages. This paper has examined this interaction in the case of Uruguay, which stands out for having a highly centralized wage bargaining setting. Also, due to the historical lack of credibility of the monetary authorities in keeping inflation inside the target, wage indexation practices are widespread.

The first part of the paper describes how the wage bargaining process works in Uruguay and presents reduced-form estimates of a standard wage Phillips Curve, using the Galí (2011) framework. In the aggregate, nominal wage growth displays partial adjustment and indexation to lagged annual CPI, but it also reacts to labor market indicators (either the unemployment rate or labor productivity, but not both). The main finding from that section is that nominal wage growth is related to its own lag, a price inflation indexing variable, and the level in the unemployment rate. Specifications where labor productivity growth replaces the unemployment rate suggest that this variable is also a driving force for nominal wage growth. Based on this reduced form evidence, the second part of the paper studies the interaction of price and wage inflation, and the role of monetary policy credibility in general equilibrium. It presents a medium-scale open economy New Keynesian DSGE model as in Adrian et al. (2021), that is modified to include the relevant wage rigidities and indexation and is estimated using Bayesian methods on Uruguayan data.

The DSGE model parameter estimates confirm the role of partial nominal wage adjustment and lagged indexation to annual CPI inflation in the wage formation process. The parameter estimates also suggest that the domestic price inflation Phillips Curve exhibits a significant degree of backward-looking behavior, which is symptomatic of low credibility by the central bank. As a result of these features, inflation displays high persistence in response to shocks. In a counterfactual exercise, wages are assumed to be sticky but indexed to the central bank inflation target. By muting price-wage feedback effects, CPI inflation exhibits less persistence, and the central bank faces a more favorable trade-off with respect to stabilizing inflation and the output gap. It is important to emphasize that wage indexation practices do not appear in a vacuum but are a response to lack of central bank credibility and/or the presence of large monetary shocks (Gray, 1976). Hence, lowering the degree of backward indexation in the economy and moving to indexing wages to the central bank target can only happen as long as inflation fluctuations are stable around the central bank target. An interesting extension would be to precisely endogenize the degree of indexation as a function of the central bank credibility.

Finally, the paper investigates the role of foreign exchange interventions, which are allowed for in the Adrian et al. (2021) model. Given the model and the parameter estimates, the estimated effects of conducting FXI are quantitatively small. One possibility is that this is the case during normal/average times, as was found also by Bucacos et al. (2019). One important extension would be to estimate the relevant parameters that measure frictions in a state-dependent way, although the fact that Uruguay has not suffered periods of large financial stress over the last two decades may complicate identification.

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