INTERNATIONAL MONETARY FUND

IMF Country Report No. 22/17

URUGUAY

SELECTED ISSUES

January 2022

This paper on Uruguay was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on November 11, 2021.

Copies of this report are available to the public from

International Monetary Fund • Publication Services
PO Box 92780 • Washington, D.C. 20090
Telephone: (202) 623-7430 • Fax: (202) 623-7201
E-mail: publications@imf.org Web: http://www.imf.org
Price: $18.00 per printed copy

International Monetary Fund
Washington, D.C.

INTERNATIONAL MONETARY FUND

URUGUAY

SELECTED ISSUES

November 11, 2021

Approved By
Western Hemisphere Department

Prepared by Natasha Che and Chiara Fratto

CONTENTS

TABLES

EXPORT PRODUCT DIVERSIFICATION ANALYSIS FOR URUGUAY WITH MACHINE LEARNING 33

FIGURES

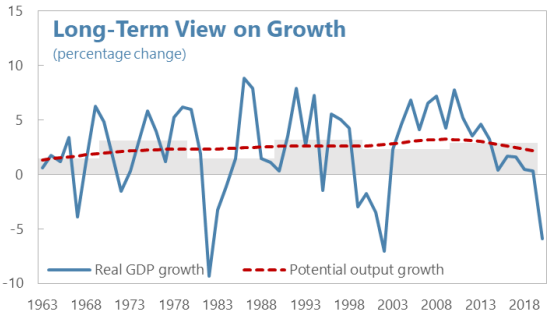
TABLES

URUGUAY'S POTENTIAL GROWTH: WHAT TO EXPECT AFTER THE PANDEMIC?

Uruguay's growth history has been characterized by the influence of external shocks—including commodity price cycles, regional crises and, recently, the pandemic. Underlying this volatile history, long-term trends have also shaped Uruguay's growth. This SIP explores the role of these different factors to shed light on what Uruguay's potential growth could be after the pandemic.

A. A Long-term View on Growth

Over the last 6 decades, Uruguay's growth (2.3 percent per year on average) has been considerably lower than in peer countries (3.6 precent) and subject to significant volatility. Long-term population dynamics can account for about ½ of this lower growth, while volatility has been driven by regional crises and commodity price cycles.



1. Uruguay's economy has experienced pronounced volatility. While, on average, the economy growth 2.3 percent a year since 1963, the country experienced some pronounced setbacks—most notably due to the Latin American debt crisis of the early 1980s, the Brazil' s crisis in the late 1990s, the Argentinian crisis of 2001 and the associated Uruguayan crisis of 2002—but also some periods of strong growth. By historical standards, GDP growth was exceptionally high during 2004-14, buoyed by the rebound from the 2002 crisis and a favorable commodity cycle. More recently, however, as the commodity boom came to an end, growth became stagnant (averaging 0.9 percent in 2015-19) despite the absence of any mayor negative external shock.[1] This weak performance poses questions about medium-term growth prospects. The section dissect Uruguay's economic performance over time and in comparison to peer countries to shed light on key factors that could drive growth going forward.

2. A growth accounting exercise allows to examine the proximate drivers of economic growth and the recent slowdown. The exercise decomposes growth into contributions from labor, capital, and total factor productivity (TFP), relying on data from the Penn World Tables 10.0. The sample is restricted to 1978-2019 and 91 countries due to data availability issues. The labor contribution is further decomposed into average hours worked per worker, human capital (proxied by a Mincer equation of the average years of schooling) and the number of people employed (which

[1] The recent GDP rebasing lowered the initial growth estimates, as the contribution of some of the most dynamic sectors (e.g., transport and communications) was revised down.

is governed by demographic dynamics and the employment-to-population rate). [2] The physical stock of capital (henceforth capital) is estimated from data on investment in buildings and different types of machineries using the perpetual inventory method. TFP is estimated as a residual.[3]

3. Notwithstanding volatile contributions over different periods, capital accumulation was the primary driver of Uruguay's growth (Table 1). Over the last 4 decades, nearly 60 percent of GDP growth reflected investment in physical capital while the contributions of TFP (about 15 percent), employment (20 percent) and human capital accumulation (15 percent) were more muted. Interesting, hours worked contributed negatively to growth, detracting about 0.2 percent per year. The latter has been a constant phenomenon throughout, as hours worked declined in all the subperiods of analysis in which data is available. GDP growth and its components have been sensitive to external forces, displaying strong positive contributions in the 1990's and the commodity boom years (2006-09 and 2010-14), and significantly lower contributions in the early 2000's (Argentina and Uruguay's crises), and the pre-pandemic years that followed the commodity boom (2015-19).

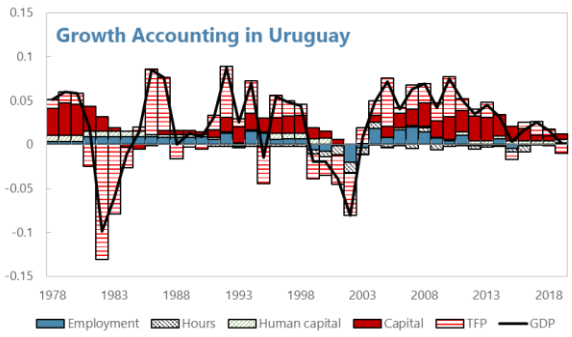


Table 1. Uruguay: Growth Accounting

		Contributions				
	GDP Growth	Employment	Human Capital	Hours	Capital	TFP
1978-2019	2.5%	0.5%	0.4%	-0.2%	1.4%	0.4%
1990-2019	2.9%	0.4%	0.3%	-0.3%	1.5%	0.9%
1991-99	3.6%	0.6%	0.4%	-0.2%	1.6%	1.2%
2000-05	-0.2%	-0.1%	0.1%	-0.5%	0.6%	-0.2%
2006-09	5.4%	1.5%	0.2%	-0.2%	2.0%	1.9%
2010-14	4.7%	0.4%	0.3%	-0.2%	2.6%	1.6%
2015-19	1.3%	-0.1%	0.4%	-0.2%	1.0%	0.2%

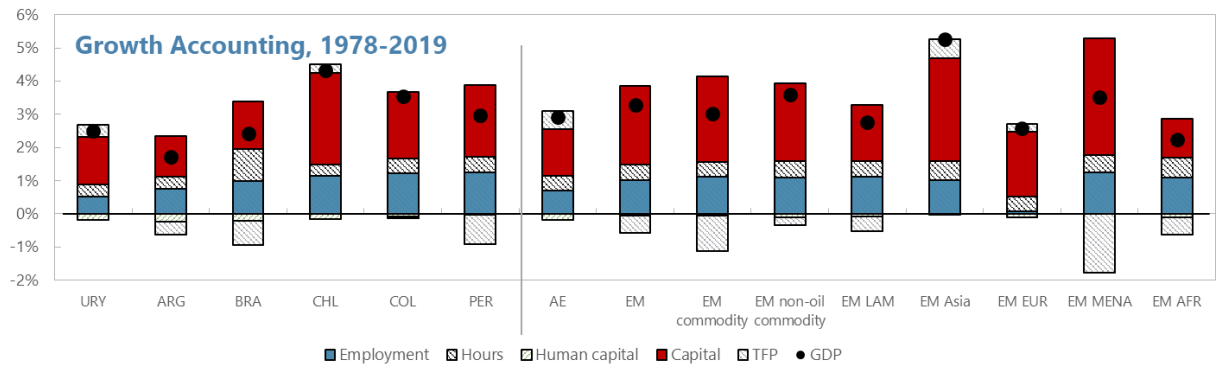
Source: Penn World Tables 10.0. Note: data for 2016-19 uses 2016 weights for GDP growth and 2005 weights for capital stock formation. Average GDP growth for the period 2015-19 using 2005 weights is 1.3 percent. When average hours worked are missing, their contribution is set to zero.

4. Uruguay's long-term growth has been considerably lower than in peer economies—reflecting mainly slower capital accumulation and employment growth (Table 2). The pace of growth of the Uruguayan economy was 0.8 (1.1) percentage points lower than in other EMs (non-oil

[2] Data on average hours worked are available only starting 1990. For the period 1978-89, these are assumed to be constant and equal to the 1990 value. Data for years of schooling comes from Barro-Lee and missing years are interpolated.

[3] For further information on the Penn World Tables, please refer to Feenstra et al. (2015). Short-term changes in TFP also include changes in factors utilization.

commodity exporting EMEs)—a difference that compounds to 39 (57) percent higher cumulative growth for the latter group. Within the region, Uruguay's growth has been in line with that of Brazil but considerably below other Latin American countries (except Argentina), mainly driven by slower employment growth and capital accumulation.



Source: staff calculations, Penn World Tables 10.0

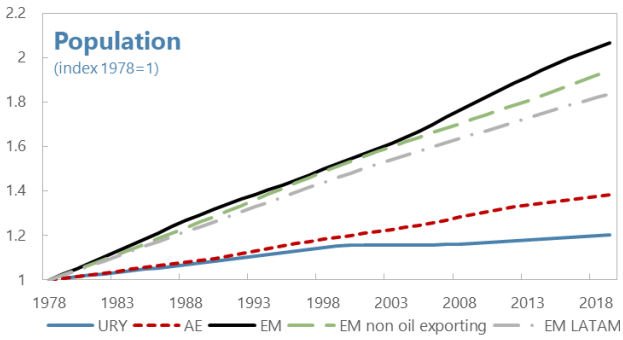
Table 2. Uruguay: Growth Accounting. Cross-Country Comparison, 1978–2019

	GDP growth	Contributions				
		Employment	Human capital	Hours	Capital	TFP
URY	**2.5%**	**0.5%**	**0.4%**	**-0.2%**	**1.4%**	**0.4%**
ARG	1.7%	0.8%	0.4%	-0.2%	1.2%	-0.4%
BRA	2.4%	1.0%	1.0%	-0.2%	1.4%	-0.7%
CHL	4.3%	1.1%	0.3%	-0.2%	2.8%	0.3%
COL	3.5%	1.2%	0.4%	-0.1%	2.0%	-0.1%
PER	3.0%	1.3%	0.4%	0.0%	2.2%	-0.9%
AE	2.9%	0.7%	0.4%	-0.2%	1.4%	0.6%
EM	**3.3%**	**1.0%**	**0.5%**	**0.0%**	**2.4%**	**-0.5%**
EM commodity exp.	3.0%	1.1%	0.5%	-0.1%	2.6%	-1.1%
EM non-oil com. exp.	**3.6%**	**1.1%**	**0.5%**	**-0.1%**	**2.4%**	**-0.2%**
EM LAM	2.8%	1.1%	0.5%	-0.1%	1.7%	-0.4%
EM Asia	5.3%	1.0%	0.6%	0.0%	3.1%	0.6%
EM EUR	2.6%	0.1%	0.4%	-0.1%	2.0%	0.2%
EM MENA	3.5%	1.2%	0.5%	0.0%	3.5%	-1.8%
EM AFR	2.2%	1.1%	0.6%	-0.1%	1.2%	-0.5%

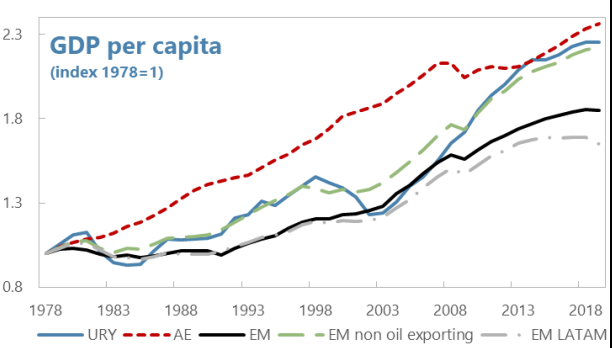
Source: Penn World Tables 10.0. Note: When average hours worked are missing, their contribution is set to zero. Country averages are unweighted. The sample is restricted to 91 countries due to data availability.

After accounting for population growth, Uruguay's performance has been in line with peers. GDP growth can be decomposed into population growth and per capita GDP growth. The

demographic factors account for the observed difference in GDP growth between Uruguay and peers. As a matter of fact, Uruguay's population has grown at a significantly slower pace than in other EMEs (0.5 percent per year in Uruguay compared to 1.1 percent in non-oil commodity exporting EMEs). Surprisingly, Uruguay's population growth has been lower than in AEs too. On the other hand, GDP per capita grew on average at the same pace as in non-oil commodity exporting EMEs. For years, GDP per capita in Uruguay and peers grew more slowly than AEs, but growth sped up in the last years thanks to the commodity price boom. Overall, the patterns of GDP per capita in non-oil commodity exporting countries in the last twenty years and the strong correlation with commodity prices highlight the large role that commodity cycle has played for the economic development of these countries.

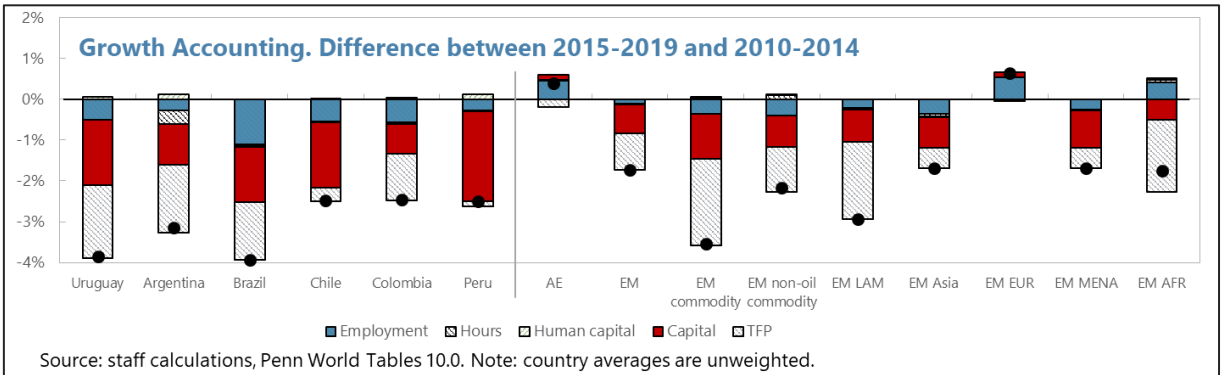


Source: Penn World Tables 10.0, staff calculations. Note: country averages are unweighted.



Source: Penn World Tables 10.0, staff calculations. Note: country averages are unweighted.

5. The end of the commodity boom led to a marked growth slowdown across EMEs—although more pronounced in Uruguay—in the years preceding the pandemic. Uruguay's low growth in the last five years mirrors the slowdown of the region and other non-oil commodity exporting EMEs, in the context of the end of the commodity boom. Both the direct effects from reduced commodity prices and spillovers from neighboring countries account for Uruguay's weaker economic performance. However, compared to other non-oil commodity exporting EMEs, Uruguay's slowdown was significantly more pronounced (1.7 percentage points larger), mostly explained by a starker slowdown in capital accumulation and productivity.



Source: staff calculations, Penn World Tables 10.0. Note: country averages are unweighted.

Table 3. Uruguay: Growth Accounting. Difference Between 2014–19 and 2010–14						
		Contributions				
	GDP growth	Employment	Human capital	Hours	Capital	TFP
URY	**-3.8%**	**-0.5%**	**0.0%**	**0.0%**	**-1.6%**	**-1.8%**
ARG	-3.1%	-0.3%	-0.3%	0.1%	-1.0%	-1.7%
BRA	-3.9%	-1.1%	0.0%	0.0%	-1.4%	-1.4%
CHL	-2.5%	-0.6%	0.0%	0.0%	-1.6%	-0.3%
COL	-2.5%	-0.6%	0.0%	0.0%	-0.7%	-1.1%
PER	-2.5%	-0.3%	0.0%	0.1%	-2.2%	-0.1%
AE	0.4%	0.5%	0.0%	0.0%	0.1%	-0.2%
EM	**-1.7%**	**-0.1%**	**0.0%**	**0.0%**	**-0.7%**	**-0.9%**
EM commodity	-3.5%	-0.4%	0.0%	0.0%	-1.1%	-2.1%
EM non-oil commodity	**-2.2%**	**-0.4%**	**0.1%**	**0.0%**	**-0.8%**	**-1.1%**
EM LAM	-2.9%	-0.2%	0.0%	0.0%	-0.8%	-1.9%
EM Asia	-1.7%	-0.3%	-0.1%	0.0%	-0.8%	-0.5%
EM EUR	0.7%	0.5%	0.0%	0.0%	0.1%	0.0%
EM MENA	-1.7%	-0.2%	0.0%	0.0%	-0.9%	-0.5%
EM AFR	-1.8%	0.4%	0.1%	0.0%	-0.5%	-1.8%

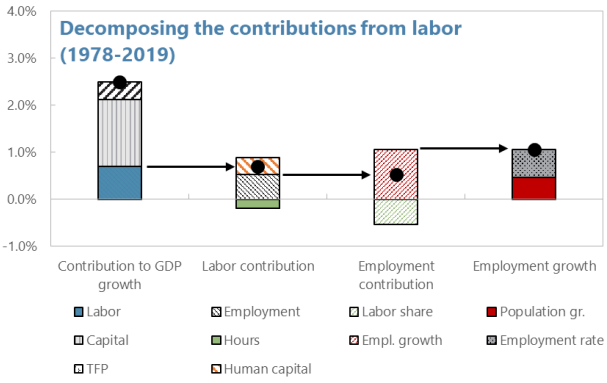
Source: Penn World Tables 10.0. Note: data for Uruguay for 2016-19 uses 2016 weights for GDP growth and 2005 weights for capital stock formation. Average GDP growth for the period 2015-19 using 2005 weights is 1.3 percent. When average hours worked are missing, their contribution is set to zero.

