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What is the Effect of Domestic Demand Shocks on Inflation in a Small Open Economy? Chile 2000-2021

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What is the Effect of Domestic Demand Shocks on Inflation in a Small Open Economy? Chile 2000-2021

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Abstract. This study decomposes the factors that determined inflation in Chile during the period 2000-2021. We find that the main determinants of domestic inflation are variables of external origin and the exchange rate. Domestic demand has played a rather limited role as an inflationary factor. In general, in normal periods, increases in domestic demand explain no more than 20% of observed inflation. The average monthly inflation observed during the 2000-2021 period reached 0.3%, which means that domestic demand increases in normal periods explain a monthly inflation of 0.06%. Surprisingly, the extraordinary periods of rapid acceleration in demand as a result of highly expansionary fiscal policies and/or of the large withdrawals from pension retirement savings had a rather modest effect on the acceleration of inflation. Only in the last 5 months of 2021 we can detect some effects of the expansion in domestic demand on inflation. This study corroborates an expected fact in a small and open economy like Chile's: most domestic price changes are determined by foreign price changes.

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What is the Effect of Domestic Demand Shocks on Inflation in a Small Open Economy? Chile 2000-2021

This paper studies the determinants of inflation in Chile during the first two decades of the 21st century. Its main motivation is to assess the importance of fluctuations in domestic demand on domestic inflation. This is an important issue considering that Keynesian policies in a context of recession, low levels of utilization of productive capacity and high unemployment, promotes increases in domestic spending through higher public spending, higher social subsidies and related measures such as the reduction of compulsory savings imposed on workers through the AFP system.³ Precisely these policies were implemented in Chile in a very aggressive way during the COVID-19 crisis over the 2020-21 period.

A key issue is the evaluation of the impacts of these Keynesian policies. Determining the inflationary effect of these policies is of vital importance for future design of demand policies. The idea of Keynesianism is that, under conditions of underutilization of productive capacity and unemployment, increases in demand translate into more use of productive capacities and eventually into their expansion, and not necessarily into higher inflation. If the expansion of demand fundamentally generates higher inflation, we could conclude that demand policies are of limited value. This is what motivates this research: In the years 2020 and 2021 we have experienced a natural experiment of important policies to expand demand at rates rarely seen in the recent history of Chile. The idea is to take advantage of this gigantic experiment to evaluate the relevance of demand policies for an economy like Chile's in crisis conditions.

Chile is a small and extremely open economy, both to trade and capital flows. This, in principle, would suggest that if the Purchasing Power Parity (PPP) hypothesis holds even in its weakest versions, such as, for example, relative parity, or even if a quasi PPP condition prevails (Hegwood and Papell, 1998), the inflationary effect of demand policies, such as those implemented in 2020 and 2021, would be limited.⁴ This in turn would imply that domestic demand stimuli would be effective in promoting production and employment and possibly investment, with a small inflationary effect. In other words, well-implemented demand policies in a country affected by a chronic lack of demand caused mainly by a high concentration of income and low wages, could trigger a spiral of growth and development over the medium term.

The evidence regarding the empirical validity of the PPP in any of its versions is mixed. Taylor (2002) has argued that in periods when exchange rate regimes remain stable, the quasi PPP reflects domestic prices in small open economies quite well. The evidence from empirical studies on the applicability of PPP in any of its forms is varied. In general, they find evidence for at least the weak version of the PPP. For example, Crowover et al. (1996) and Hongjun Li et al. (2015)

³ The AFPs are Chile's pension fund administrators.

⁴ Quasi PPP refers to the case in which relative prices between countries affected by strong structural shocks may diverge but the real exchange rate reverts over time to a medium-term level. Or similarly, PPP (defined on the basis of relative prices) conditional on such shocks would be valid even in the short run.

found that even the absolute PPP hypothesis holds, while Carlsson et al. (2008) concluded that weaker versions of the PPP are relevant. Kasuya and Ueda (2000) also find evidence in favor of PPP. An exception is a study by Céspedes and Gregorio (1999) applied to Chile that finds no evidence of the PPP for the period 1977-1997. However, as Taylor (2002) points out, this is to be expected given the repeated changes in the exchange rate regimes that occurred in Chile during the period considered by this study. Further, Korap and Aslan (2010) show that the PPP can be confirmed as a steady state relationship for Turkey. Taylor and McMahon (1988) generally find evidence confirming PPP as an equilibrium condition where the exchange rate tends to converge to a stable equilibrium value.

In this paper we adopt an eclectic position allowing for the possibility that domestic demand factors may affect inflation in confluence with external inflation. It is specified that the determinants of the variation in domestic inflation are inflationary variations abroad, variations in the nominal exchange rate and internal demand factors. Since the exchange rate is likely to be affected by demand factors we allow for a simultanous determination of inflation and exchange rate.

1. The Model

We start with a basic price equation, which we subsequently modify to account for several potential econometric issues and to include some additional dynamic considerations,

$$p_t = A P_t^{\alpha} E_t^{\beta} D_t^{\gamma} e^{\mu_t} \tag{1}$$

Where p_t is the level of the domestic price index in month t; A is a constant, P_t is the price index abroad; E_t is the nominal exchange rate; D_t is the level of internal demand; α , β , γ are parameters and μ_t is the statistical error.