6. The historical view presented above indicates that long-term trends in labor markets and commodity price cycles have been key drivers of Uruguay's growth. The next sections shed further light on these specific aspects to help distill some lesson on how they could shape economic growth going forward.

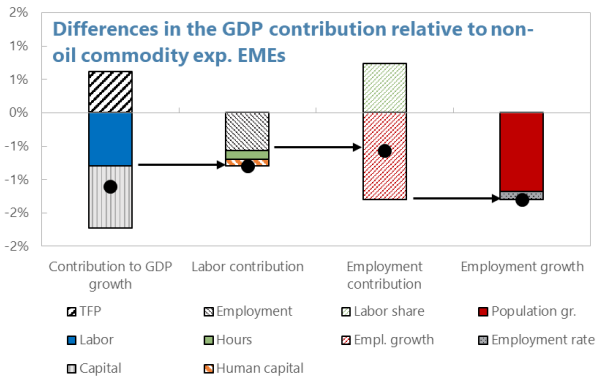
B. Labor and Human Capital

The low growth contribution from labor reflects population dynamics and the erosion of human capital following the 2002 crisis.

7. Population growth has contributed less than in peer countries to raising GDP. A breakdown of the labor contribution into its components (employment, hours, and human capital) indicates that the difference in labor contribution vis-à-vis peers arises mainly from employment (which, in turn, reflects mainly differences in population growth). That is, Uruguay's population has been growing considerably slower than in peer economies. The contributions from hours worked and the employment-to-population rate have also been lower, commanding an analysis of the frictions in the labor market. High school dropout rates may explain the lower human capital accumulation. Interestingly, while Uruguay's labor share decreased in line with the global trend, it has done so by less than in peer economies thanks in part to long-standing policies of worker protection.

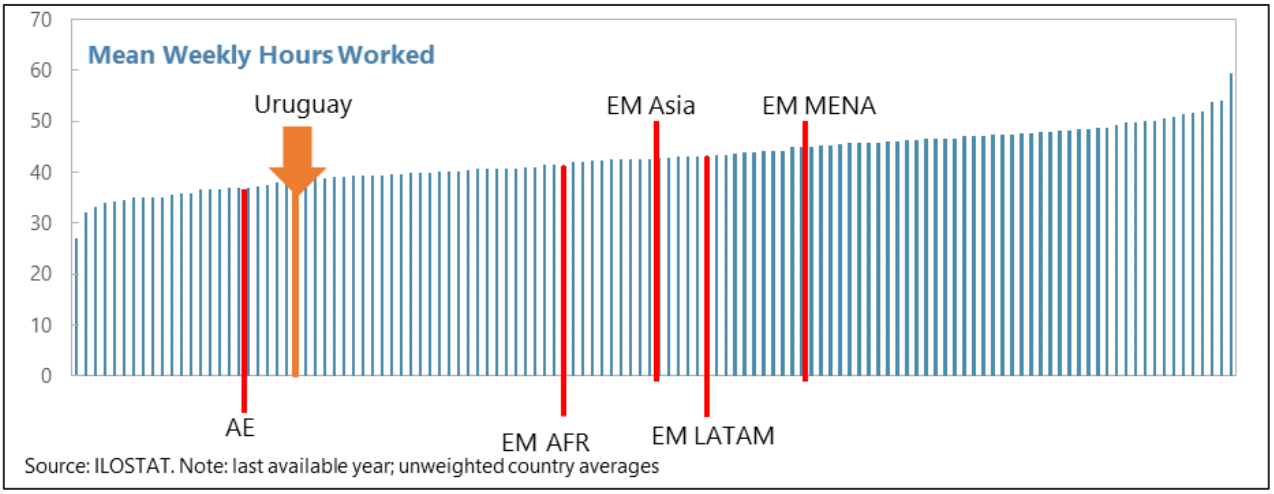


Source: Penn World Tables 10.0, staff calculations.



Source: Penn World Tables 10.0, staff calculations.

8. Following a steady decrease over the years, average hours worked in Uruguay are now lower than in peer countries. On average, Uruguayan employees worked 38.4 hours per week in 2018, compared to an average of 43 hours in EMEs. Uruguay's numbers are comparable to the average AE, despite having a considerably lower level of income. This is the result of a long-term downward trend that started in the 1990s.[4],[5] While in the same period average hours worked were decreasing also elsewhere in the world, Uruguay has a steeper downward trend than both AEs and other EMEs.

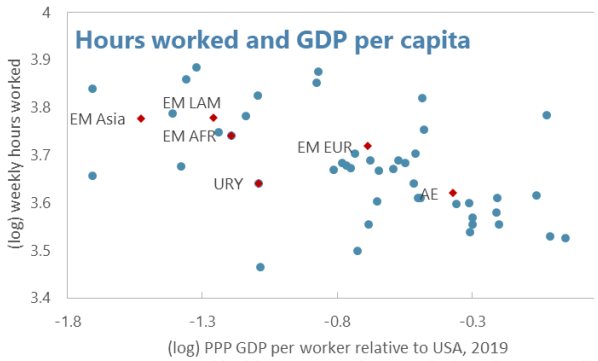


Source: ILOSTAT. Note: last available year; unweighted country averages

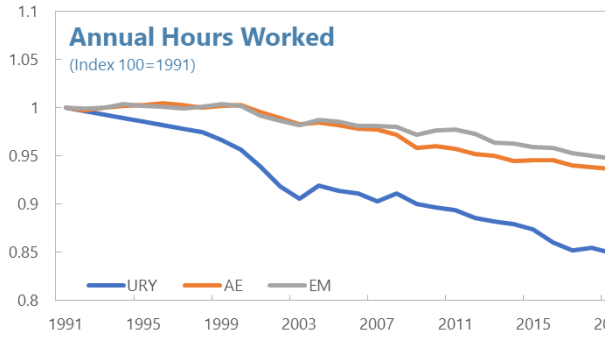
[4] ILO provides alternative data for average weekly hours worked, which display the same pattern.

[5] The global decrease in average hours worked could be accounted for by the increase in female labor force participation.

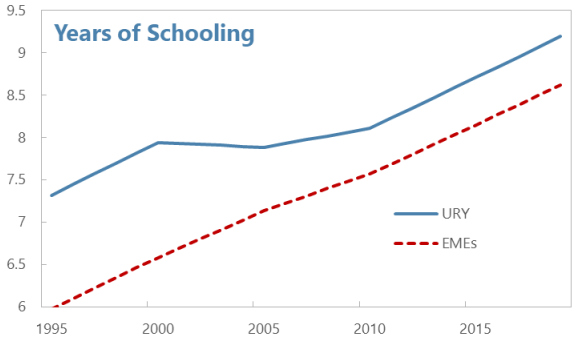
Figure 1. Uruguay: Hours Worked and Human Capital in Uruguay

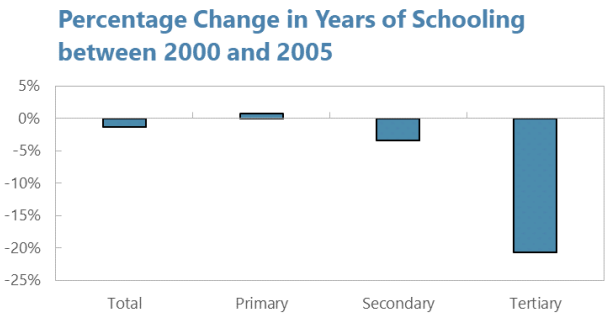


Source: ILOSTAT, Penn World Tables 10.0. Note: hours worked uses last year avail



Source: The Conference Board





Source: Barro-Lee.

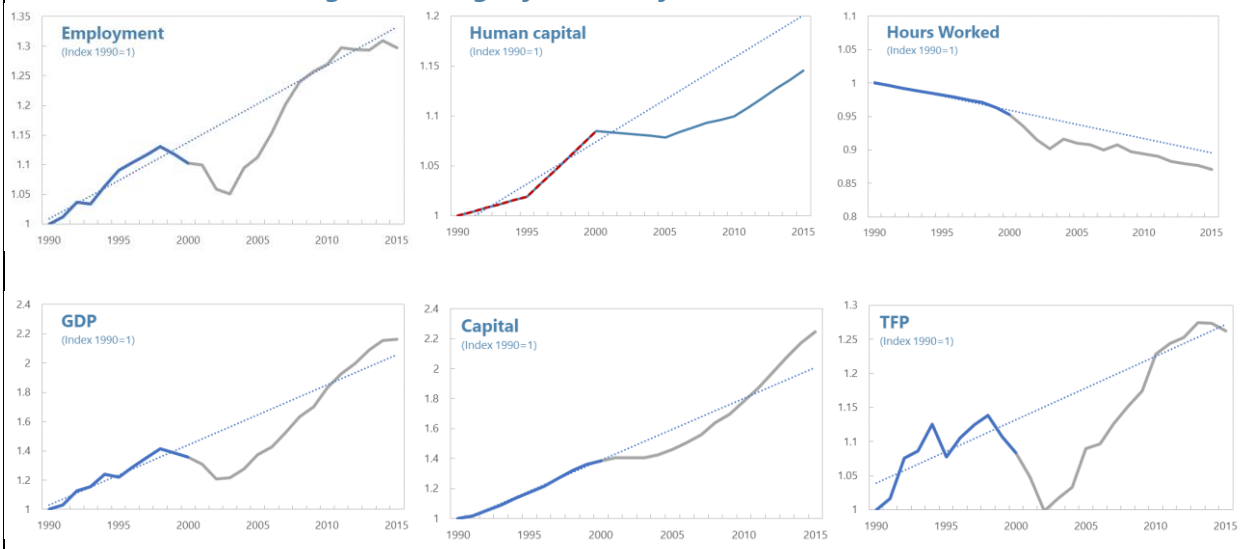
Source: Barro-Lee. Note: missing years are interpolated. Country averages are unweighted.

9. The 2002 crisis resulted in a (relative) erosion of human capital still visible two decades later and an acceleration in the reduction of hours worked, despite a full recovery in GDP. The 2002 crisis caused a significant slowdown in years of schooling—especially in tertiary and, to a lesser extent, secondary education—which was never recovered. This erased the advantage in human capital relative to other EMEs that the country had built in previous decades.[6, 7] Similarly, hours worked remained 3% below the pre-crisis trend, adding to the long-term reduction and further increasing the distance between Uruguay and peers in this respect. The labor market issues arisen during the 2002 crisis for many years have been hidden by an acceleration in capital accumulation, partly driven by the commodity boom, which favored the full recovery of the GDP levels (Figure 1). When the commodity boom ended, these issues came back at the forefront.

[6] Due to data limitations, we cannot exclude other factors contemporaneous to the 2002 crisis accounting for the observed drop in human capital and years of schooling.

[7] On the role of human capital as driver of growth in Uruguay, see de Brun (2004).

Figure 2. Uruguay: Recovery from the 2002 Crisis

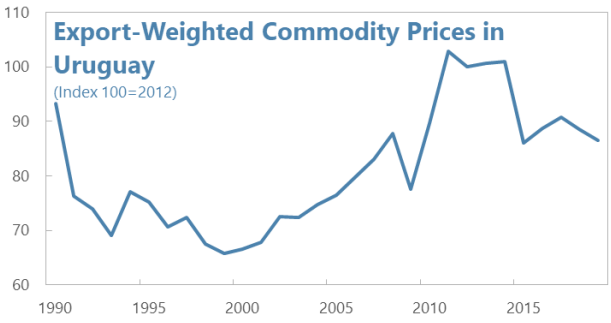


Source: Penn World Tables 10.0, staff calculations. Note: the linear trend is computed on 1990-2000 data.

C. The Role of the Commodity Price Cycle

Commodity prices have been an important driver of growth in Uruguay and other commodity exporters, accounting for a large fraction of the exceptional growth in 2010-14 and the subsequent slowdown. The effect of commodity prices is particularly visible in employment and capital accumulation.

10. Fluctuations of Uruguay's commodity export prices have been sizable over the last 2 decades. Prices started rising gradually in early 2000 and, after a short pause during the 2008-09 global financial crisis, they resumed their upward trend. The boom ended in 2014 when prices started falling rapidly, up until the pandemic. As discussed before, the period of booming commodity prices was associated with higher growth in many emerging economies, including Uruguay. Symmetrically, the subsequent decrease saw a slowdown in growth.[8] Disentangling the effect of commodity prices on growth is of the essence to shed light on potential growth going forward, whether a repeat of the last commodity price boom can be expected or not.



Source: Gruss and Kebhaj (2021)

[8] See for instance Céspedes and Velasco (2012) on the relationship between terms of trade movements and output.

11. The impact of the commodity cycle on growth is estimated in a panel setting. The estimation follows the local projection method pioneered by Jorda (2005). Specifically, the following specification is estimated:

$$\Delta^h y_{i,t} = \alpha_i^h + \alpha_t^h + \sum_{j=0}^{J} \beta_j{}^h \Delta s_{i,t-j} + \sum_{k=1}^{K} \gamma_k{}^h \Delta y_{i,t-k} + \varepsilon_{i,t+h}, \quad h = 0,...H,$$

where $s_{i,t}$ is the commodity export price constructed by Gruss and Kebhaj (2021). The index uses data on commodity prices weighted by lagged export shares for each country; *K* is number of lags of the dependent variable; *J* is the number of lags of the commodity terms of trade; *H* is the time horizon of the impulse response function. Regressions include time fixed effects and country fixed effects to control respectively for economic trends common to all countries, and country-specific characteristics that are constant over time. The model is estimated using an OLS.[9] The sample encompasses commodity exporting EMEs during 1960-2019 and uses annual data from a number of sources, including Penn World Tables, IMF World Economic Outlook, and Gruss and Kebhaj (2021). Impulse responses are estimated with *K*=4 lags of the dependent variable, *J*=4 lags for the commodity terms of trade, *H*=5 years. Results are robust to alternative specifications of the impulse response function and to different time periods. In particular, results are not sensitive to the inclusion of the years of the global financial crisis.[10]

12. Swings in export prices have sizable and long-lasting effect on output and its components (Figure 2). A one percent increase in commodity export prices is estimated to increase GDP by 0.02 percent on impact and 0.1 percent after five years. The impact on output mainly reflects the effect through capital accumulation and employment. A one percent temporary increase in commodity export prices gradually increases investment, to raising it by about 0.3 percent at a five-year horizon and leading to an increase in the stock of capital of 0.1 percent over a five-year horizon. Meanwhile, employment also increases gradually to about 0.07 percent over a five-year horizon. The effect on average hours worked and TFP is not significant, and the magnitudes are small.[11] These results indicate that temporary commodity price shocks can have sizable and long-lasting effects on the level of output (although not on growth) primarily through capital accumulation and employment.

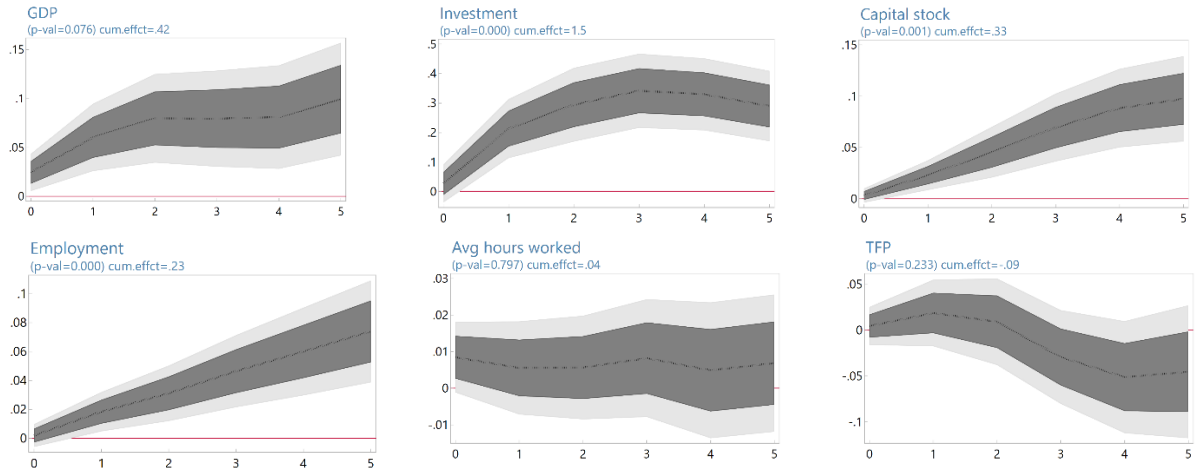
13. The last commodity boom partially accounts for Uruguay's growth during the 2004-14 period. Based on the estimates above and the observed commodity prices for Uruguay—which increased on average by 3 percent annually during 2004-14—the commodity boom accounts for 1.2 percentage points GDP growth per year above the historical average. Zooming in, estimates

[9] List of countries included in the analysis: Algeria, Angola, Argentina, Azerbaijan, Bahrain, Brazil, Brunei Darussalam, Chile, Colombia, Costa Rica, Ecuador, Gabon, Guatemala, Guyana, Indonesia, Iran, Kazakhstan, Kuwait, Libya, Malaysia, Oman, Paraguay, Peru, Qatar, Russia, Saudi Arabia, Syria, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Uruguay, Venezuela.

[10] For a general-equilibrium approach on the effect of commodity prices, see Frache, Rodríguez (2021).

[11] During the period of high commodity prices, oil prices increased significantly as well. Being an oil importer, Uruguay's terms of trade only improved around 2014. However, it turns out that the effect of import and export prices is asymmetric and import prices do not have a significant effect on economic conditions.

Figure 3. Uruguay: Impulse Responses to a Commodity Export Price Increase



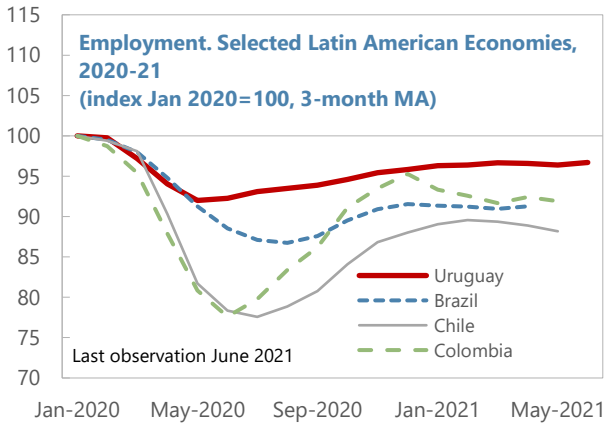
Sources: Penn World Tables, IMF WEO, Gruss and Kebhaj (2021) and own estimations. P-values for an F-test on the coefficients being significant at any time horizon are reported.

indicate that the commodity boom contributed to raising output growth primarily through faster capital accumulation (1 percent higher) and employment (0.7 percent higher). Similarly, the drop in commodity prices after 2014 accounts for about 0.2 lower growth annually during 2015-19. They also account for the negative employment growth and decreasing employment rates observed in the period.

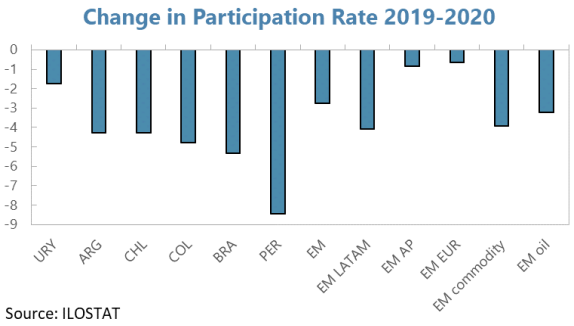
D. The Effects of the Pandemic on Growth

The pandemic is expected to lower potential growth relative to its pre-pandemic trend. The drop in potential output is accounted for by a strong reduction in employment and labor force participation, and a slowdown in investment and productivity. School closures also reduced human capital accumulation.

14. At the peak of the pandemic, employment in Uruguay fell by 8 percent, but overall, the labor market has remained resilient. While 152 thousand workers lost their job and those who retained their jobs worked significantly fewer hours, the impact on the labor market has been mild compared to other Latin American countries, thanks to early successes in the containment of the virus. The participation rate in Uruguay



dropped by merely 1.7 percentage points, compared to an average among EM in Latin America of 4.1 percentage points. However, employment has yet to reach pre-pandemic levels. Those who left the labor force may never re-enter after health conditions normalize. Firms might be reluctant to hire, in a context of low productivity and uncertain global demand. Similarly, hours worked significantly dropped during the pandemic, with people in April 2020 working on average twelve fewer hours than they did at the beginning of the year. The situation has improved since the peak of the pandemic, but hours worked have not gone back to pre-pandemic levels, and, if the pandemic resembles the rebound following the 2002 crisis, they never will.



Source: ILOSTAT

15. While Uruguay entered the pandemic well positioned to face the challenges posed by the education system, the switch to distance learning resulted in more than ½ year of school lost. Uruguay has high levels of digitalization, internet access, and computer ownership in the population, including among the lowest quantile of the income distribution. In Uruguay, 77 percent of the population has Internet access, compared to an average in Latin America of 56 percent and the gap in Internet access between the poorest and the richest quintile is one of the smallest in Latin America (World Bank 2020). Access to a mobile phone with Internet in Uruguay is almost close to 100 percent (UNICEF, 2020). Nevertheless, relying on estimates from a World Bank study on the effectiveness of distance learning in Chile (World Bank, 2020b), Uruguayan students in 2020 enrolled in primary and secondary education may have lost between 0.79 and 0.63 years of school due to school closures.[12] Because of school closures, the impact on human capital translates into 2.5 percent lower GDP per capita than it would have been otherwise.[13] The pandemic was also felt on school enrolments and drop-out rates, reversing the progress made in this area.[14] The experience of 2002 indicates that this effect—together with possible impact on college enrollments—may be long lasting.

16. The pandemic reduced investment, although the impact on the stock of capital is minimal. Investment contracted by 0.5 percent in 2020, implying a negative capital contribution of -1.3% in the year, although the impact on the overall capital stock was small. The recovery is also likely to spur new investment opportunities, in a similar fashion as the 2002 crisis, thanks to renewed interest in green energy and digitalization, unless the recovery from the pandemic stalls.

[12] This assumes a loss in quality-adjusted years of education due to school closures between 12% and 3% and that schools in Uruguay have been closed or partially closed for at least 90 percent of the academic year. The resulting range of years of school lost is between 0.79 (= 0.9*(1.0-0.12)) and 0.63 years of school (= 0.9*(1.0-0.30)).

[13] This figure is computed using a Mincer equation and years of schooling as a proxy for human capital accumulation.

[14] INEEd (2021).

17. The extraordinary adjustments in production factors, in particular labor inputs, was offset by an increase in productivity during the pandemic. While the drop in production in 2020 was large, the reduction in production inputs (employment, hours worked, and capital) was even larger. As a result, productivity in 2020 increased, in stark contrast with past crises, when productivity was the largest margin of adjustment and production factors remained relatively stable. As a matter of fact, the magnitude of the reduction in hours worked and employment was extraordinary by historical standards.

Table 4. Uruguay: Growth Accounting During the Pandemic

		Contributions				
	GDP growth	Employment	Human capital	Hours	Capital	TFP
2020	-5.9%	-1.8%	0.0%	-5.7%	-1.3%	2.9%

Source: staff calculations.

18. For the future, the COVID-19 crisis might erode past improvements in GDP per capita, but long-lasting negative effects on GDP growth are less likely. If human capital and hours worked remain permanently low, as they did during the 2002 crisis, the level of GDP per worker might never fully recover. As a matter of fact, primary and secondary school students may not be able to make up for the time lost during the pandemic. This would not have implications on GDP growth, but it would result in a significant erosion in GDP per capita and a setback in the fight for poverty reduction.

19. On the other hand, the structural changes spurred by the pandemic might translate into a boast in productivity and investment. The pandemic has also highlighted how advanced Internet access and digitization are important strengths Uruguay should continue to leverage and develop, and they might entail important productivity gains in the medium-term.

E. Post-Pandemic Growth

In absence of reforms, Uruguay is likely to return to pre-pandemic low growth although, if sustained, high commodity prices could provide support to growth again.

20. The next years are likely to see a strong rebound from the pandemic. In the past, Uruguay has displayed strong GDP rebounds after deep recessions. If history repeats itself, we might witness a full recovery in employment and capital, and at least a partial recovery in hours worked. The rebound from the pandemic will drive growth in the near future, mirrored by improvements in the labor market.

21. Faster potential growth might spur from a new commodity cycle, with benefits on GDP, employment, and capital accumulation. Fueled by the global demand and the recovery from COVID-19, food prices are expected to remain high in the foreseeable future (IMF October 2021 WEO), resulting in a positive impact on GDP and its components. The commodity cycle could add 1.3 percentage points to the annual GDP growth, favor employment growth and capital

accumulation. This estimate is the average effect of commodity export prices on GDP growth in a sample of 32 countries in the last sixty years. While this model is a reasonable benchmark, the effect in Uruguay might differ from the average. Moreover, other forces may have been at play, including the rebound from the 2002 crisis and indirect effects from fast-growing neighboring countries. In general, these estimates are subject to significant uncertainty, for instance if commodity prices turned out lower than currently forecasted.

Table 5. Uruguay: Growth Outlook for the Next Five Years

		Contributions				
	GDP growth	Employment	Human capital	Hours	Capital	TFP
Historical trend (1978-2019)	2.5%	0.5%	0.4%	-0.2%	1.4%	0.4%
Pre-pandemic trends (2014-19)	0.9%	-0.1%	0.4%	-0.2%	1.0%	-0.2%
- with high commodity prices	1.3%	0.5%	…	…	0.8%	…
- with rebound from COVID-19	0.5%	0.3%	0%	0.2%	0%	0%
Total growth average (2022-26)	2.7%	0.7%	0.4%	0.0%	1.8%	-0.2%

Source: staff calculations. Note: Commodity price boom assumes a 4.1 percent average increase in export prices for the period 2020-26. The rebound from COVID-19 assumes part of the recovery occurs in 2021, and, for the period 2022-26, it assumes a full recovery in employment and capital, and a partial recovery in hours worked.

22. Beyond the next five years, structural reforms in key sectors will be needed to sustain growth. Over the medium-term, the boost to growth from elevated commodity prices and the recovery from the pandemic is likely to fade away. Tackling structural impediments (e.g., enhancing labor market flexibility, improving efficiency and competitiveness through SOE reform, improving education outcomes, investing in digitalization and green energy, etc.) will be key to sustain strong growth.

References

Azevedo, Joao Pedro; Hasan, Amer; Goldemberg, Diana; Iqbal, Syedah Aroob; Geven, Koen. 2020. Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates. Policy Research Working Paper; No. 9284. World Bank, Washington, DC.

Céspedes, Luis Felipe, and Andrés Velasco. 2012. "Macroeconomic Performance during Commodity Price Booms and Busts." IMF Economic Review 60 (4): 570–99.

De Brun, Julio, 2004, Growth in Uruguay: factor accumulation or productivity gains? Inter-American Development Bank, Regional Operations Department 1. Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182.

Frache, Serafín, and Rodríguez, Helena (2021), Un modelo estocástico de equilibrio general para la economía uruguaya con producción de commodities, Documento de trabajo 006 - 2021, Banco Central del Uruguay.

Gruss, Bertrand, and Suhaib Kebhaj. 2021. Commodity terms of trade: A new database. International Monetary Fund.

INEEd (2021). Aristas 2020. Primer informe de resultados de tercero y sexto de educación primaria.

Jordà, Òscar, 2005, "Estimation and inference of impulse responses by local projections." American economic review 95, no. 1 (2005): 161-182.

World Bank, 2020, Impacto del COVID-19 en los Resultados de Aprendizaje y Escolaridad en Chile: Analisis con Base en Herramienta de Simulacion Proporcionada por el Banco Mundial (Spanish). Washington, D.C.: World Bank Group.

World Bank, 2020b, Latin American Economic Outlook 2020: Digital Transformation for Building Back Better. Chapter 3. The digital transformation for all.

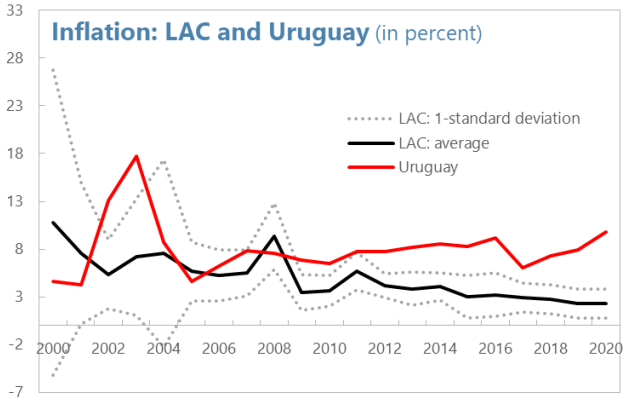
UNICEF 2020, COVID-19 and primary and secondary education: the impact of the crisis and public policy implications for Latin America and the Caribbean. UNDP LAC C19 PDS No. 20.

STRUCTURAL DETERMINANTS OF INFLATION[1]

This paper studies the impact of structural factors on inflation level and stickiness across Latin American countries. It finds that greater labor market flexibility—reflected in wage setting and decentralized bargaining schemes—leads to lower inflation. Similarly, more disciplined fiscal policies (especially linked to the implementation of fiscal rules) and, to a lesser extent, central bank transparency and independence also help reduce inflation. The results also indicate that implementing reforms along some of these dimensions in Uruguay could have meaningful impact in terms of permanently lowering inflation.

A. Introduction

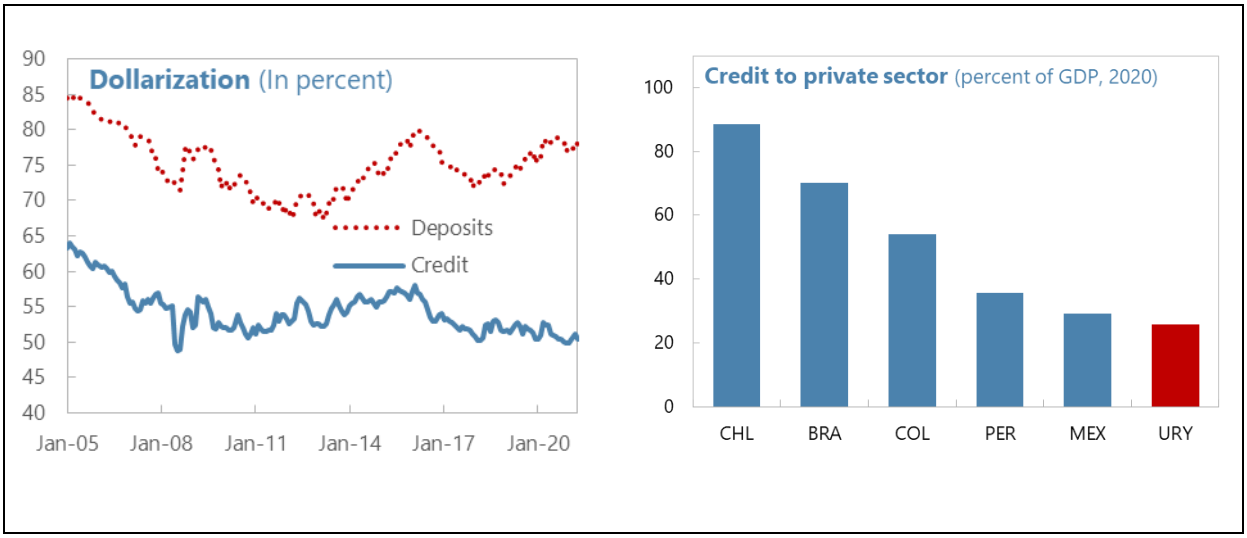
1. Uruguay's inflation rate has been one of the highest in the region and persistent throughout business cycles. Inflation around the world and in the region has come down significantly in the past two decades, but Uruguay has been lagging the common trend.



2. High inflation has hampered Uruguay's financial deepening and eroded competitiveness. Persistently high inflation has been a root cause of high dollarization—as agents have resorted to US dollar assets to hedge against inflation. This, in turn, has resulted in an underdeveloped financial system, with low credit to the private sector (as firms and households are reluctant to borrow in foreign currency). The high inflation deferential vis-à-vis trade partners has also contributed to eroding the country's external competitiveness.

3. The high and sticky inflation may have structural causes. Conventional business cycle models see inflation as a function of cyclical factors and monetary conditions, such as output gap, unemployment rate, and money supply. Although these factors help describing the cyclical fluctuations of inflation, they do not paint the whole picture about the large and persistent differences in inflation across countries. Slower-moving structural factors such as wage setting mechanism, the degree of fiscal responsibility or the institutional setting of the monetary authority may play a role.

[1] By Natasha Che.



4. Understanding the structural causes of inflation is important for de-dollarization, promoting credit growth, and designing pro-growth policies for Uruguay. The Uruguayan authorities have expressed a clear intention to lower inflation, with efforts so far mostly focused on central bank monetary policy actions, i.e., interest rate setting and monetary policy communication. The structural causes of high inflation, however, may go beyond the mandate of the central bank. More clarity on the non-monetary contributors to inflation can help inform the policy agenda in this regard. This paper examines the role of labor market policy, central banking institutions, and fiscal responsibility as structural drives of inflation in Uruguay and peer countries.

B. How Structural Factors Can Affect Inflation

5. Labor market rigidities can lead to a higher equilibrium level of inflation. Cukierman (1992) proposed that, when wage stickiness is high, the effect from unanticipated monetary expansion for boosting output and employment is relatively large. This gives the authorities a greater incentive to inflate the economy. Over time, private sector agents recognize this policy motive and adjust their price-setting behavior accordingly. Nevertheless, with higher wage rigidity, the incentive to inflate is higher. In equilibrium, the inflation rate is higher where wage stickiness is high, even though the goal of higher employment may not be achieved. Thus, a hypothesis of the paper is that a more flexible labor market, where wages are competitively determined, contributes to a lower (long-run) inflation rate.