We first express equation (1) in logarithms. Additionally, to account for the possibility of unit roots we estimate this equation using log first differences,

$$\Delta lnp_t = \alpha \Delta lnP_t + \beta \Delta lnE_t + \gamma \Delta lnD_t + \Delta \mu_t$$
(2)
Where $\Delta lnx_t \equiv lnx_t - lnx_{t-1}$, for $x_t = \begin{cases} P_t \\ E_t \\ D_t \end{cases}$

We use as proxies for the variable ΔlnP_t inflation in countries that are most important for Chile's trade, that is, The United States, the European Community and China. Changes in the exchange rate, ΔlnE_t , are measured monthly in Chile. The variable ΔlnD_t is more difficult to measure, we assume that domestic demand grows in normal periods at a stable rate consistent with the long-term growth of the economy except in periods of crisis where domestic demand may be massively affected by exceptional fiscal policies such as unusual increases or reductions in social subsidies or other policies such as the withdrawal of savings held by the population in retirement

funds in the AFPs or in unemployment funds, and others. Thus, for the purposes of its econometric estimation, equation (2) is adjusted as follows,

$$\Delta lnp_t = \gamma_0 + \sum_{1}^{n} \gamma_i d_i + \alpha \Delta lnP_t + \beta \Delta lnE_t + \Delta \mu_t$$
(3)

Where d_i (i = 1, 2, ... n) are dummy variables with values equal to 1 in period i and equal to zero in periods $j \neq i$. The effect of changes in demand on inflation, $\gamma \Delta lnD_t$, can be decomposed into an effect corresponding to periods of stability where demand increases at a stable rate, γ_0 , plus the effect of changes in demand in abnormal periods or critical, where it is affected by emergency fiscal or monetary measures to face particular crises γ_i (i = 1, 2 ... n), where n abnormal periods are considered. Therefore, the effect of changes in demand on inflation in period i is equal to $\gamma \Delta lnD_t = \gamma_0 + \sum_{i=1}^{n} \gamma_i d_i$. We also consider an alternative specification for the demand factors, using a continuous proxy indicator of monthly demand assuming that it changes proportionally with the index of economic activity (IMACEC). That is, we assume that ΔlnD_t is positively correlated with $\Delta IMACEC$ (the result using this specification is reported in the appendix).

Equation (3) is also augmented using past values of the dependent variable on the right-hand side to capture possible lagged effects of the variables on inflation. This makes it possible to obtain measures of the short- and medium-term effects of the independent variables on the level of inflation.

Estimation methods. The estimation of equation (3) can be affected by simultaneity bias. Two methods of estimation of the expanded equation (3) are used alternatively: Two Stage Least Squares (TSLS) using instrumental variables for the exchange rate in order to avoid simultaneity biases that may be due to the fact that the exchange rate can be affected by domestic inflation. We use lagged exchange rate levels as instrumental variables. In addition to estimates by TSLS, we also use the GMM method which can be considered as a test of the robustness of the TSLS estimated coefficients.

The data. The estimation of these equations is implemented using monthly data for the period 2000-2021, years in which there are no important structural changes that affect the determination of the exchange rate, thus satisfying the Taylor requirement for the validity of the PPP in any of its forms. The data source used are those provided by official institutions. In particular, the inflation data for Chile, the United States, China, and the eurozone were obtained, respectively, from the National Institute of Statistics (INE), the Bureau of Labor Statistics (BLS), the National Bureau of Statistics (NBS) and the European Statistical Office (Eurostat). The data of the nominal exchange rate, the Monetary Policy Rate (TPM) and the monthly index of economic activity (IMACEC) were obtained from the Statistical Database of the Central Bank of Chile. In the appendix we present the complete descriptive statistics of the data used in the regressions.

The natural experiments and the dummy variables. The dummy variables for abnormal periods included in the model (3) are six. The first dummy variable (d_1) takes the value 1 for the period between September 2008 and September 2009. This dummy is used to capture the effect of the

international crisis that hit Chile in those months when important changes occur both in production and domestic monetary and fiscal policies. The second dummy variable (d_2) takes the value 1 for the period between October 2009 and February 2010, which corresponds to the period of recovery from the crisis.

The third dummy variable (d_3) becomes activated for the period between April 2020 and July 2020, months in which the economic effects of the pandemic are present, but when significant social subsidies and AFP withdrawals have not yet been implemented. The fourth dummy variable (d_4) takes the value 1 for the period between August 2020 and December of the same year, period in which the effects of the pandemic coincide with those of the first social subsidies and the first AFP withdrawal, which occured in July 2020. The fifth dummy variable (d_5) takes the value 1 for the period between January 2021 and April 2021, a period in which social subsidies are greatly increased and the second AFP withdrawal in December 2020 has its effect on domestic demand. Finally, the sixth dummy variable (d_6) takes the value 1 for the period between May 2021 and December 2021 when the effects of the third AFP withdrawal (April 2021) plus the high social subsidies (IFE) are present.⁵

Thus, these dummies capture the impact of the various natural experiments that took place in the years 2020 and 2021. They show the great depth of the natural experiments that occurred in those years, including the naked impact of the pandemia that took place in April to July 2020 when there were no policy protection yet (d_3) . Then there is a period where the experiment, includes the combined impact of the pandemia and the earliest and very limited social subsidies, d_4 . The clearest demand effects should be captured through the coefficients of the dummies d_5 and, especially, d_6 , which are the periods when the unusual demand stimuli are present in a very intense and persistent manner. It is actually a period of greatest demand stimuli in the recent history of the country. Therefore, it is expected that if demand stimuli cause higher inflation, then these coefficients should be positive and significant.

2. Results

In this section we present the results of the estimations by TSLS and GMM. Table 1 shows the results of the second stage of the estimation by instrumental variables where the variable explained is monthly inflation.

Number of observations	261
Wald chi2(11)	176.14
Prob > chi2	0.0000
R-squared	0.2908

Table 1. Estimation using the	TSLS method: Month	lv inflation in Chile

⁵This is also the period when the Central Bank's monetary policy rate (TPM) starts to rise quite rapidly. In the appendix we explicitly use the changes in the TPM with lags as an additional explanatory variable.

Chile Inf.	Coefficient	Robust Std. Err.	Z	p> z	Confidence Interval (95%)	
ΔE	0.1070	0.0295	3.63	0	0.0492	0.1648
US Inf.	0.4974	0.0713	6.98	0	0.3577	0.6370
China Inf.	0.0554	0.0379	1.46	0.144	-0.0189	0.1298
Eurozone Inf.	0.0399	0.0484	0.83	0.409	-0.0549	0.1348
d_1	-0.0006	0.0014	-0.44	0.663	-0.0034	0.0022
d_2	-0.0011	0.0018	-0.64	0.522	-0.0046	0.0023
d_3	0.0007	0.0010	0.72	0.472	-0.0012	0.0026
d_4	0.0025	0.0015	1.66	0.098	-0.0005	0.0054
d_5	0.0000	0.0016	-0.01	0.993	-0.0031	0.0031
d_6	-0.0012	0.0016	-0.75	0.453	-0.0043	0.0019
Chile Inf. L_1	0.3299	0.0701	4.71	0	0.1926	0.4673
γ_0	0.0005	0.0003	1.76	0.079	-0.0001	0.0011

Where L_i (i = 1, 2, ... n) denotes the lag number i of the corresponding variable. Relevant aspects of the results of Table 1 are the following: first, the importance of external inflation, especially that of the US, is very high and significant. Second, the exchange rate is another variable that plays a quantitatively important and significant role. Thirdly, the low significance of the demand variables is striking, with the exception of the coefficient of the constant, which can be interpreted as the effect of the variation in demand in normal periods, which is barely significant at 90%. The dummy variables that capture possible inflationary changes due to acceleration in demand in particular periods are generally not significant, with the sole exception of dummy 4, which captures the effect of the first AFP withdrawal and the first social subsidies that occurred between August and December 2020. In any case, its effect is barely significant at 90%.

An interpretation of the demand estimators in Table 1 is **that the increases in demand in normal periods explain on average around 0.05% inflation per month when the average monthly inflation in normal periods reached 0.29%, that is, increases in demand explain 17% of the inflation in normal periods.** Thereby, although the effect of normal demand growth would have some effect on inflation, the effect of demand in exceptional periods, captured by the six dummy variables, does not seem to have played any additional role in explaining the inflation.

However, the estimates in Table 1 show only the direct effect of these variables on inflation by keeping the exchange rate constant. It is possible that a significant part of the inflationary effect of some of these variables and of demand occurs through its effect on the exchange rate. We capture these indirect effects through the first stage of the TSLS estimation that we present below. Table 2 shows the estimators of the first stage of the TSLS regression where the exchange rate is the variable that is explained based on the exogenous variables plus the instruments.

Table 2	. Estimators	of the first	stage:	The exchange	rate
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Number of observations	261
F(13, 247)	4.99
Prob > F	0.0000
R-squared	0.1522
Adjusted R-squared	0.1075

ΔE	Coefficient	Robust Std. Frr.	t	p> t	Confidence Interval (95%)	
US Inf.	-0.8468	0.6114	-1.38	0.167	-2.0510	0.3575
China Inf.	-0.3650	0.2568	-1.42	0.157	-0.8708	0.1409
Eurozone Inf.	0.0575	0.3741	0.15	0.878	-0.6793	0.7943
d_1	0.0006	0.0131	0.04	0.966	-0.0252	0.0264
d_2	-0.0030	0.0193	-0.16	0.877	-0.0411	0.0351
d_3	-0.0192	0.0087	-2.21	0.028	-0.0364	-0.0021
	-0.0143	0.0106	-1.35	0.178	-0.0350	0.0065
d_5	-0.0066	0.0068	-0.97	0.332	-0.0200	0.0068
d_6	0.0196	0.0073	2.68	0.008	0.0052	0.0340
Chile Inf. L_1	0.3831	0.6110	0.63	0.531	-0.8205	1.5866
$\Delta E L_1$	0.2512	0.0620	4.05	0	0.1291	0.3733
$\Delta E L_2$	-0.0381	0.0568	-0.67	0.503	-0.1501	0.0738
$\Delta E L_3$	-0.0358	0.0659	-0.54	0.588	-0.1656	0.0940
γ ₀	0.0032	0.0022	1.44	0.152	-0.0012	0.0075

Where L_i (i = 1, 2, ..., n) denotes the lag number i of the corresponding variable. As can be seen in Table 2, only dummy 6 has a positive and significant effect on the exchange rate. This dummy corresponds to the period from May 2021 to December of the same year, which corresponds to the period of acceleration in demand when the fiscal demand stimuli and the third AFP withdrawal are combined.⁶ The coefficient of this dummy suggests that the expansion of demand explains a 1.96% increase in the monthly nominal exchange rate. **Important effect that has an indirect impact on inflation, reaching a net effect on inflation of 0.19% per month. In other words, the demand effect of the second half of 2021 explains almost 25% of the average inflation of that period, which was 0.83% per month.**

In addition to the TSLS estimation, we also use the GMM method, whose results can be considered as part of the robustness analysis of the TSLS estimators. Table 3 provides the results using the GMM method.

⁶ Also in this period, large-scale adjustments in the monetary policy rate (TPM) took place. In the appendix we report this same estimate separating the effect of the TPM.

Table 3. Estimation by GMM.