6. Backward-looking wage indexation can also lead to higher and stickier inflation. When past inflation becomes a fixed component in wage determination, the wage increase can then feed into future price increases and perpetuate the previous inflation level, other things equal. In addition, backward-looking indexation can make disinflation initiatives costly. Specifically, when nominal wages are dependent on past inflation while current inflation comes down, the real wages increase, which tend to reduce labor demand and output, leading to short-term contractionary effects (Cottarelli et al, 1998). Thus, facing pervasive backward wage indexation, the authorities may

need doubly strong political will to implement disinflation initiatives. Extensive indexation may also be a manifestation of labor market rigidities, as the market does not adjust according to micro-level information, but rather, relying on macro indicators which contain less information of firm or sector level performances. Moreover, since greater indexation may reduce the social cost of inflation, it may weaken the economy's aversion to inflation in general (Fischer & Summers, 1989).

7. The prevalence of centralized wage bargaining may increase both equilibrium inflation level and its stickiness by reducing wage flexibility and inducing backward indexation. A centralized wage bargaining system is inherently more rigid than a decentralized system, as the former has a harder time assimilating locally-originated information on productivity growth and productivity differentials across firms and industries. The higher cost in obtaining new information inputs in a centralized bargaining system may encourage the use of backward-looking wage indexation, since the information on past inflation is easy to obtain compared to other more granular data. In addition, if the legal and institutional environment in a centralized bargaining arrangement increases the bargaining position of large unions, it may lead to higher wages and lower employment (McHugh, 2002) and, in turn, increases the authorities' incentive to inflate. We therefore hypothesize that a more centralized bargaining process is associated with higher and stickier inflation.

8. The quality of central bank institutions can also affect inflation. Central bank independence and transparency may be more conducive to low inflation. By separating the central bank from a wider agenda of promoting growth and, instead, committing expressly to price stability, these institutions can counteract the inflationary bias of a more discretionary monetary policy. Thus, having a more transparent and independent central bank may be associated with lower inflation.

9. Responsible fiscal policies can support a lower inflation level. Countries with a large negative fiscal imbalance may have a stronger incentive to use inflation as an intangible tax to help alleviate fiscal problems (Cottarelli et al, 1998). In addition, deficit spending may bid up labor costs, which, combined with wage rigidity, may perpetuate a higher inflation level.[2] Thus, one can expect a positive relationship between the government's fiscal deficit and the level of inflation, as well as between public debt and inflation. On the flip side, institutions that support fiscal discipline, such as fiscal rules, may be associated with a lower inflation level. Responsible fiscal management may be especially important for countries dependent on commodity exports. Case studies (e.g. Holden, 2013) show that conservative fiscal policy plays a large role in regulating the upward pressure on domestic demand and price/wage inflation created by a booming export sector in commodities or natural resources. We therefore hypothesize that lower public debt and government deficit, as well as the presence of fiscal rules, should be associated with lower inflation.

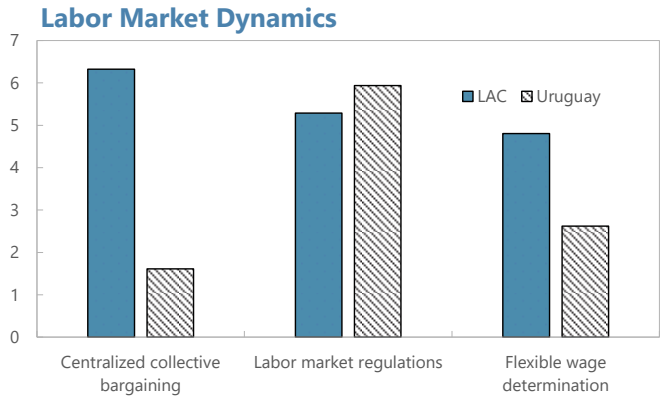
[2] Mello and Ponce (2021) found a positive correlation between budge deficit and inflation expectations.

C. Data and Stylized Facts

10. The analysis focuses on 18 Latin American countries. The countries included are Argentina[3], Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.[4] The time period covered is 1995–2018, though some of the structural variables are available for shorter periods, as explained below.

11. Data on labor market institutions, central bank institutions, and fiscal responsibility come from various sources.[5]

- **Labor market dynamics.** The paper uses an index on "flexibility of wage determination" by Global Competitiveness Report (GCR). The index is based on the cross-country survey question: "Wages in your country are set by a centralized bargaining process (=1) or up to each individual company (=7)". In other words, the higher the index, the more frequently that wages are determined by individual employers. However, the current batch of GCR data is only available starting 2007. The paper also uses the indicator for "centralized collective bargaining", from Fraser Institute's Economic Freedom Index. This indicator is essentially based on the same survey from GCR, but it harmonizes data from earlier years, when the survey question was phrased somewhat differently, to get a longer time series. This indicator runs from 2000. Fraser Institute also publishes a composite index on the "flexibility of labor market regulations". This is an aggregation of several sub-indices that measure how employer-friendly labor market regulations are, including i) minimum wage regulation, ii) hiring and firing regulation, iii) centralized collective bargaining, iv) hours regulation, and v) mandated cost of worker dismissal.



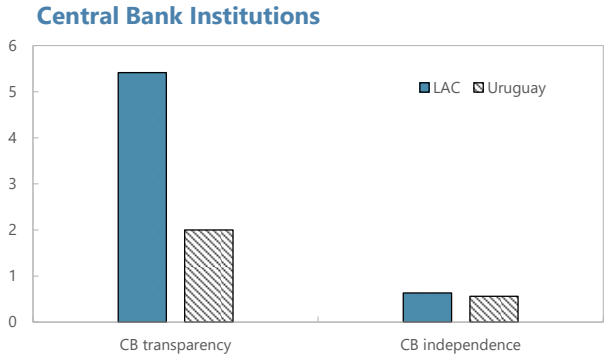
- **Central bank institutions**. Two indices are used: The first is an index on central bank independence by Garriga (2016), although it is only updated to 2012. The second is an index on central bank transparency by Dincer and Eichengreen (2014), which runs from 1998 to 2014.

[3] Inflation data for Argentina is taken from the World Economic Outlook as reported by the country authorities.

[4] Venezuela is not included in the sample used for the regression results presented in later sections of the paper, given that the country is an outliner in many of the structural valuables as well as in inflation. The results do not change qualitatively with Venezuela included.

[5] The LAC average is calculated over 2010-18, including all sample countries except Venezuela. For Uruguay, 2018 data is used.

The latest data for these two indices are then extrapolated to 2018 using the last actual observation available.[6]



- **Fiscal responsibility.** The paper considers the impact of fiscal deficit, public debt-to-GDP, and the presence of fiscal rules on inflation. The data on primary structural balance from WEO is used. We use the structural balance measure in order to mitigate the influence of the business cycle, which affects both inflation and the fiscal balance. The fiscal rules data is taken from the IMF's Fiscal Rules and Fiscal Councils Database, which flags four types of rules: budget balance rules (BBR), debt rules (DR), expenditure rules (ER), and revenue rules (RR). We derive a composite fiscal rule indicator by adding the four together. In other words, the value equals 0 if a country does not have any fiscal rule and equals 4 if all four types of rules are present. Although the database is carefully constructed, it has limited country coverage and only include 10 of our sample countries. In addition, the database is only updated to 2014. Thus, the last data observations are extrapolated to 2018.

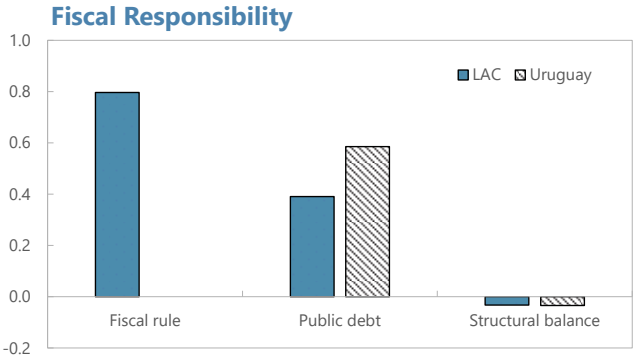
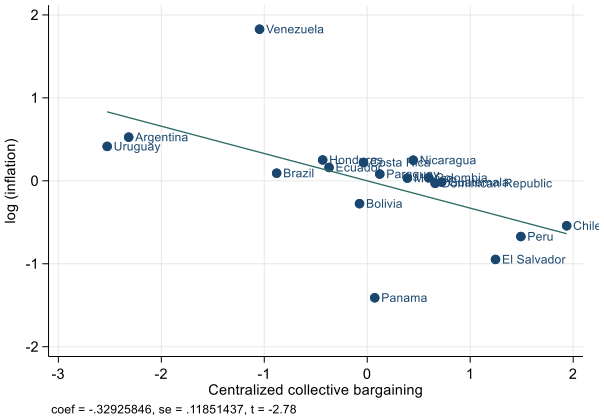


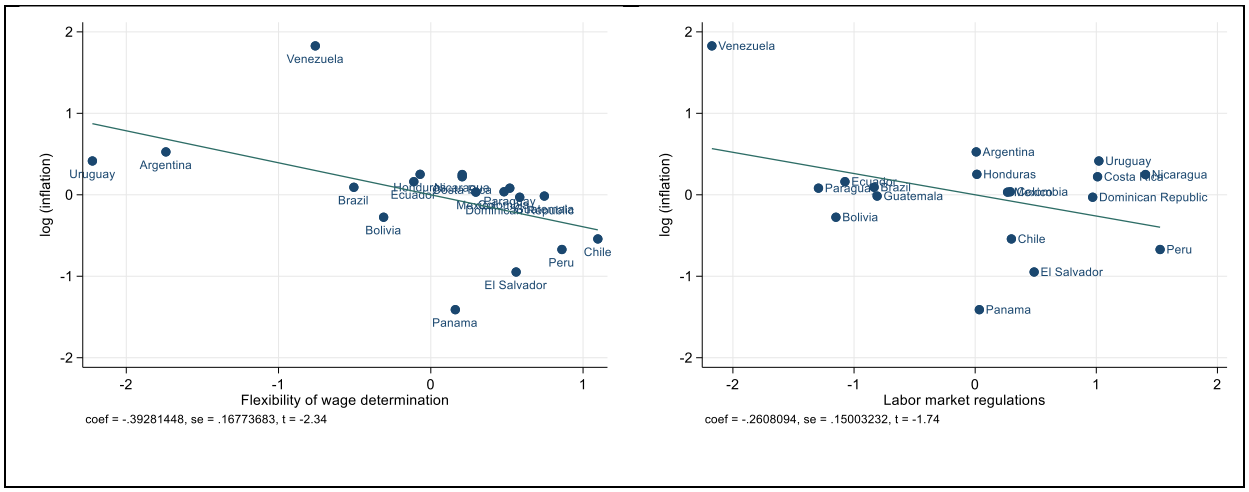
Table 1. Uruguay: Summary Statistics of Main Variables

Variable	Observations	Mean	std	Min	Max
Inflation	409	0.10	0.34	-0.01	6.48
Centralized collective bargaining	348	6.19	1.40	1.61	8.85
Flexibility of labor market regulations	349	5.19	1.11	2.10	7.37
Wage flexibility	196	4.68	0.89	2.21	6.11
Central bank transparency	210	4.89	2.10	1.00	8.50
Central bank independence	432	0.64	0.17	0.17	0.83
Primary structural balance	291	-0.02	0.02	-0.10	0.05
Public debt	383	0.41	0.22	0.04	1.81
Fiscal rule	446	0.5	0.78	0	2

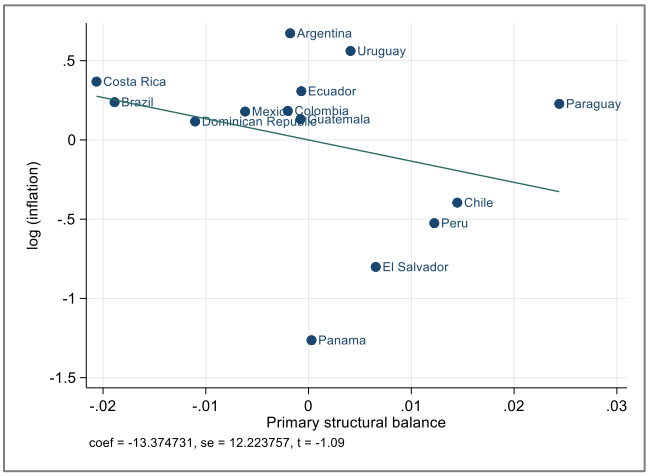
[6] Dassatti and Licandro (2020) compared Uruguay's scoring in different cross-country measures of central bank transparency, and noted that Uruguay's scores have improved in more recent periods.

12. Simple cross-sectional correlations show a significant negative relationship between labor market flexibility and inflation. As indicated in the charts—which plot partial regression of a country's average inflation on its average score of labor market indicators, without control variables—economies with more centralized collective bargaining schemes tend to have higher inflation. In other words, more flexibility of wage determination is associated with lower inflation. The overall flexibility of labor market regulations is also associated with lower inflation, although the negative relation in the chart seems largely driven by one outlier (Venezuela).



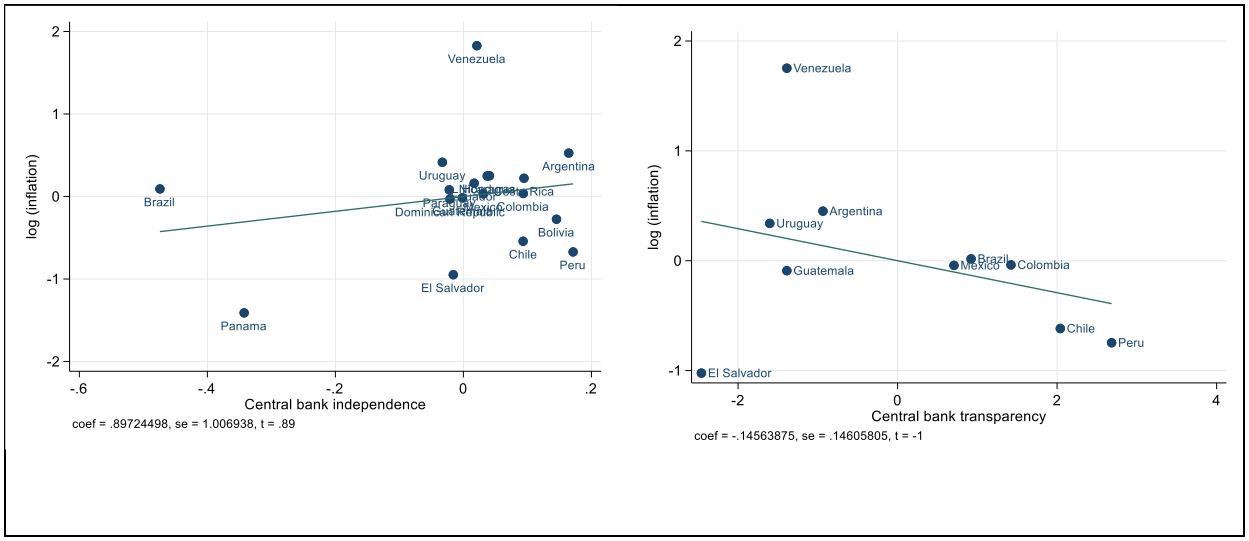


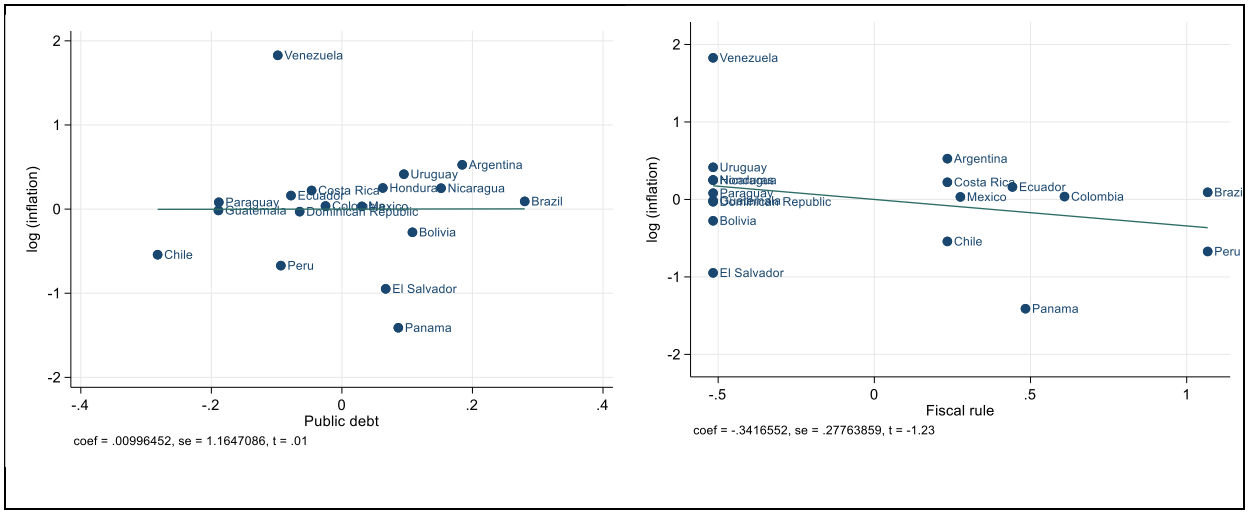
13. Some measures related to the central bank's institutional setting seems associated with inflation, although data limitations are important. Central bank transparency appears negatively correlated with inflation, although there is no clear link between central bank independence and inflation. As mentioned earlier, however, the data for the latter index is only updated to 2012. Thus, results should be interpreted with caution. In addition, the within-country time variation in the indicator is minimal, which makes identification more difficult in a regression setting, as discussed in the next section.