Number of observations	261
Wald chi2(11)	192.14
Prob > chi2	0.0000
R-squared	0.3019

Chile Inf.	Coefficient	Robust Std. Err.	Z	p> z	Confidence Interval (95%)	
ΔE	0.1046	0.0296	3.54	0	0.0466	0.1626
US Inf.	0.5157	0.0684	7.54	0	0.3816	0.6497
China Inf.	0.0550	0.0374	1.47	0.142	-0.0184	0.1283
Eurozone Inf.	0.0345	0.0477	0.72	0.47	-0.0590	0.1280
d_1	-0.0008	0.0014	-0.58	0.563	-0.0035	0.0019
<i>d</i> ₂	-0.0011	0.0017	-0.62	0.537	-0.0044	0.0023
d_3	0.0006	0.0010	0.65	0.516	-0.0013	0.0025
d_4	0.0024	0.0015	1.61	0.107	-0.0005	0.0053
d_5	0.0000	0.0016	0.02	0.982	-0.0030	0.0031
d_6	-0.0012	0.0016	-0.75	0.456	-0.0043	0.0019
Chile Inf. L ₁	0.3370	0.0693	4.86	0	0.2012	0.4728
γ_0	0.0005	0.0003	1.71	0.088	-0.0001	0.0011

As can be seen by comparing tables 1 and 3, the values and significance of the parameters estimated by TSLS and GMM are quite similar. In both estimates, the most important variables that affect domestic inflation are external inflation, particularly that of the United States, and the exchange rate. On the other hand, the direct effect of domestic demand seems to be of little significance. However, given the importance of the exchange rate as a determinant of inflation as stated above, it is possible that the demand effect on inflation occurs fundamentally through this variable. For this reason we focus on the estimation of the first stage of the TSLS in order to include the possible indirect effect of demand on the exchange rate as a factor that drives inflation.

Direct effect of domestic demand. Using the estimated parameters, it follows that the estimated effect of domestic demand in a normal period is γ_0 and in the abnormal period *i* is $\gamma_0 + \gamma_i$, where i = 1, 2, ..., 6 is associated with the period in which the dummy d_i takes the value 1.

In general, the direct effect of the demand impulses in all the periods considered is very small and of low statistical significance. The figures presented in tables 1 to 3 consider only the individual statistical significance of each variable. In addition, we consider the joint significance of all demand variables on inflation. Joint significance tests of demand effects. We perform a joint significance test on the constant and the parameters of the dummy variables that are defined for the years 2020 and 2021. Specifically, the null hypothesis for both estimation methods is,

$$H_0: \gamma_0 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$$

The tests yielded a p-value of 0.0711 and 0.0932 for the estimation by TSLS and GMM, respectively. This implies that with 90% confidence we can reject the null hypothesis that simultaneously the parameters associated with these dummy variables and the constant are zero. However, with 95% confidence we cannot reject this hypothesis. Then, in general, the direct effect of demand factors on inflation appears to be of weak statistical significance. Moreover, we perform the following joint significance tests,

$$H_0: \gamma_0 = \gamma_i = 0, \qquad i = 1, \cdots, 6$$

With the results of the TSLS estimation we can reject this hypothesis for i = 3,4 with 95% confidence. For the estimation with GMM we can reject this hypothesis for i = 4 with 95% confidence and for i = 3 with 90% confidence. However, we cannot reject it for the other periods.

Total effect of demand on inflation. The total effect of demand is calculated using the parameters estimated by TSLS. This consists of the partial effect of demand on inflation, given the exchange rate, which is obtained directly from the demand parameters estimated in the second stage of TSLS (Table 1). Additionally, there is the indirect effect of demand on the exchange rate, which is obtained using the parameters estimated in the first stage of the TSLS. Therefore, the total effect of demand in period i on inflation is,

$$\Delta Inf_i = \gamma_0 + \gamma_i + \beta(\varepsilon_0 + \varepsilon_i) \tag{4}$$

Where ΔInf_i is the total effect on inflation caused by the increase in demand in period *i*, β is the parameter of the second stage that measures the impact of the exchange rate on inflation and $\varepsilon_0 + \varepsilon_i$ is the effect of demand in period *i* on the exchange rate that is obtained from the estimation of the equation of the first stage shown in Table 2. To calculate the standard error of equation (4) we use the TSLS estimators. However, a disadvantage of doing this is that this method imposes zero values for the covariances between the estimated parameters in separate equations. For this reason we have also estimated the model using Three Stage Least Squares (not shown in the tables) which does allow us to derive the covariances between different equations.

Table 4. Total effect of domestic demand on inflation and p-values corresponding to the null hypothesis that the respective coefficients are equal to zero

	<i>i</i> = 1	<i>i</i> = 2	<i>i</i> = 3	i = 4	<i>i</i> = 5	<i>i</i> = 6
Coef.	0.0003064	-0.0005773	-0.0004938	0.001796	0.0001465	0.0017634
p-value						
2SLQ	0.7968	0.7660	0.8190	0.3526	0.9473	0.2841
p-value						
3SLQ	0.7195	0.6878	0.7427	0.1961	0.9055	0.1463

Thus, when we consider the effects through the exchange rate the impact of demand on inflation becomes greater, but these effects are generally not significant as can be seen in Table 4. Only for the period May-December 2021 the p-value is close to having some statistical significance. Using equation (4) we obtain that for the four-month period September-December 2021, the period with the highest inflationary effect of demand, the total average monthly effect of demand reaches a value close to 0.17%. Given that the average monthly inflation of those four months reached 0.95%, the impact of domestic demand explains around a fifth of the observed inflation. Then, if monetary policy had totally suppressed the expansion of domestic demand, total inflation would have been 5.4% instead of 7.2%.

3. Simulations

With the parameters estimated by TSLS, the average inflation for 2021 and the last quarter of the same year was simulated. To this end, data on external inflation for the United States, China and the eurozone, lagged inflation for Chile and the variation in the nominal exchange rate were included.

Table 5. Simulation of average inflation for the year 2021 and the last quarter of the sameyear with the parameters estimated by 2SLS.

Simulation: Inflation in Chile (average contributions, 2021 and 4th quarter of 2021)							
Average Inf. 4° quarter 2021	ΔE	US Inf.	China Inf.	Eurozone Inf.	Chile Inf. L_1	Simulation: Predicted value	
0.86667%	0.30060%	0.27157%	0.01605%	0.02133%	0.33000%	0.93955%	
Average Inf. 2021	∆ <i>E</i>	US Inf.	China Inf.	Eurozone Inf.	Chile Inf. L_1	Simulation: Predicted value	
0.59167%	0.13601%	0.28427%	0.00718%	0.01633%	0.18150%	0.62530%	

As can be seen in Table 5, the model is capable of simulating with some precision the inflationary events of the year 2021. This gives some certainty of the explanatory capacity of the model used. In the appendix we provide additional simulations for each month in 2021 and also for the months of January and February 2022, months that are not part of the sample used to estimate the model.

4. VAR Model

In order to characterize the simultaneous dynamic interactions between domestic inflation, the variation in the nominal exchange rate, and the variation in the Monetary Policy Rate (TPM), we use a Vector Autoregressive (VAR) model. We start from a general model of the form

$$y_t = v + \sum_{i=1}^{p} A_i y_{t-i} + B x_t + \mu_t$$
 (5)

Where $y_t = (y_{1t, \dots, y_{kt}})'$ is a $(k \ x \ 1)$ vector containing the changes over time of the k endogenous variables; A_i are $(k \ x \ k)$ arrays of parameters; x_t is a $(k_e \ x \ 1)$ vector of exogenous variables; B is a $(k \ x \ k_e)$ matrix of coefficients; ν is a $(k \ x \ 1)$ parameter vector and μ_t is assumed to be white noise, that is, $E(\mu_t) = 0$; $E(\mu_t \mu_t') = \Sigma$ and $E(\mu_t \mu_s') = 0$ para $t \neq s$.

To select the lag model that best fits the data, we apply the Bayesian Information Criterion (BIC) model selection criterion. There is diverse evidence that shows that this criterion is one of those that achieves the best predictive performance (Lütkepohl (1985) and Clark (2004)). We also used the Akaike Information Criterion (AIC) and found that, after applying different specifications for model (5), both criteria suggest that the model that best fits the data is a VAR (1), so we select the following model for the estimates⁷

$$y_t = v + A_1 y_{t-1} + B x_t + \mu_t$$
 (6)

Where y_t is a $(3 \ x \ 1)$ vector of the endogenous variables considered, that is, domestic inflation, the variation of the nominal exchange rate and the variation of the Monetary Policy Rate (TPM). In addition, the vector x_t contains the inflation of the United States, China and the Eurozone. Analyzing the stability of the specification (6) it is obtained that all the eigenvalues are in the unit circle, then the model is stable and allows us to carry out analyzes on the results obtained in the estimations.

The next subsection presents the results of the estimates and the dynamic relationships between domestic inflation, the variation in the nominal exchange rate and the variation in the Monetary Policy Rate, for this the orthogonalized impulse response functions (IRF) of a shock in the variation of the TPM and a shock in the variation of the nominal exchange rate on inflation are analyzed. These IRFs are calculated using the Cholesky decomposition, this allows us to analyze

⁷ It is important to note that the main results presented in the next subsection are not qualitatively altered when considering the other specifications that were evaluated with these criteria.

the direct effect of the shock on inflation. Additionally, Granger causality tests are performed and the prediction error is decomposed.

Data. The data used in the estimates is the same as the model in the previous section, that is, data from monthly first differences in the period 2000-2021.

4.1 VAR: Results

The results of the estimations of the model (6) are presented below.

	Coefficient	Std. err.	z	P> z	Confidence Interval (90%)	
ΔE						
$\Delta E L_1$	0.2670208	0.064315	4.15	0	0.161233	0.372809
Chile Inf. L_1	0.37395	0.44234	0.85	0.398	-0.35363	1.101535
$\Delta \text{TPM} L_1$	0.0093916	0.012409	0.76	0.449	-0.01102	0.029803
US Inf.	-0.6543436	0.454322	-1.44	0.15	-1.40164	0.092949
China Inf.	-0.3334025	0.264478	-1.26	0.207	-0.76843	0.101625
Eurozone Inf.	0.1397398	0.393051	0.36	0.722	-0.50677	0.78625
ν_1	0.0022626	0.00216	1.05	0.295	-0.00129	0.005816
Chile Inf.						
$\Delta E L_1$	0.0280341	0.007919	3.54	0	0.015009	0.041059
Chile Inf. L_1	0.3557654	0.054464	6.53	0	0.26618	0.445351
$\Delta \text{TPM} L_1$	0.0025765	0.001528	1.69	0.092	6.33E-05	0.00509
US Inf.	0.4315452	0.055939	7.71	0	0.339533	0.523557
China Inf.	0.0098239	0.032564	0.3	0.763	-0.04374	0.063388
Eurozone Inf.	0.0450226	0.048395	0.93	0.352	-0.03458	0.124626
ν_2	0.0008119	0.000266	3.05	0.002	0.000374	0.001249
ΔΤΡΜ						
$\Delta E L_1$	0.5670869	0.262242	2.16	0.031	0.135737	0.998437
Chile Inf. L_1	-0.6430093	1.80364	-0.36	0.721	-3.60973	2.323715
Δ TPM L_1	0.6380204	0.050599	12.61	0	0.554792	0.721249
US Inf.	2.480006	1.852495	1.34	0.181	-0.56708	5.52709
China Inf.	0.2028631	1.078407	0.19	0.851	-1.57096	1.976684
Eurozone Inf.	-0.8832105	1.602662	-0.55	0.582	-3.51935	1.752933
ν_3	-0.0000129	0.008809	0	0.999	-0.0145	0.014477

Tabla 6. Estimation: VAR(1)

Where L_1 denotes the first lag of the corresponding variable and v_i (i = 1,2,3) are constants. Now, we will analyze the effect of a shock in the variation of the TPM and the exchange rate on Inflation. Figure 1 shows the effect of an unexpected increase in one standard deviation of the change in the TPM on inflation. The graphs show that this shock has a small, but positive and statistically significant effect on inflation in the short term, reaching a peak in the third month approximately; then the effect falls and stops being statistically significant. Therefore, an unexpected increase in the variation of the TPM is associated with a small but perceptible increase in inflation in the short term. This is surprising since one would expect a rise in the TPM to have a negative, not a positive, effect on inflation. One possible explanation is that, in a small, open economy with inflation generated abroad, the effect of a rise in the TPM translates into an increase in the cost of imported products due to the higher cost of inventories and of imported intermediate goods. The increase in import costs may thus contribute to exacerbating rather than reducing inflation. In other words, the effect of the increase in import costs on inflation that the rise in the TPM may entail may be stronger than the effect of the reduction in domestic demand.