14. Fiscal discipline seems to be associated with lower inflation. Countries running a higher structural primary balance, on

average, appear to have lower inflation on average. The presence of fiscal rules is also associated with lower inflation although the relationship, as expressed through simple correlation, does not appear significant. As for the average public debt level, the correlation plot does not show any clear relationship with inflation.





D. Empirical Method

15. We formally explore the impact of structural factors on inflation in a multi-variate setting, along the lines of Cottarelli et al (1998), and Kandil et al (2009). Specifically, inflation is modeled as a function of past inflation, as well as cyclical and structural factors, as follows:

$$\pi_{i,t} = \alpha_i + \beta\pi_{i,t-1} + \gamma X_{i,t} + \delta s_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $\pi_{i,t}$, is current inflation of country i, $s_{i,t}$ is the structural factor under investigation, and $X_{i,t}$ is a set of control variables mostly related to business cycle and monetary conditions. The latter include 1) output gap and primary fiscal balance to capture the business cycle's impact on inflation; 2) monetary base as percent of GDP, to represent the monetary stance, 3) import-to-GDP ratio, to capture the degree of openness of the economy, and 4) world inflation, to capture the impact of external inflation trend. We expect the coefficients for 1) and 2) to be positive. For 3), the hypothesis is that a more open economy with a higher import ratio would tend to have a lower inflation (Romer, 1993). The rationale is that the more open the economy, the smaller the real benefits of boosting output from surprise monetary expansion, as the welfare loss from the real terms of trade loss dominates. Thus, a lower equilibrium rate of inflation may be observed. For 4), the coefficient is expected to be positive, as part of the domestic inflation may be imported. Including this control also helps capture the impact of the common long-term shift in the global inflation environment, which has had a distinctive downward trend during the past decades.

16. The model is estimated using OLS and system GMM. The fixed effect estimation for dynamic panels that include lagged dependent variables as regressors lead to biased estimates for the lagged variable (Nickell, 1981), especially in the scenario where the time dimension is not significantly larger than the dimension of the panel. To avoid this issue, we employ the system GMM estimator by Blundell and Bond (1998), which is an extension of Arellano and Bond (1991).

E. Results

Structural Factors and Inflation

17. Labor market institutions appear to be important determinants of the level of inflation (Table 2). The estimates for wage flexibility and the absence of centralized collective bargaining are negative and significant for both OLS and GMM estimators, although the coefficients are larger for the GMM estimator. The centralized collective bargaining indicator covers a longer time series, so we consider it a preferred measure to the first one. Taking the numerical estimates at face value, the results indicate that a 1-unit increase in the wage flexibility score (i.e. 1-unit reduction in centralized collective bargaining score) leads to around 20 percent reduction in inflation level.[7] The variable for "flexibility of labor market regulations" is not significant in either estimator.

18. Regarding the control variables, the world inflation has the expected sign, while the others are mostly not significant. In most regressions, the output gap has a positive sign, as expected. But contrary to our prior, the import ratio variable has mostly positive signs, albeit not significant in most of the specifications. Higher primary balance[8] is shown to be mostly associated with higher inflation, though the estimates are not significant. This variable could be picking up the business cycle variation (i.e., when the economy is booming, fiscal performance tends to improve

[7] Note that this is percentage reduction from current inflation level, not reduction in the percentage point of inflation rate.

[8] This is the raw primary balance as percent of GDP, not the structural balance.

while inflation also tends to be higher) that is not effectively captured by the output gap variable. None of the estimated coefficient for base money is significant.

Table 2. Uruguay: Labor Market Flexibility and Inflation[1/]

	Wage Flexibility		Collective Bargaining		Labor Market Regulations	
VARIABLES	(1) OLS	(2) Dynamic panel	(3) OLS	(4) Dynamic panel	(5) OLS	(6) Dynamic panel
log(inflation)$_{-1}$	0.32***	0.16	0.40***	0.16	0.54***	-0.11
	(0.11)	(0.17)	(0.10)	(0.16)	(0.08)	(0.21)
Wage flexibility$_{-1}$	-0.29***	-0.38***				
	(0.07)	(0.11)				
Centralized collective bargaining$_{-1}$			-0.17***	-0.21***		
			(0.04)	(0.06)		
Labor market regulations$_{-1}$					-0.08	0.18
					(0.05)	(0.18)
Output gap	0.03	0.01	-0.01	-0.01	0.01	-0.03*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Import ratio	0.13	0.26	0.19**	0.28	0.09	-0.24
	(0.10)	(0.18)	(0.09)	(0.21)	(0.10)	(0.29)
Primary balance	2.17	-0.98	1.54	0.53	1.21	2.52
	(2.67)	(3.73)	(1.91)	(3.37)	(2.08)	(3.16)
Base money	-0.74	-2.85	-0.34	-3.29	-0.03	-0.44
	(0.94)	(4.10)	(0.71)	(3.43)	(0.79)	(2.85)
log(world inflation)	0.45***	0.52***	0.46***	0.44***	0.40***	0.71***
	(0.09)	(0.12)	(0.09)	(0.07)	(0.09)	(0.14)
Constant	-1.09***	-0.94	-1.08***	-1.15	-1.35***	-5.54**
	(0.32)	(0.74)	(0.29)	(0.75)	(0.47)	(2.07)
Observations	110	110	193	193	193	193
R-squared	0.49		0.46		0.40	

1/ For all tables, standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

19. Central bank institutions also play a role in determining the level of inflation (Table 3). The indicators on central bank transparency and independence are both negative and significant in the OLS regression—i.e., higher scores in central bank transparency and independence lead to lower inflation. However, while the coefficient for central bank independence remains negative, only the transparency variable is significant in the system GMM setting. As mentioned earlier, since these are long-term institutional variables, they do not change much from year to year. The lack of within-country variation may have made identification harder in the GMM setting since it relies on first differences of variables. In addition, the time coverage for both variables are shorter than our full sample. The later years' observations are filled by extrapolating earlier years' data. This probably also reduced identification. In terms of magnitude of impact, the GMM estimate indicates that a 1-unit increase in the central bank transparency score is associated with 10 percent reduction in inflation.

Table 3. Uruguay: Central Bank Institutions and Inflation				
	Transparency		Independence	
VARIABLES	(1) OLS	(2) Dynamic panel	(3) OLS	(4) Dynamic panel
log(inflation) $_{-1}$	0.49***	-0.35	0.57***	0.34*
	(0.11)	(0.57)	(0.07)	(0.16)
Central bank transparency$_{-1}$	-0.04*	-0.10**		
	(0.02)	(0.04)		
Central bank independence$_{-1}$			-0.47**	-3.42
			(0.24)	(9.47)
Output gap	0.04**	0.00	0.01	-0.01
	(0.02)	(0.04)	(0.02)	(0.05)
Import ratio	-0.32**	-0.87	0.15	0.78
	(0.14)	(0.77)	(0.10)	(1.62)
Primary balance	1.41	9.34	1.59	2.37
	(2.54)	(14.37)	(1.86)	(9.48)
Base money	0.49	1.76	-0.08	-1.73
	(1.05)	(4.96)	(0.70)	(8.68)
log(world inflation)	0.22**	0.26	0.37***	0.34**
	(0.10)	(0.39)	(0.08)	(0.12)
Constant	-2.17***	-5.47	-1.31***	0.94
	(0.48)	(3.59)	(0.38)	(7.84)
Observations	133	133	217	217
R-squared	0.42		0.44	

20. Fiscal institutions also affect inflation, though some results are not statistically significant. The results indicate that, consistent with the hypothesis, higher structural deficits and public debt levels lead to higher inflation, while the introduction of fiscal rules reduces inflation. However, only the public debt variable is significant in both OLS and GMM settings. The fiscal rule variable is significant in the GMM specification, while primary structural balance is not significant in either setting. One explanation for the lack of significance for primary balance is that a higher deficit in any single year may not be a true indication of a lack of fiscal discipline, thus its relationship with equilibrium inflation is weak. In contract, the debt level is the accumulated result of fiscal management over an extended period of time, thus a more informative indicator of fiscal discipline. As for fiscal rule, aside from the fact that fiscal rules impose material constraints on fiscal management, the presence of fiscal rules itself may be a signal that the authorities are taking fiscal responsibility seriously. In terms of magnitude, according to the GMM estimation results, a 10 percentage point increase in the debt-to-GDP ratio is associated with 10 percent increase in inflation, other things equal, while implementing one type of fiscal rules reduces inflation by around 18 percent.

Table 4. Uruguay: Fiscal Responsibility and Inflation

	Primary Structural Balance		Public Debt		Fiscal Rules	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	OLS	Dynamic panel	OLS	Dynamic panel	OLS	Dynamic panel
log(inflation) $_{-1}$	0.56***	0.20	0.56***	-0.02	0.56***	0.27*
	(0.08)	(0.16)	(0.08)	(0.19)	(0.07)	(0.13)
Primary structural balance	-1.91	-4.25				
	(1.80)	(5.78)				
Public debt			0.38*	1.18**		
			(0.22)	(0.41)		
Fiscal rule$_{-1}$					-0.07	-0.17**
					(0.05)	(0.06)
Primary balance			-0.10	1.98	1.87	2.61
			(1.99)	(3.93)	(1.92)	(3.34)
Import ratio	-0.03	-0.12	0.08	0.42	-0.00	-0.23
	(0.09)	(0.33)	(0.08)	(0.26)	(0.08)	(0.23)
Output gap	0.01	-0.02	0.02	0.01	0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Base money	-0.16	6.31	-0.34	-7.53	0.08	-2.95
	(0.91)	(15.92)	(0.76)	(4.39)	(0.67)	(5.33)
log(world inflation)	0.41***	0.54***	0.41***	0.57***	0.36***	0.55***
	(0.10)	(0.16)	(0.09)	(0.10)	(0.09)	(0.15)
Constant	-1.97***	-3.75**	-1.91***	-3.20***	-1.77***	-2.83***
	(0.35)	(1.67)	(0.31)	(0.65)	(0.28)	(0.93)
Observations	179	179	211	211	217	217
R-squared	0.42		0.45		0.44	

21. Strengthening some of Uruguay's institutional features could contribute to significantly reduce the level of inflation. Table 5 presents the estimated magnitudes of inflation reduction if Uruguay's scores in the select structural variables were at the sample average levels for LAC countries. While these estimates should be interpreted with caution, including because they were explored in the econometric estimations one at a time, they give a sense of the importance of tackling structural features as a way to reduce inflation. Based on that and on the estimated impacts of various structural variables on inflation, we can calculate what the inflation rate would be if Uruguay's levels for these structural variables were at our sample average of LAC countries. The table shows that changes in labor market dynamics would likely yield the biggest impact on inflation for Uruguay, followed by improving central bank transparency and implementing fiscal rules.[9]

[9] We did not take into account the fiscal rule that was recently implemented in Uruguay, since the rule is new. The calculation of the fiscal rule gap in Table 5 assumes no fiscal rule for Uruguay.

Table 5. Uruguay: Estimated Potential Reduction in Inflation [1/]					
	Reduce centralized collective bargaining	Increase flexible wage determination	Improve central bank transparency	Implement fiscal rules	Reduce public debt
Percentage reduction in inflation	99%	83%	34%	14%	2%
Projected inflation rate (in %)	4.9	5.3	7.3	8.6	9.6
1/ From the 2020 inflation level of 9.8 percent.					

Structural Factors and Inflation Stickiness

22. One way that structural factors can affect inflation is by increasing its persistence. For example, as discussed earlier, backward wage indexation to past inflation can make it harder for future inflation to adjust downwards, as wages and prices feed into each other. It also increases the output/employment cost of any policies attempting to reduce inflation, as real wages will increase in the short term. Thus, if the labor market institutions encourage wide-spread wage indexation, inflation may become stickier. Lack of central bank transparency and independence can also lead to stickier inflation, as the central bank may lack the effective tool and/or resolution to change the status quo and shift inflation to a different equilibrium.

23. To explore the effect of structural factors on inflation stickiness, we modify the baseline specification to include an interaction term, between lagged inflation and the underlining structural factor:

$$\pi_{i,t} = \alpha_i + \beta\pi_{i,t-1} + \gamma X_{i,t} + \delta s_{i,t} + \theta\pi_{i,t-1} \cdot s_{i,t} + \varepsilon_{i,t} \quad (2)$$

Typically, inflation exhibits stickiness to a certain extent, manifested as the positive coefficient β for the lagged inflation. If a structural factor increases (decreases) such stickiness, θ, the coefficient of the interaction term between past inflation and the structural factor, should be positive (negative).

24. Tables 6-8 present estimation results of Equation 2 for the structural factors of concern. Table 6 shows that the interaction term is negative and significant for wage flexibility and centralized collective bargaining in both OLS and GMM specifications. The interaction term for labor market regulations is also negative, but it is insignificant in either specification. Overall, this lends support to the hypothesis that one of the ways flexible wages can lead to lower inflation is by making inflation less sticky.

Table 6. Uruguay: Labor Market Flexibility and Inflation Stickiness

	Wage Flexibility		Collective Bargaining		Labor Market Regulations	
VARIABLES	(1) OLS	(2) Dynamic panel	(3) OLS	(4) Dynamic panel	(5) OLS	(6) Dynamic panel
log(inflation) $_{-1}$	1.45***	2.21**	1.17***	1.47**	1.31***	1.14
	(0.50)	(0.83)	(0.34)	(0.52)	(0.50)	(0.87)
Wage flexibility$_{-1}$	-0.86***	-1.33**				
	(0.27)	(0.46)				
log(inflation) x Wage flexibility$_{-1}$	-0.21**	-0.38**				
	(0.10)	(0.16)				
Centralized collective bargaining$_{-1}$			-0.47***	-0.65**		
			(0.12)	(0.22)		
log(inflation) $_{-1}$ x Centr. collective bargaining$_{-1}$			-0.11**	-0.17**		
			(0.05)	(0.07)		
Labor market regulations$_{-1}$					-0.48*	-0.48
					(0.28)	(0.47)
log(inflation) $_{-1}$ x Labor market regulations$_{-1}$					-0.13	-0.13
					(0.09)	(0.15)
Output gap	0.03*	0.03	-0.00	-0.01	0.01	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Import ratio	0.15	0.19	0.21**	0.20	0.16	0.12
	(0.10)	(0.16)	(0.08)	(0.15)	(0.11)	(0.16)
Primary balance	2.05	1.36	1.03	-1.34	1.09	-2.01
	(2.63)	(3.81)	(1.94)	(2.97)	(2.11)	(3.13)
Base money	-0.71	-0.99	-0.33	-0.09	-0.27	-0.26
	(0.94)	(0.74)	(0.71)	(0.89)	(0.83)	(0.84)
log(world inflation)	0.44***	0.46***	0.46***	0.53***	0.39***	0.48***
	(0.09)	(0.13)	(0.09)	(0.14)	(0.09)	(0.15)
Constant	1.94	4.14*	1.04	1.79	1.12	0.48
	(1.34)	(2.27)	(0.86)	(1.38)	(1.70)	(2.87)
Observations	110	110	193	193	193	193
R-squared	0.51		0.48		0.40	

25. Table 7 reports the estimates for central bank institutions with the interaction term added. Again, due to the lack of within-country variation and shorter time coverage for these variables, clear identification is harder to achieve. The interaction term is negative for central bank transparency, but the coefficient is insignificant. For the central bank independence score, the interaction term is negative and significant in the GMM estimate but is positive and insignificant in OLS.

26. Table 8 reports similar estimates for fiscal responsibility variables. None of the interaction terms are significant for primary balance, debt level, and fiscal rules. Not only that, it appears adding the interaction term also makes the structural factor itself lose identification, in the case of fiscal rules and debt level. Overall, the results suggest that even though fiscal discipline tends to lead to lower inflation as shown in the results in Table 4, the mechanism likely does not involve reducing inflation stickiness.

Table 7. Uruguay: Central Bank Institutions and Inflation Stickiness

	Transparency		Independence	
VARIABLES	(1) OLS	(2) Dynamic panel	(3) OLS	(4) Dynamic panel
log(inflation) $_{-1}$	0.69***	3.54	0.34	4.69*
	(0.19)	(5.85)	(0.38)	(2.47)
Central bank transparency$_{-1}$	-0.16	-1.64		
	(0.12)	(2.44)		
log(inflation) $_{-1}$ x Central bank transparency$_{-1}$	-0.04	-0.61		
	(0.04)	(1.00)		
Central bank independence$_{-1}$			0.46	-21.35
			(1.58)	(12.69)
log(inflation) $_{-1}$ x Central bank independence$_{-1}$			0.32	-6.54*
			(0.57)	(3.66)
Output gap	0.04*	0.11	0.01	-0.01
	(0.02)	(0.28)	(0.02)	(0.04)
Import ratio	-0.33**	6.06	0.15	0.76
	(0.13)	(9.33)	(0.09)	(1.31)
Primary balance	0.93	-135.95	1.58	7.10
	(2.69)	(145.23)	(1.87)	(6.88)
Base money	0.69	186.86	-0.13	-2.74
	(1.08)	(218.99)	(0.70)	(4.13)
Log (world inflation)	0.24**	1.74	0.37***	0.16
	(0.10)	(1.53)	(0.09)	(0.17)
Constant	-1.61**	3.93	-1.97*	12.99
	(0.62)	(12.92)	(1.04)	(9.79)
Observations	133	133	217	217
R-squared	0.42		0.44	

F. Conclusion

27. Various structural factors can affect inflation outcomes. This paper investigates whether a country's inflation level is affected by structural factors related to the flexibility in wage setting and labor market regulations, central bank institutions, and fiscal discipline. Our focus is on Uruguay and other LATAM countries, which share many similar external shocks and business cycle patterns. The paper finds evidence that more flexible wage determination, greater central bank transparency and independence, as well as greater fiscal discipline are all associated with lower inflation, to various extents.

28. Tackling certain structural features, including some beyond the control of the central bank, would support Uruguay's disinflation plan. In particular, enhancing the flexibility of wage setting mechanisms (to allow for greater decentralization), strengthening central bank transparency and independence, and increasing fiscal disciple (including through an effective implementation of the fiscal rule) could have important bearing on achieving the BCU's disinflation plan.

Table 8. Uruguay: Fiscal Responsibility and Inflation Stickiness

	Primary Structural Balance		Public Debt		Fiscal Rules	
VARIABLES	(1) OLS	(2) Dynamic panel	(3) OLS	(4) Dynamic panel	(5) OLS	(6) Dynamic panel
log(inflation) $_{-1}$	0.50***	0.82	0.55***	0.14	0.54***	0.18
	(0.09)	(0.73)	(0.11)	(0.74)	(0.08)	(0.20)
Primary structural balance	-16.01*	40.53				
	(8.21)	(97.07)				
log(inflation) x Structural balance	-4.20	22.75				
	(2.60)	(34.44)				
Public debt			0.41	1.14		
			(0.66)	(5.42)		
log(inflation) $_{-1}$ x Public debt			0.04	0.23		
			(0.23)	(2.02)		
Fiscal rule$_{-1}$					0.01	0.34
					(0.31)	(0.40)
log(inflation) $_{-1}$ x Fiscal rule$_{-1}$					0.03	0.18
					(0.10)	(0.13)
Output gap	0.00	-0.07	-0.00	-0.01	-0.00	-0.01
	(0.02)	(0.06)	(0.01)	(0.02)	(0.01)	(0.01)
Import ratio	-0.00	-0.03	0.07	0.12	0.00	-0.33
	(0.10)	(0.33)	(0.07)	(0.31)	(0.08)	(0.39)
Primary balance	3.25	5.91	0.59	2.01	1.44	2.61
	(2.73)	(8.80)	(1.45)	(5.93)	(1.46)	(2.28)
Base money	0.52	-13.03	0.00***	0.00	0.00***	0.00
	(1.03)	(15.95)	(0.00)	(0.00)	(0.00)	(0.00)
log(world inflation)	0.36***	0.94	0.40***	0.44**	0.36***	0.56***
	(0.11)	(0.57)	(0.08)	(0.16)	(0.08)	(0.11)
Constant	-2.14***	-1.48	-1.92***	-3.17	-1.82***	-3.35***
	(0.38)	(1.86)	(0.37)	(2.08)	(0.26)	(0.84)
Observations	179	179	229	229	236	236
R-squared	0.43		0.60		0.61	

References

Christoffel, Kai, and Tobias Linzert. "The role of real wage rigidity and labor market frictions for inflation persistence." *Journal of Money, Credit and Banking* 42, no. 7 (2010): 1435-1446.

Cottarelli, Carlo, Mark Griffiths, and Reza Moghadam. *The Nonmonetary Determinants of Inflation: A Panel Study*. IMF Working Paper 98/23, 1998.

Cukierman, Alex. "Central Bank Strategy, Credibility, and Independence: Theory and Evidence." *Journal des Économistes et des Études Humaines* 3, no. 4 (1992): 581-590.

Dassatti, Cecilia, and Gerardo Licandro. "Measuring monetary policy transparency in Uruguay." *DT BCU* (2020).

Dincer, N. Nergiz, and Barry Eichengreen. "Central bank transparency and independence: updates and new measures." (2013).

Fischer, Stanley, and Lawrence H. Summers. "Should governments learn to live with inflation?." *The American Economic Review* 79, no. 2 (1989): 382-387.

Garriga, Ana Carolina. "Central bank independence in the world: A new data set." *International Interactions* 42, no. 5 (2016): 849-868.

Gwartney, James, Robert Lawson, and Seth Norton. *Economic freedom of the world: 2008 annual report*. The Fraser Institute, 2019.

Holden, Steinar. "Avoiding the resource curse the case Norway." *Energy Policy* 63 (2013): 870-876.

Kandil, Magda E., Hanan Morsy, and Enrique A. Gelbard. "Determinants of Inflation in GCC." *IMF Working Papers* 2009, no. 082 (2009).

McHugh, James. "Wage centralization, union bargaining, and macroeconomic performance." IMF Working Paper (2002).

Mello, Miguel, and Jorge Ponce. "Fiscal policy and inflation expectations". *Banco Central del Uruguay Working Papers* (2021).

Schaechter, Andrea, Tidiane Kinda, Nina Budina, and Anke Weber. *Fiscal Rules in Response to the Crisis: Toward the" Next-Generation" Rules: A New Dataset*. International Monetary Fund, 2012.

EXPORT PRODUCT DIVERSIFICATION ANALYSIS FOR URUGUAY WITH MACHINE LEARNING[1]

While progress has been made in diversifying export destinations, diversification of Uruguayan goods exports has declined over the past two decades, reflecting an increasing role of agricultural commodities and a shrinking manufacturing sector. Export recommendations generated from machine learning algorithms suggest that diversification efforts could usefully rebalance away from commodities and focus on the higher value-added manufacturing categories that support agricultural and raw material production.

A. Introduction

1. A diversified export portfolio can foster sustainable growth and economic stability. The relationship between export diversification and countries' economic performance has been extensively studied in the economic literature. Overall, the existing research indicates that export diversification is a key element in the process of economic development, particularly for developing and emerging market countries trying to catch up with advanced economies. Numerous studies provide evidence of a positive association between export diversification and economic growth and stability (e.g. Imbs and Wacziarg, 2003; Klinger and Lederman 2004 and 2011; Cadot et al., 2011), as a wider range of profitable export products makes growth more sustainable, and reduces the volatility of growth.

2. The economic literature shows that countries with export structures dominated by commodity exports based on natural resources tend to have lower long-term growth and stability. A vast number of economic studies is devoted to studying the impact of natural endowments, e.g. oil and gas, precious metal, and abundant agricultural land, on economic growth. The general conclusion is that, contrary to intuition, natural endowments, though providing economic advantages in the short term, are not necessarily a blessing to long-term growth. See for example, Frankel (2010), Bahar & Santos (2018), Bacha & Fishlow (2011).

3. Past studies reveal multiple reasons why a dominance of commodity exports may not be conducive to long-term growth. Specifically,[2]

- Notwithstanding large cyclical swings, agricultural commodity prices have been on long-term declining trend.

[1] By Natasha Che.

[2] The literature on the so-called "natural resource curse" documents these patterns for various countries and time periods. See surveys by Frankel (2010) and Harvey et al (2018).

- Countries with a history of dependence on commodity exports tend to have a more concentrated export structure and a less developed industrial sector, although the latter is the source of most productivity increases and technology innovation.

- The higher volatility of commodity exports, especially agricultural exports, arising from fluctuations in world prices and weather shocks, usually translates into greater macroeconomic volatility.

- High reliance on commodity exports often correlates with under investment in human capital and other reforms.

For these reasons, commodity exporters' economies are often plagued by high macro volatility, undiversified export structure, slow developing industrial sector, high fiscal deficit and weak governance and human capital accumulation. Diversifying away from commodities may be desirable for most economies.

4. However, not all types of export diversification are equal, and a growth-friendly diversification strategy needs to be consistent with a country's comparative advantages. Diversification for its own sake is hardly a recipe for sustainable growth. A foundational idea of the classical international trade theory is that under free trade, countries will tend to export what they have a comparative advantage in. In fact, industrial policies that do not favor the most efficient use of a country's factor endowment often lead to negative growth outcomes (see, for example, Lin, 2009). On the other hand, delayed industrialization can also lead to poor growth outcomes, as the experience of many resource-rich countries that are entrenched in their over-dependence on commodity exports has shown (e.g., Frankel, 2010).[3] Thus, well-targeted industrial policies can be beneficial to growth. Designing growth-friendly industrial policies, however, requires identifying areas of comparative advantage where there is untapped potential for diversification. This paper uses machine learning algorithms for collaborative filtering to explore potential areas of export diversification for Uruguay.

B. Measuring Export Diversification

5. Throughout this paper, export diversification is measured by the number of export products a country has with high "revealed comparative advantage" (RCA). The RCA score, first introduced by Balassa & Noland (1965), is a popular measure in the economic literature for calculating the relative importance of a product in a country's export basket. Formally, the RCA score of country i in product j can be calculated as:

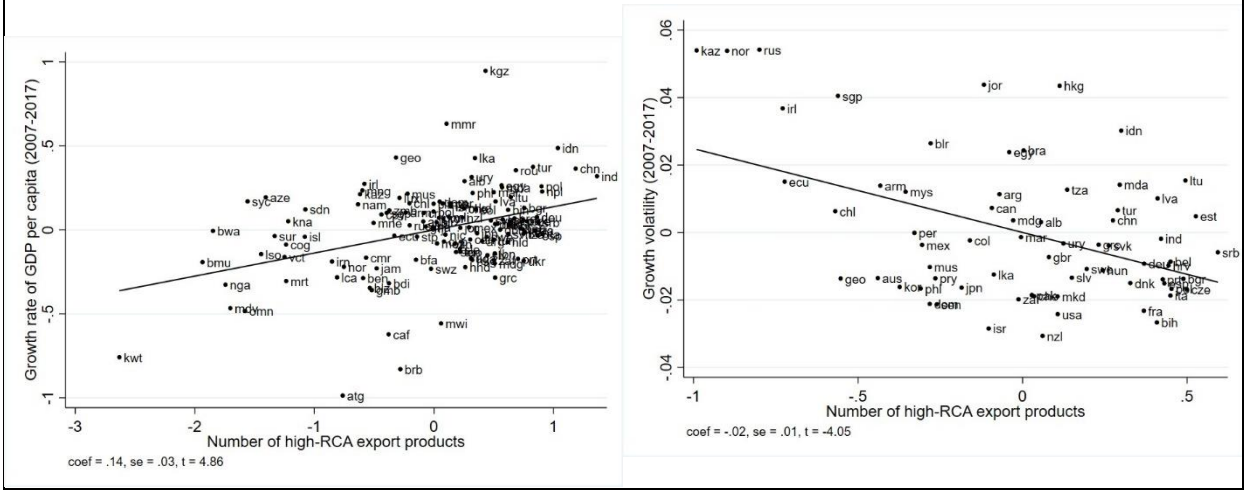
$$RCA_{pc} = \frac{E_{pc}/E_c}{E_p/\sum_{p' \in P} E_{p'}}$$

[3] Relatedly, Hausmann et al. (2007) finds that countries that export more sophisticated, or knowledge-intensive products, tend to grow faster, controlling for initial income levels.

where E_{pc} is the export value of product p from country c, E_c is the total export values of country c, E_p is the total exports of product p from all countries around the world, and $\sum_{p' \in P} E_{p'}$ is the total world exports.

6. A high-RCA export product for country c is defined as a product with its $RCA_{pc} > 1$. This is the case when a product's share in the country's total exports is greater than the share of the same product in world exports, indicating that the country has a *comparative advantage* in the product relative to the rest of the world. The interest of the paper is not in recommending products that a country can export a little of, but rather in identifying products that the country can potentially have a high RCA in, in other words, those products that highly align with a country's *latent comparative advantages*. Using data for 2007-17,[4] Figure 1 shows that controlling for country size, GDP growth rate is positively related to the number of high-RCA exports a country has, and growth volatility is negatively related to the number of high-RCA exports.

Figure 1. Uruguay: Number of High-RCA Exports vs GDP Growth and Growth Volatility



7. Compared to countries of similar sizes, Uruguay's level of diversification in goods exports is about average. Unsurprisingly, the number of high-RCA exports is positively correlated with country size as many industries need a minimum scale to be sustainable. Thus, smaller economies—with less capital, labor, and other production endowments—tend to produce fewer product categories than larger countries. Currently the number of high-RCA exports in Uruguay is about the level that would be predicted by its population size. Comparing Uruguay's number of high RCA exports with those of other countries of smilar size also shows that Uruguay is in the middle of the pack (Figure 2).

[4] The number of high RCA exports are calculated at SITC 4-digit product level.

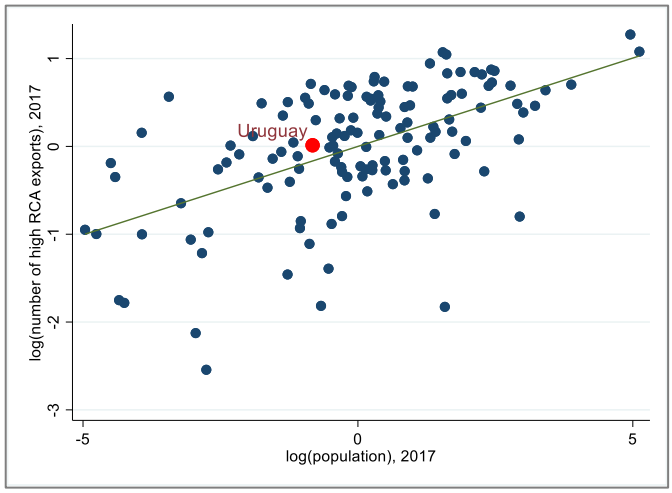
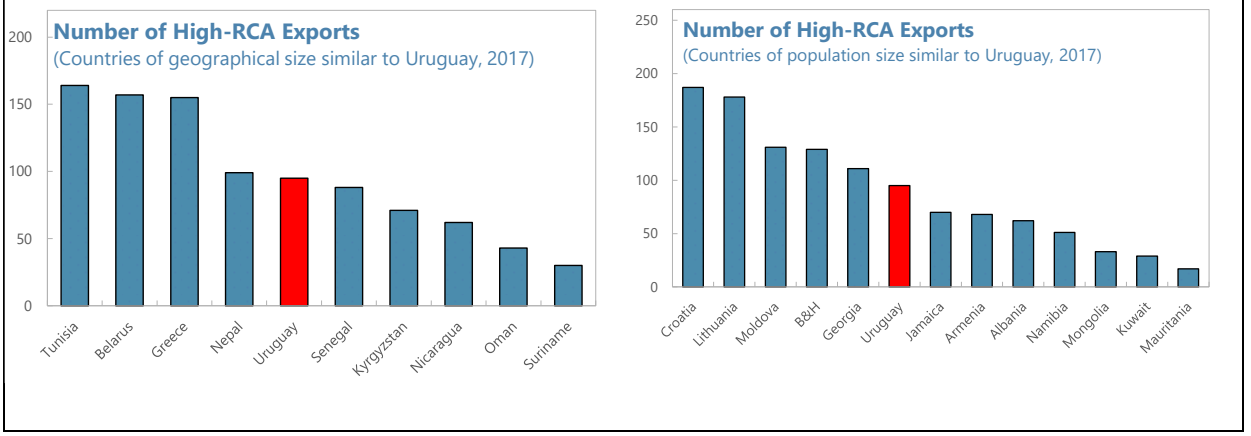


Figure 2. Uruguay: Export Diversification in Countries of Similar Sizes to Uruguay