Another possible explanation of the effect of the variation of the TPM on inflation is that, since the TPM is a variable controlled by the Central Bank and the increases in this variable are due to the expectations that this institution has about future inflation, then if on average these expectations are correct an increase in the variation of the TPM may be associated with increases in inflation in the short term.



Figure 1. Orthogonalized IRF of a shock in the variation of the TPM on inflation.

Note: The graph on the left shows the CI for asymptotic estimates of standard errors and the one on the right for bootstrap estimates.

As the estimates using the Cholesky decomposition are not necessarily invariant to the order of the endogenous variables, we present the IRFs for different orders in Figure 2. In this figure we can observe that the qualitative results shown in Figure 1 change only for one order (in which the effect is not statistically significant) and for some other orders of the Cholesky decomposition the increase in inflation is instantaneous and falls monotonically to zero as the months go by, unlike what is derived in Figure 1.



Figure 2. Orthogonalized IRF of a shock in the variation of the TPM on inflation for different orders in the Cholesky decomposition

The effect of an unexpected increase in the change in the exchange rate also depends on the order of the Cholesky decomposition. In fact, as shown in Figure 3, for some orders the effect on inflation increases instantaneously and falls to zero as the months go by, and for other orders the effect increases until it reaches a peak in the second month and then falls to zero in the seventh month approximately. However, the effect is always positive and statistically significant.





In the appendix the IRFs are presented without orthogonalizing. Figure A1 shows that the effect on inflation of a 1% increase shock in the variation of the nominal exchange rate is positive and reaches a peak of almost 0.03% in the second month approximately, then it starts to fall monotonically to zero reaching it in the seventh month. On the other hand, Figure A2 shows that the effect on inflation of an unexpected increase of 1% in the variation of the TPM is associated with an increase in inflation in the short term, reaching a peak of approximately 0.003% in the second month, after which it begins to be not statistically significant.

The results of the Granger causality test presented in Table 7 show with 90% confidence that both the variation of the TPM and the variation of the exchange rate (and jointly these two variables) help predict inflation. On the other hand, the change in the exchange rate (and this change jointly with inflation) help predict the change in the TPM. As the variation of the TPM is a control variable that is affected by the expectations of relevant macroeconomic variables, among them the variation of the exchange rate, this result is consistent and suggests that changes in the variation of the TPM are associated with changes in future inflation.

Table 7. Granger causality test

Null hypothesis			chi2	Prob > chi2
Inflation	does not cause to	ΔE	0.71468	0.398
ΔΤΡΜ	does not cause to	ΔE	0.57277	0.449
Inflation and ΔTPM jointly	does not cause to	ΔE	1.7919	0.408
ΔE	does not cause to	Inflation	12.533	0
ΔΤΡΜ	does not cause to	Inflation	2.8435	0.092
ΔE and Δ TPM jointly	does not cause to	Inflation	15.082	0.001
ΔE	does not cause to	Δτρμ	4.6762	0.031
Inflation	does not cause to	Δτρμ	0.1271	0.721
ΔE and inflation jointly	does not cause to	Δτρμ	4.7643	0.092

The decomposition of the forecast error, on the other hand, indicates with 90% confidence that the variance of the error incurred in the forecast of inflation is not affected by a shock in the variation of the TPM but is affected by the variation in the exchange rate, in particular, the fraction of the variance of the error incurred in forecasting inflation due to an exchange rate shock increases in the short run from 0% and reaches approximately 22% after the fourth month.

Conclusion

Three important conclusions emerge from this study:

1. The main conclusion is the corroboration that domestic demand has played a rather limited role as an inflationary factor in Chile. In general, in normal periods, increases in domestic demand explain no more than 20% of observed inflation. The monthly average inflation observed during the 2000-2021 period reached 0.3%. From this we estimate that the increases in demand in normal periods explain an inflation of 0.06% per month.

2. The second conclusion is that, surprisingly, the extraordinary periods of rapid acceleration in demand as a result of highly expansionary fiscal policies and/or AFP withdrawals had a rather modest effect on the acceleration of inflation. Only in the last 5 months of 2021 we can detect some effects of the expansion in demand on inflation, explaining almost 33% of the inflationary acceleration that occurs in those months.

3. Finally, this study corroborates an expected fact in a small and open economy like Chile's; most domestic inflation is determined by foreign inflation.

Appendix

Descriptive statistics. The following table presents a summary of the data used in the estimates.

Variable	Number of observations	Mean	Std. Err.	Min	Max
Chile Inf.	264	0.003	0.004	-0.012	0.015
US Inf.	264	0.002	0.004	-0.019	0.012
China Inf.	264	0.002	0.006	-0.014	0.026
Eurozone Inf.	264	0.001	0.004	-0.015	0.013
ΔE	264	0.002	0.027	-0.070	0.166
d_1	264	0.049	0.217	0.000	1.000
d_2	264	0.019	0.137	0.000	1.000
d_3	264	0.015	0.122	0.000	1.000
d_4	264	0.019	0.137	0.000	1.000
d_5	264	0.015	0.122	0.000	1.000
d_6	264	0.030	0.172	0.000	1.000

Table A1. Summary of the data

Table A2. Simulation of monthly inflation for the year 2021 and January and February 2022 (months outside the sample) with the estimates by TSLS.