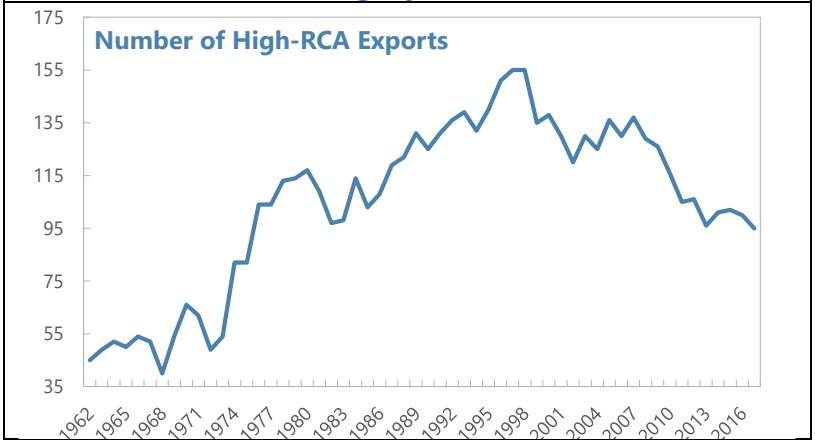


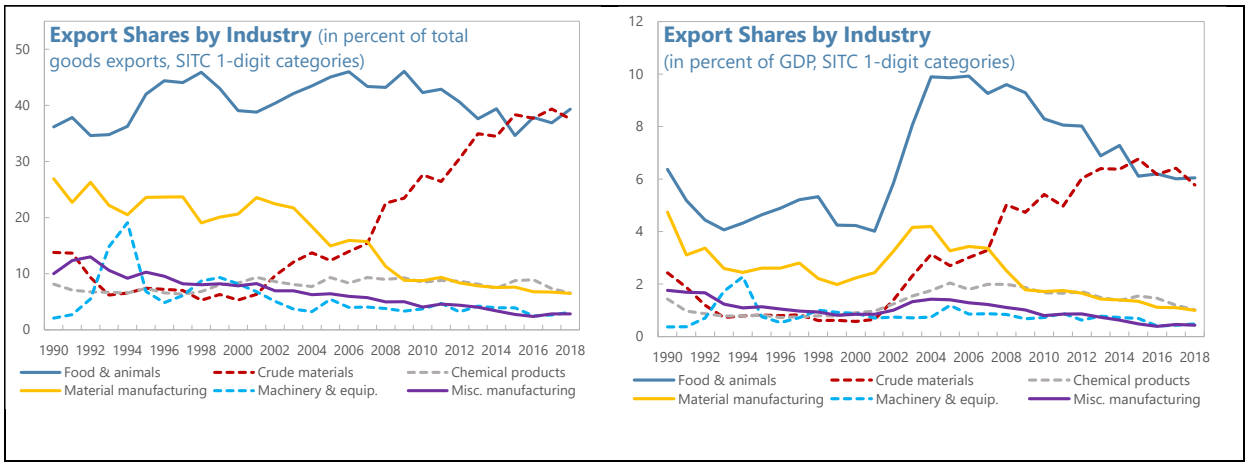
8. However, over the past 20 years, Uruguay's goods exports have become less diversified. In late 1990s, Uruguay had over 150 high-RCA exports, placing the country in the "most diversified" category for its size group at the time. Over the past 20 years, though, the number of high-RCA exports has been consistently dropping, to about 2/3 of its peak level. It is worth noting that the analysis focuses on goods exports only. Service exports' share in total exports of Uruguay has been relatively constant over the past three decades, at around 35 percent of total exports. These consist of mainly tourism and select other services such as information technology.

C. Why Uruguay's Goods Exports Have Become Less Diversified

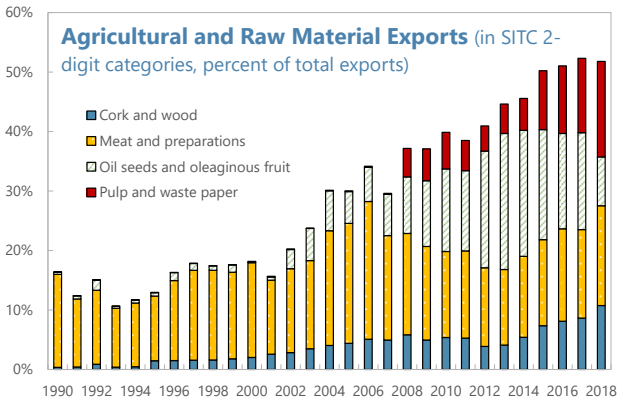
9. Some of the general predicaments of commodity exporters are apparent in Uruguay. Agricultural commodities have been increasingly dominating Uruguayan exports since the late 1990s, and currently represent 80 percent of the country's goods exports (40 percent food, 40 percent raw materials).

Figure 3. Uruguay: The Number of High-RCA Exports from Uruguay, 1962–2018

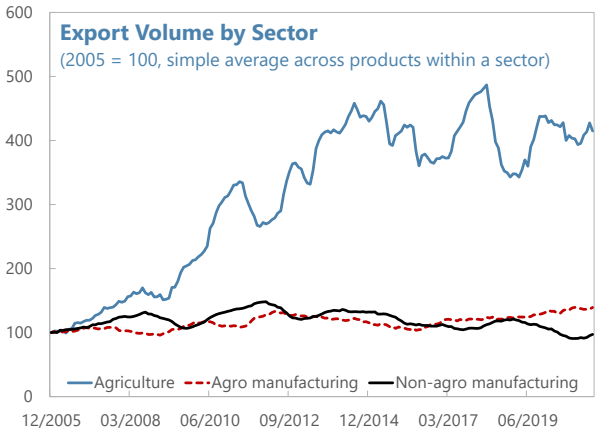




10. Agricultural exports concentrate in meat, soybeans, and more recently, forestry products. Meat products have been a staple in Uruguayan exports for decades, with a relatively stable share in total exports of about 20 percent. The increase in commodity exports since the early 2000s has been mostly driven by the growth of the soybean and forestry sectors, reflecting improved prices and large foreign investments. With the price boom ending in 2014, soybean exports declined in importance in both quantity and value, as investors in the sector increasingly moved to neighboring countries with lower production cost such as Paraguay and Brazil. In contrast, forestry exports, including wood and paper pulp, are poised to grow further with the new large foreign direct investment.

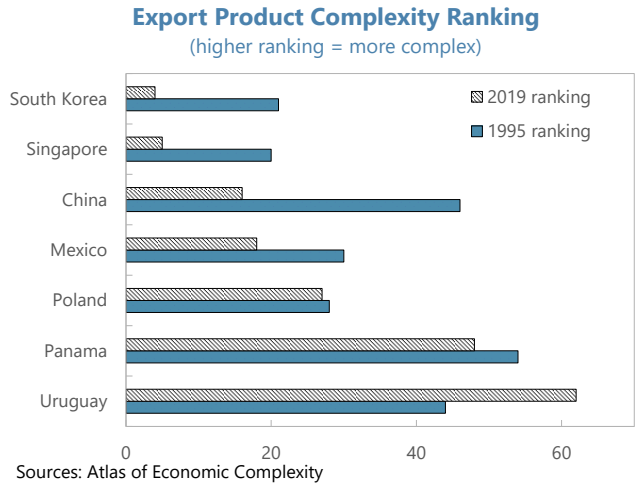


11. In the meantime, there has been signs of de-industrialization. Material manufacturing (primarily textile and leather) and some other categories of basic manufacturing (apparel and footwear) once occupied a significant place in Uruguay's export structure. "Material manufacturing" and "miscellaneous manufacturing" combined was over 35 percent of total goods exports (about 7 percent of GDP) at the beginning of the 1990s. By 2018 their shares had declined to less than 10 percent of total exports. This reflects both the rapid advance of commodity exports and stagnating manufacturing exports.



Sources: UN Comtrade and staff calculation.

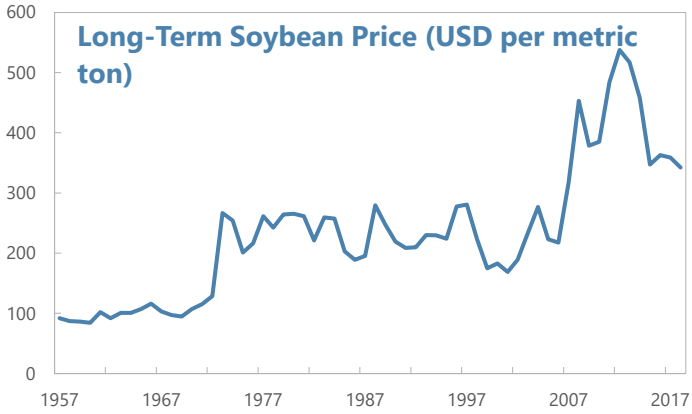
12. The decline of basic manufacturing is not necessarily a concern by itself, but the issue is it is not replaced by other non-commodity exports of higher value added. Most countries go through evolutionary shifts in their industrial and export structures accompanying their economic development. For example, decades ago, labor-intensive, low-value-added manufacturing products (e.g. textile and footwear) were a large share of exports from countries like Japan and South Korea. As these countries developed, domestic labor costs grew, their exports of basic manufacturing were increasingly priced out of the international markets, leading to a decline in the share of basic manufacturing in total exports. But in their place emerged other manufacturing exports of higher sophistication and value added—e.g. electronics, vehicles, specialized instruments—that align with these countries' increased physical and human capital and technology know-how. In contrast, the decline in basic manufacturing in Uruguay does not appear to have been followed by industrial upgrades as indicated by the country's decline in ranking (from 44 to 62) in the export product complexity index.



Sources: Atlas of Economic Complexity

13. The commodity price boom of 2003-14 likely contributed to the decline in non-commodity exports and the increased concentration in fewer products. The impact of the commodity price boom on export diversification was twofold. First, the boom in the commodity sector attracted capital, labor, and entrepreneurial resources away from the non-commodity tradable sector to the commodity sector, as well as to the non-tradable sector, due to the increased

demand and prices of the latter. Secondly, the exchange rate appreciation and real wage increase prompted by a commodity price boom made the non-commodity exporting sector less competitive. The result was a more concentrated export structure in primary commodities.



14. To summarize, Uruguay's exports have become more concentrated over the years due to a multitude of factors. These include increased dominance of commodity exports, real exchange rate appreciation and domestic wage increases that reduced the competitiveness of the more traditional non-commodity exports, and the fact that few new non-commodity export categories have emerged to replace the ones that lost traction. Reducing the disruptive impact of commodity price cycles on the normal industrialization process while maintaining the comparative advantage in commodity exports is an important policy challenge.

D. Machine Learning Algorithms to Explore Export Diversification Options

15. A collaborative-filtering based methodology is applied to identify export diversification opportunities for Uruguay. The methodology follows Che (2020) and Che & Zhang (2021). The intuition behind the methodology is that (i) insights about a country's latent comparative advantages can be gained by looking at other countries with similar comparative advantages, and (ii) a country is likely to have a latent comparative advantage in products that are closely related to existing high RCA products that the country already exports.

16. The methodology employs three main algorithms. These, already widely used in online collaborative filtering recommender systems, are product-based and country-based K Nearest Neighbors (KNN), and Singular Value Decomposition (SVD). These are so-called "top-N recommendations," i.e., the goal of the algorithms is to generate a list of N product categories that a country can have the largest comparative advantages in. The algorithms are used to predict the RCA scores of products by SITC 4-digit categories for the country under study, using the training dataset of export values by country and export volumes in each category. The top-N recommendations are the N products with the highest predicted RCA scores.[5]

17. The methodology accurately predicts the export structure and its evolution for several high growth countries. Che (2020) shows that all three algorithms produce diversification recommendations that closely align with countries' current export structure and comparative advantage profiles, for high-growth countries including China, India, Poland, and Chile. Che and Zhang (2021) further apply the product-based KNN algorithm to close to 200 countries and show

[5] For a detailed account of the methodology and rationales behind the algorithms, see Che (2020).

that countries whose export structure closely aligns with the algorithm-recommended structure have higher growth and lower growth volatility.

18. The data used in the recommendation system can be represented as a $m\ x\ n$ matrix R, where m is the number of countries in the database, and n is the total number of SITC 4-digit products. Each element of R (i.e., r_{ij}) is country i's RCA score in product j. R is a sparse matrix due to the fact that each country only exports a subset of the products in the SITC universe. In the case that country i does not export any product j, r_{ij} = 0. If an implementation uses multiple years of export data, then each country-year is a row in R, i.e., $m = c$ x y, where c is the number of countries in the dataset, and y is the number of years included. In most versions of implementations discussed below, y=1, i.e., if the task is to generate export recommendations for country i in 2017, only the cross-country export data for 2017 is included in the training set.[6]

Neighborhood-Based Algorithms

Product-Based KNN

19. KNN is one of the most frequently used methods in solving classification and pattern recognition problems and is a popular approach in constructing recommender systems. The basic idea of KNN is learning by analogy- classifying the test sample by comparing it to the set of training samples most similar to it. Different KNN implementations vary in terms of their choices of how the similarity between input vectors is calculated. In the present paper, the cosine similarity score is used as the similarity measure.

20. The intuition behind the current paper's product-based KNN implementation is simple. First the algorithm looks at what products a country already has a revealed comparative advantage in and, then, recommends other products that are similar to the former products (similar in the sense that they share common exporters). To explain the approach in more details, let's first rewrite the RCA score matrix R as:

$$R = [\boldsymbol{p}_1, \boldsymbol{p}_2, \dots, \boldsymbol{p}_n]$$

where $\boldsymbol{p}_j$ is a vector of length m that represents the RCA scores of product j for all the m countries in the sample:

$$\boldsymbol{p}_j = \begin{bmatrix} r_{1j} \\ r_{2j} \\ \cdot \\ \cdot \\ r_{mj} \end{bmatrix}$$

[6] The paper experimented with including multiple years of data in the training set, but found no significant improvement in the evaluation metrics, while the model took longer to compute as the size of m increases.

21. In machine learning terminology, each product in the sample has *m* features. The cosine similarity between products i and j is equal to $(\boldsymbol{p}_i \cdot \boldsymbol{p}_l)/\left(\left\|\boldsymbol{p}_j\right\| \|\boldsymbol{p}_l\|\right)$, which ranges from -1, when the two vectors are the exact opposite, to 1, when the two are the same. The intuition is that by comparing the two sets of countries that export i and j, and how important the products are in the countries' export baskets, information can be inferred regarding how closely related the two products are.

22. The implementation of the product-based KNN recommender for country i involves the following steps:

a. Represent each product in the SITC 4-digit product space as a vector of RCA scores, $\boldsymbol{p}_j$.

b. Select the set of K products in which country i has a revealed comparative advantage, i.e. $r_{ij} > 1$. Let's call it the high-RCA product set of country i.

c. For each $j \in [1, n]$, calculate the predicted value of r_{ij} as the weighted average RCA score of the high-RCA product set, weighted by the cosine similarity between product j and the products in the country's high-RCA set.

d. The recommended products for country i are the N products with the highest predicted r_{ij} values.

Country-Based KNN

23. The exercise can also be thought of as "recommending" other countries similar to the country in question. In other words, instead of recommending product categories related to a countries' existing export products, the algorithm can be thought as finding a group of countries that are similar to country i. And because these countries have similar comparative advantages, the products they export, beyond the ones country i is already exporting, can be good candidates for diversification for country i. More specifically, the RCA score matrix R can be represented as:

$$\boldsymbol{p}_j = \begin{bmatrix} q_1 \\ q_2 \\ . \\ . \\ q_m \end{bmatrix}$$

where qi is a vector of length n that represent country i 's RCA scores for the n product categories in the SITC 4-digit product space.

24. The execution of the country-based KNN algorithm for country i can then be broadly described as follows:

a. Calculate the cosine similarity score between $\boldsymbol{q}_i$ and $\boldsymbol{q}_j$, where $1 \leq j \leq m$, and $j \neq i$.

b. Select a set of K countries with the highest similarity scores to country i.

c. For each $l \in [l, n]$, calculate the predicted value of r_{il} as the weighted average RCA score of product l across the K countries, weighted by the similarity score between each country and country i.

d. The recommended products for country i are the N products with the highest predicted r_{ij} values.

25. It is important to note that although the product-based and country-based KNN recommenders apply similar algorithmic logic, the differences in the perspectives of the two methods lead to different recommendation results, as will be demonstrated in the next section. Generally speaking, since in the data sample $n > m$,[7] it may be easier to identify the relatedness between products with more accuracy than to identify similar countries, which make the product-based KNN a superior approach. The results presented in the next section confirm this hypothesis.

Matrix Factorization Algorithm

26. The KNN algorithms, though intuitive and easy to implement, suffer from some significant drawbacks. First, these algorithms have limited scalability. As the sizes of m and n increase, the amount of computation required to calculate the similarity scores increases at $O(n)$ time, reducing the performance of the algorithm on larger data sets. Another disadvantage of the KNN algorithms is their problem with sparse data. Since the KNN algorithms require explicitly calculating similarities among vectors, the calculation becomes increasingly inaccurate when there's a lot of missing data in matrix R. This problem is exacerbated by the fact that the algorithm essentially treats each row of the product vector (or the country vector) as independent features of equal importance, which is not the most efficient use of information in the data, and also makes missing rows generally more damaging, compared to algorithms that impose some discretion on the relative importance of different data points. For the current use case, the first drawback is not a big concern, as the m and n of the country-product space are relatively small, especially when we do not include multiple years in the calculation. The second drawback is more problematic, as it implies that the KNN algorithms would perform worse on countries that are significantly under-diversified, i.e. lots of missing entries in R for these countries. This would potentially defeat the purpose of the exercise, as under-diversified countries are arguably the ones that are most in need of diversification recommendations.