	Simulation of monthly inflation in Chile (contributions, 2021-February 2022)										
Year	Month	Mon. Inf. 2021	ΔE	US Inf.	China Inf.	Eurozone Inf.	Chile Inf. L ₁	Simulation			
2021	1	0.7%	-0.16734%	0.21269%	0.05381%	0.00800%	0.09900%	0.20617%			
2021	2	0.2%	-0.01413%	0.27372%	0.03733%	0.00800%	0.23100%	0.53592%			
2021	3	0.4%	0.05692%	0.35416%	-0.02650%	0.03600%	0.06600%	0.48659%			
2021	4	0.4%	-0.28048%	0.41095%	-0.02130%	0.02400%	0.13200%	0.26517%			
2021	5	0.3%	0.06860%	0.40086%	-0.00534%	0.01200%	0.13200%	0.60811%			
2021	6	0.1%	0.22061%	0.46453%	-0.02139%	0.01200%	0.09900%	0.77476%			
2021	7	0.8%	0.36179%	0.24053%	0.01610%	-0.00400%	0.03300%	0.64742%			
2021	8	0.4%	0.43077%	0.10330%	0.00535%	0.01600%	0.26400%	0.81941%			
2021	9	1.2%	0.05357%	0.13580%	0.00000%	0.02000%	0.13200%	0.34137%			
2021	10	1.3%	0.42567%	0.41541%	0.04278%	0.03200%	0.39600%	1.31186%			
2021	11	0.5%	-0.01792%	0.24567%	0.02124%	0.01600%	0.42900%	0.69399%			
2021	12	0.8%	0.49404%	0.15363%	-0.01587%	0.01600%	0.16500%	0.81279%			
2022	1	1.2%	-0.35070%	0.40000%	0.01200%	0.01200%	0.26400%	0.33730%			
2022	2	0.3%	-0.198%	0.450%	0.036%	0.036%	0.396%	0.72%			

Simulations. Table A2 presents a simulation of monthly inflation for the year 2021 and for the months of January and February 2022, which are outside the sample. As can be seen, the simulations carried out based on the estimated coefficients replicate the inflation rates reasonably well in most of the months.

Robustness tests. Several model robustness tests were implemented. First, the monthly index of economic activity (IMACEC) was considered as an additional control variable. Table A3 shows these estimators. As can be seen, the fundamental results: that domestic inflation is explained primarily by foreign inflation and the exchange rate are maintained. The role of demand factors in both normal and exceptional periods is of minor importance.

I. Incorporating IMACEC as a proxy for demand effects

Number of observations	261
Wald chi2(12)	171.80
Prob > chi2	0.0000
R-squared	0.2670

Table A3. Second stag	e of the estimation	by TSLS adding the	variation of the IMACEC

Chile Inf.	Coefficient	Robust Std.	Z	p> z	Confidence Interval	
		Err.			(95)	%)
ΔE	0.1122	0.0295	3.8	0	0.0544	0.1700
US Inf.	0.5255	0.0758	6.94	0	0.3770	0.6740
China Inf.	0.0691	0.0391	1.77	0.077	-0.0075	0.1457
Eurozone Inf.	-0.0028	0.0647	-0.04	0.965	-0.1297	0.1241
d_1	-0.0006	0.0014	-0.39	0.694	-0.0034	0.0023
<i>d</i> ₂	-0.0011	0.0018	-0.62	0.532	-0.0047	0.0024
d_3	0.0011	0.0011	1.03	0.303	-0.0010	0.0032
d_4	0.0022	0.0016	1.41	0.158	-0.0009	0.0053
d_5	0.0002	0.0017	0.1	0.919	-0.0032	0.0036
d_6	-0.0014	0.0017	-0.83	0.407	-0.0047	0.0019
Chile Inf. L ₁	0.3290	0.0712	4.62	0	0.1895	0.4685
ΔΙΜΑCEC	0.0054	0.0049	1.1	0.271	-0.0042	0.0151
γ_0	0.0005	0.0003	1.54	0.124	-0.0001	0.0011

When we use the IMACEC as a proxy for demand stimuli, the results remain practically identical when we compare the results of Tables A3 and Table 1 in the text. The estimated coefficients remain very stable. In particular, the IMACEC does not seem to be an important variable that explains inflation. The same happens when the GMM method is used in the estimation.

Number of observations	261
Wald chi2(12)	187.14
Prob > chi2	0.0000
R-squared	0.2752

Table A4. Estimation by GMM adding the variation of the IMACEC

Chile Inf.	Coefficient	Robust Std.	z	p> z	Confidence Interval (95%)	
		Err.				
ΔE	0.1106	0.0296	3.73	0	0.0525	0.1686
US Inf.	0.5443	0.0730	7.46	0	0.4013	0.6874
China Inf.	0.0704	0.0385	1.83	0.068	-0.0051	0.1459
Eurozone Inf.	-0.0112	0.0642	-0.17	0.861	-0.1371	0.1146
d_1	-0.0007	0.0014	-0.49	0.623	-0.0034	0.0021
<i>d</i> ₂	-0.0011	0.0018	-0.61	0.541	-0.0046	0.0024
<i>d</i> ₃	0.0011	0.0011	1.01	0.311	-0.0010	0.0032
d_4	0.0022	0.0016	1.37	0.172	-0.0009	0.0053
d_5	0.0002	0.0017	0.13	0.899	-0.0032	0.0036
d_6	-0.0015	0.0017	-0.88	0.376	-0.0048	0.0018
Chile Inf. L ₁	0.3383	0.0702	4.82	0	0.2006	0.4759
ΔΙΜΑCEC	0.0058	0.0049	1.19	0.234	-0.0038	0.0154
γ_0	0.0004	0.0003	1.46	0.144	-0.0002	0.0010

II. Incorporating the Central Bank

Another test of the robustness of the estimators is implemented using the monetary policy rate (TPM) directly as the explanatory variable of monthly inflation. Since the effect of the TPM on inflation is expected to be subject to lags, we use this variable with three lags. Table A5 shows these results. As can be seen in this table, the inclusion of the lagged TPM variables does not affect the value of the key coefficients, which continue to be external inflation and exchange rate variations. Surprisingly, the TPM does not appear statistically significant in any of its lags. The different lags of the TPM are also not significant when we estimate the first stage of the estimation by TSLS (Table A6).

Number of observations	261
Wald chi2(14)	187.80
Prob > chi2	0.0000
R-squared	0.2824

Tabla A5. Second stage of the estimation by TSLS adding the variation of the TPM

Chile Inf.	Coefficient	Robust Std.	Z	p> z	Confidence Interval (95%)	
		Err.				
ΔE	0.1101	0.0292	3.77	0	0.0529	0.1673
US Inf.	0.5173	0.0746	6.93	0	0.3710	0.6636
China Inf.	0.0459	0.0390	1.18	0.238	-0.0304	0.1223
Eurozone Inf.	0.0310	0.0490	0.63	0.527	-0.0651	0.1272
d_1	-0.0001	0.0015	-0.07	0.948	-0.0030	0.0028
d_2	-0.0008	0.0018	-0.46	0.644	-0.0043	0.0026
d_3	0.0015	0.0012	1.25	0.211	-0.0008	0.0038
d_4	0.0026	0.0015	1.71	0.088	-0.0004	0.0055
d_5	0.0000	0.0016	0.01	0.992	-0.0031	0.0031
d_6	-0.0021	0.0019	-1.13	0.258	-0.0057	0.0015
Chile Inf. L_1	0.3185	0.0746	4.27	0	0.1723	0.4648
Δ TPM L_1	0.0022	0.0020	1.11	0.268	-0.0017	0.0061
Δ TPM L ₂	-0.0004	0.0026	-0.15	0.883	-0.0055	0.0048
Δ TPM L ₃	0.0019	0.0017	1.12	0.263	-0.0014	0.0053
γ_0	0.0005	0.0003	1.68	0.093	-0.0001	0.0011

Number of observations	261
F(16, 244)	4.92
Prob > F	0.0000
R-squared	0.1605
Adjusted R-squared	0.1054

ΔE	Coefficient	Robust Std.	t	p> t	Confidence Interval (95%)	
		Err.				
US Inf.	-0.9386	0.6009	-1.56	0.12	-2.1222	0.2449
China Inf.	-0.3600	0.2628	-1.37	0.172	-0.8776	0.1575
Eurozone Inf.	0.0646	0.3750	0.17	0.863	-0.6741	0.8034
d_1	-0.0011	0.0149	-0.07	0.944	-0.0304	0.0283
d_2	-0.0027	0.0195	-0.14	0.891	-0.0411	0.0357
d_3	-0.0209	0.0115	-1.82	0.07	-0.0436	0.0018
d_4	-0.0143	0.0107	-1.34	0.181	-0.0353	0.0067
d_5	-0.0064	0.0068	-0.95	0.342	-0.0197	0.0069
d_6	0.0220	0.0069	3.2	0.002	0.0085	0.0355
Chile Inf. L_1	0.4282	0.5910	0.72	0.469	-0.7358	1.5923
Δ TPM L_1	0.0101	0.0147	0.69	0.491	-0.0188	0.0391
Δ TPM L_2	-0.0284	0.0201	-1.41	0.159	-0.0680	0.0112
Δ TPM L_3	0.0106	0.0191	0.55	0.58	-0.0271	0.0483
$\Delta E L_1$	0.2541	0.0615	4.13	0	0.1329	0.3752
$\Delta E L_2$	-0.0511	0.0575	-0.89	0.375	-0.1643	0.0622
$\Delta E L_3$	-0.0257	0.0677	-0.38	0.705	-0.1592	0.1077
γ_0	0.0033	0.0022	1.48	0.139	-0.0011	0.0076

Additionally, the TPM is also not statistically significant when the GMM method is used (Table A7).

Tabla A7. Estimation by GMM adding the variation of the TPM

Tabla A7. Estimation by Givilvi adding the variation of						
Number of observations	261					
Wald chi2(14)	206.86					
Prob > chi2	0.0000					
R-squared	0.2880					

Chile Inf.	Coefficient	Robust Std.	Z	p> z	Confidence Interval (95%)	
		Err.				
ΔE	0.1089	0.0294	3.71	0	0.0513	0.1664
US Inf.	0.5345	0.0723	7.39	0	0.3927	0.6763
China Inf.	0.0467	0.0386	1.21	0.226	-0.0288	0.1223
Eurozone Inf.	0.0246	0.0486	0.51	0.613	-0.0706	0.1198
d_1	-0.0004	0.0015	-0.26	0.798	-0.0032	0.0025
d_2	-0.0008	0.0017	-0.49	0.626	-0.0042	0.0026
d_3	0.0014	0.0012	1.15	0.25	-0.0010	0.0037
d_4	0.0025	0.0015	1.65	0.099	-0.0005	0.0054
d_5	0.0001	0.0016	0.05	0.962	-0.0030	0.0032
d_6	-0.0021	0.0019	-1.14	0.256	-0.0058	0.0015
Chile Inf. L_1	0.3285	0.0738	4.45	0	0.1839	0.4732
Δ TPM L_1	0.0021	0.0020	1.08	0.278	-0.0017	0.0060
Δ TPM L ₂	-0.0009	0.0025	-0.34	0.735	-0.0058	0.0041
Δ TPM L ₃	0.0020	0.0017	1.23	0.22	-0.0012	0.0053
γ_0	0.0005	0.0003	1.6	0.109	-0.0001	0.0011

VAR Model: Impulse Response Functions (IRFs)



Figura A1. IRF of a shock in the variation of the exchange rate on inflation for different orders in the Cholesky decomposition

Figura A2. IRF of a shock in the variation of the TPM on inflation for different orders in the Cholesky decomposition



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