27. The Singular Value Decomposition (SVD) algorithm provides a possible remedy to the problem. SVD is a matrix factorization technique widely used in dimensionality reduction and principal component analysis. The basic idea is that matrix R can be decomposed into three matrices:

$$R = USV'$$

[7]There are close to 800 product categories in the SITC 4-digit product space, while there are just over 250 countries in the sample.

where U and V are two orthogonal matrices of size m x r and n x r respectively. r is the rank of R. And S is a r x r diagonal matrix, with the singular values of R as its diagonal elements, sorted in the order of decreasing magnitude.

28. The main purpose of the decomposition is to represent the products and countries as combinations of the latent factors in the data, which are implicit, orthogonal features that can be used to characterize the entire country-product space. U represents the relationship between countries and the latent factors, while V' represents the similarity between products and latent factors. The diagonal elements of S can be thought of as the relative scaling values assigned to various latent factors.

29. To illustrate the intuition behind the algorithm, here is a simplified example. Suppose the matrix R can be summarized by three independent latent factors: labor, land, and knowledge. Row i of matrix U represents the comparative advantage of country i as a combination of the latent factors. $\boldsymbol{u}_i = [.55, .4, .05]$ would mean that country i's profile can be described as 50% labor, 40% land, and 5% knowledge- a resource-rich, developing country. Column j of matrix V' represents the characteristics of product j as a combination of latent factors. Thus $\boldsymbol{v}_j = [.15, .05, .80]'$ means that the production of product j can be characterized as 15% labor, 5% land, and 80% knowledge- a technology-product that requires mostly intangible inputs. $r_{ij} = \boldsymbol{u}_i \cdot \boldsymbol{v}_j$, scaled by the appropriate diagonal element in S. It's not difficult to see that r_{ij} would be relatively small, i.e. country i does not have a comparative advantage in producing product j. This is, of course, a very hypothetical example. In practice, the latent factors computed by the optimization algorithm are not human-interpretable, and only serve as features that more efficiently characterize data.

30. The goal of the SVD algorithm is essentially to find the best estimations of U and V', and then produce recommendations based on estimated $\widehat{r_{ij}} = \widehat{u_i} \cdot \widehat{v_j}$. In practice, because R is already sparse, observing orthogonality constraints for U and V' becomes computationally untenable. The execution of the algorithm thus centers on solving the following optimization problem:

$$\min_{\boldsymbol{u}_i, \boldsymbol{v}_j} \sum_{r_{ij} \in R} \left(r_{ij} - \boldsymbol{u}_i \cdot \boldsymbol{v}_j\right)^2 + \lambda \left(\|\boldsymbol{u}_i\|^2 + \|\boldsymbol{v}_j\|^2\right)$$

where λ is a regularization factor. The minimization is performed with stochastic gradient descent, using python Surprise library for building recommender systems. The recommended products for country i are the products with the highest predicted $\widehat{r_{ij}}$ value.

E. The Application to Uruguay

31. Export recommendations for Uruguay are derived using SITC 4-digit export data for 2017, consisting of 786 product categories and around 260 countries. Table 1 presents a few summary statistics of the results. The three algorithms identify 144, 155, and 189 products from the SITC 4-digit categories as products that Uruguay could have a comparative advantage in. The hit rate measures the percentage of recommendations with an actual RCA score greater than 1, that is,

those Uruguay is already exporting a lot of. The top-100 hit rate measures the percentage of the top 100 recommendations from each algorithm with an actual RCA score greater than 1.

Table 1. Uruguay: Summary Statistics of the Algorithm Recommendations

	Product-based KNN	Country-based KNN	SVD
Number of recommendations	144	155	189
Hit rate (in percent)	47.2	40.0	30.2
Top-100 Hit rate (in percent)	7.6	32.9	21.7

32. Table 2 compares the sectoral composition of actual high-RCA exports in 2017 with sectoral composition recommended by the models, by SITC 1-digit category. Specifically, it shows the numbers of 4-digit high-RCA exports contained in each 1-digit category, for actual and recommended exports. The shares are the numbers of 4-digit products in each category as percent of the total number of high RCA exports in actual and recommended export portfolio. Figure 4 compares the actual sectoral composition for high-RCA exports with the weighted-average composition from the three algorithms.[8]

33. Overall, the results recommend a more balanced export portfolio, shifting somewhat away from agricultural commodities and towards non-commodity manufacturing exports. Currently the largest number of high-RCA exports from Uruguay is in SITC category 0 (food and live animals) and the models pick up that Uruguay has strong comparative advantages in this category, as indicated by high numbers of recommendations in this category from all three algorithms. However, the potential to diversify further within this category appears to be limited. To increase the total number of high-RCA exports, the models indicate that Uruguay would need to expand its export diversity further in categories 2 (inedible crude materials), 6 (basic manufacturing), and 8 (other manufacturing). In addition, though Uruguay currently does not have any high-RCA exports in category 7 (machinery and transport equipment), the models suggest that the country could have a comparative advantage in some products in this category (see Table 5 for some of the examples).

Table 2. Uruguay: Actual and Recommended Export Composition for High-RCA Exports

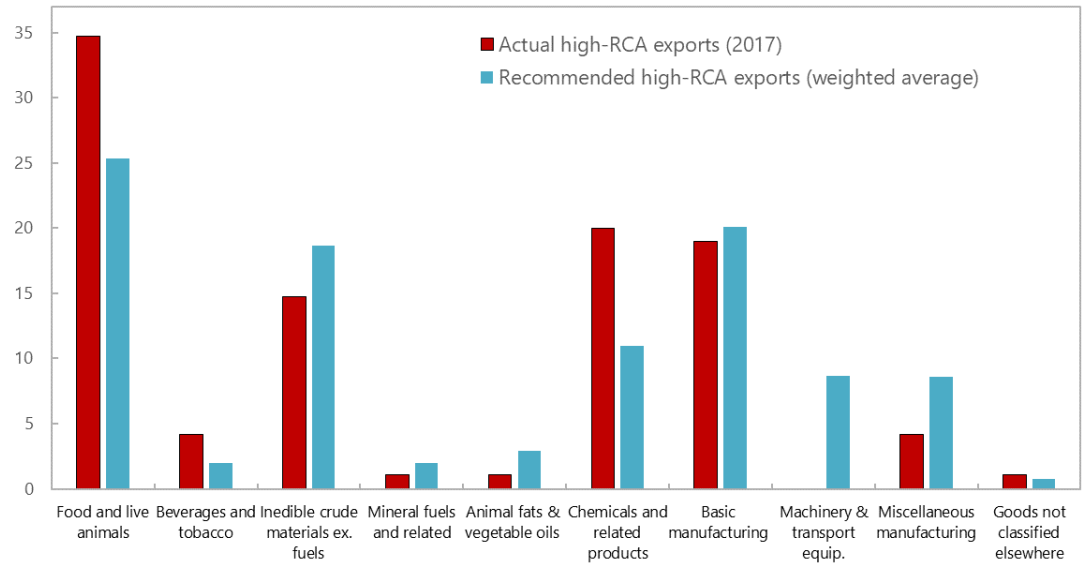
SITC code	Category	Actual high-RCA exports (2017)		Product-based KNN		Country-based KNN		SVD	
		Num.	Share (in %)	Num.	Share (in %)	Num.	Share (in %)	Num.	Share (in %)
0	Food and live animals	33	34.7	34	23.6	63	40.6	29	15.3
1	Beverages and tobacco	4	4.2	2	1.4	8	5.2	1	0.5

[8] The weights are .6, .2, and .2, for product-based KNN, country-based KNN, and SVD respectively. These are subjective weights assigned based on the algorithms' general performances according to the summary statistics. The product-based KNN model is given a higher weight because it is shown as more forward looking when the algorithms are applied to historical data from other countries.

Table 2. Uruguay: Actual and Recommended Export Composition for High-RCA Exports

2	Inedible crude materials exc. fuel	14	14.7	25	17.4	28	18.1	44	23.3
3	Mineral fuels and related	1	1.1	3	2.1	1	0.6	6	3.2
4	Animal fats & vegetable oils	1	1.1	4	2.8	4	2.6	7	3.7
5	Chemicals and related products	19	20.0	19	13.2	12	7.7	14	7.4
6	Basic manufacturing (material based)	18	18.9	30	20.8	27	17.4	39	20.6
7	Machinery & transport equip.	0	0.0	11	7.6	6	3.9	31	16.4
8	Miscellaneous manufacturing	4	4.2	15	10.4	4	2.6	17	9.0
9	Goods not classified elsewhere	1	1.1	1	0.7	2	1.3	1	0.5

Figure 4. Uruguay: Actual and Recommended Export Composition for High-RCA Exports



Sources: staff calculation

34. Tables 3 and 4 present the biggest "gainers" and "losers" by SITC 2-digit categories, when comparing the recommended export structure with the existing one. These results are based on the product-based KNN algorithm, which is the best performing one among the three algorithms. Column A in both tables report the current number of SITC 4-digit high-RCA exports in percent of the total number of high RCA exports. Column B shows the number of high-RCA exports,

as percentage of the total, from the recommendation results. Table 3 suggests that the categories showing the largest diversification potentials are select categories in manufacturing, as well as some categories in crude materials.

Table 3. Uruguay: Top 10 SITC 2-digit Categories with Increased Shares in Total High-RCA Exports[1/]

Product code	Product name	(A) Actual share	(B) Rec. share	Difference (B - A)
89	Miscellaneous manufactured articles	2.1	5.6	3.5
28	Metalliferous ores & metal scrap	1.1	4.2	3.1
72	Machinery specialized for particular industries	0.0	2.8	2.8
79	Other transport equipment	0.0	2.8	2.8
65	Textile yarn	4.2	6.9	2.7
87	Professional & scientific instruments	0.0	2.1	2.1
42	Fixed vegetable oils & fats	0.0	1.4	1.4
25	Pulp & wastepaper	1.1	2.1	1.0
84	Apparel & clothing accessories	1.1	2.1	1.0
26	Textile fibers and their wastes	3.2	4.2	1.0

1/These are results from the product-based KNN algorithm.

Table 4. Uruguay: Top 10 SITC 2-Digit Categories with Reduced Shares in Total High-RCA Exports[1/]

Product code	Product name	(A) Actual share	(B) Rec. share	Difference (B – A)
59	Chemical materials & products	5.3	4.2	-1.1
22	Oil seeds & oleaginous fruit	2.1	0.7	-1.4
02	Dairy products & birds' eggs	4.2	2.8	-1.4
05	Vegetables & fruit	4.2	2.8	-1.4
55	Oils & perfume; toilet & cleansing preparations	3.2	1.4	-1.8
53	Dyeing, tanning & coloring materials	4.2	2.1	-2.1
01	Meat & preparations	7.4	4.9	-2.5
12	Tobacco & tobacco manufactures	4.2	1.4	-2.8
24	Cork & wood	4.2	1.4	-2.8
04	Cereals & cereal preparations	9.5	6.3	-3.2

1/ These are results from the product-based KNN algorithm.

35. Table 5 provides greater granularity by focusing on the top 20 recommendations of the SITC 4-digit categories which Uruguay currently does not export much of, i.e., RCA < 1, according to the product-based KNN algorithm. Most of these top items are in the categories of machinery and equipment, as well as material manufacturing.

36. The main identified export gaps (between recommended and actual export shares) relate to higher value-added categories connected to the agricultural sector. Many of the top

recommended items in Table 5—e.g., harvesting machines, dairy machinery, textile fabrics for machinery—are production tools that support the agricultural exporting sector. In fact, the top-20 products recommended in Table 5 have an average Product Complexity Index (PCI)—an index measuring the relative knowledge intensity of products—that is higher than 70 percent of the SITC 4-digit product categories, according to the ranking by the Observatory of Economic Complexity. In contrast, Uruguay's existing export portfolio is at the 55 percentile in the product complexity ranking.[9]

37. Many of these recommendations are relatively more knowledge-intensive than Uruguay's current export profile, although still intimately related to the country's comparative advantages in agriculture. The fact that the country is a significant agricultural commodity exporter means that many of the industrial products serving agricultural production recommended in Table 5 could leverage domestic product and customer networks, opportunities for knowledge exchange, and feedback loops for product research & development. Moving in the recommended direction would allow the country to take advantage of its existing knowledge base, human capital, and production networks in agricultural products, while shielding the economy from the volatility of commodity prices to some extent, since the prices of agriculture-related manufacturing products are less variable than those of raw commodities.

Table 5. Uruguay: Top 20 SITC 4-Digit Product Recommendations with Actual RCA <1[1/]

Product code	Product name	Predicted RCA	Actual RCA
5851	Derivatives of Rubber	10.9	0.0
2711	Crude Fertilizer	4.8	0.0
6731	Iron Wire	4.5	0.0
8951	Metal Office Products	3.0	0.0
7212	Harvesting Machines	2.3	0.4
7213	Dairy Machinery	2.1	0.5
7211	Soil Preparation Machinery	2.0	0.1
6577	Textiles Fabrics for Machinery	1.9	0.1
7428	Miscellaneous Pumps	1.9	0.0
7442	Lifting and Loading Machinery	1.9	0.3
7283	Miscellaneous Mineral Working Tools	1.8	0.1
7821	Trucks and Vans	1.8	0.6
7452	Miscellaneous Non-Electrical Machines	1.8	0.1
6282	Transmission Belts	1.8	0.4
7416	Miscellaneous Heating and Cooling Equipment	1.8	0.0
6793	Iron and Steel Forging	1.7	0.0
6785	Iron Tubes	1.7	0.0
7219	Miscellaneous Agricultural Machinery	1.7	0.2
7188	Miscellaneous Engines	1.6	0.0
7429	Miscellaneous Liquid Pump Parts	1.6	0.0

1/ According to the results from the product-based KNN.

[9] See https://oec.world/en/profile/country/ury for details on the calculation of product complexity.

38. More in-depth analysis is needed on how to foster product diversification towards these higher value-added sectors. Given that Uruguay has relatively limited experience in exporting products in SITC categories 7 and 8, diversifying into these categories may require targeted efforts. Doing so requires identifying the main constraints and market frictions that prevent the emergence of these recommended products and sectors, and the related policy remedies to support diversification.

F. Conclusion

39. Uruguay's goods exports have become increasingly concentrated in the agricultural sector over the past 20 years. In late 1990s, Uruguay was one of the most diversified countries in its size group. Since then, however, the number of high-RCA export products in SITC 4-digit categories has dropped by close to 40 percent. The agricultural commodity price boom has been a key contributing factor to this trend, attracting resources away from manufacturing and the normal industrialization process.

40. The diversification recommendation models point to significant diversification potential in higher valued-added manufacturing linked to agriculture and other traditional exports. While the models confirm that Uruguay has strong a comparative advantage in agricultural commodities, they also indicate that there is potential for diversification by rebalancing towards non-commodity export categories such as material manufacturing and machinery & equipment. In particular, manufacturing categories that provide the production means for the agricultural and raw material sectors can be a promising diversification area.

41. Greater efforts to identify the key barriers to diversification are needed. While Uruguay appears to have latent comparative advantages in the above-mentioned categories—including due to the country's relative abundance in human capital and physical capital (although both need maintenance and upgrades)—the limited growth, so far, of such categories suggests that there may be barriers to their development. Further analyses are needed to identify such barriers and design policies to lift them.

References

Adeniyi, David Adedayo, Zhaoqiang Wei, and Y Yongquan. "Automated web usage data mining and recommendation system using K-Nearest Neighbor (KNN) classification method". In: Applied Computing and Informatics 12.1 (2016), pp. 90-108.

Aiginger, Karl and Dani Rodrik. "Rebirth of Industrial Policy and an Agenda for the Twenty First Century". In: Journal of Industry, Competition and Trade (2019), pp. 1-19.

Bacha, Edmar L and Albert Fishlow. "The recent commodity price boom and Latin American growth: More than new bottles for an old wine?" In: The Oxford Handbook of Latin American Economics. 2011.

Balaguer, Jacint and Manuel Cantavella-Jorda. "Structural change in exports and economic growth: cointegration and causality analysis for Spain (1961-2000)". In: Applied Economics 36.5 (2004), pp. 473-477.

Cadot, Olivier, C'eline Carr'ere, and Vanessa Strauss-Kahn. "Export diversification: what's behind the hump?" In: Review of Economics and Statistics 93.2 (2011), pp. 590-605.

Che, Natasha. "Intelligent export diversification: an export recommendation system with machine learning". IMF Working Paper, 2020.

Che, Natasha and Xuege Zhang. "High performance export portfolio: design growth-enhancing export structure with machine learning". IMF Working Paper, 2021.

Clickstreams, Multi-faceted Web. "Workshop Notes", 2005.

Feenstra, Robert and Hiau Looi Kee. "Export variety and country productivity: Estimating the monopolistic competition model with endogenous productivity". In: Journal of international Economics 74.2 (2008), pp. 500-518.

Frankel, Jeffrey A. The Natural Resource Curse: A Survey. Tech. rep. National Bureau of Economic Research, 2010.

Giri, Rahul, Mr Saad N Quayyum, and Rujun Yin. Understanding Export Diversification: Key Drivers and Policy Implications. International Monetary Fund, 2019.

Hausmann, Ricardo, Jason Hwang, and Dani Rodrik. "What you export matters". In: Journal of economic growth 12.1 (2007), pp. 1-25.

Hausmann, Ricardo and Bailey Klinger. "The structure of the product space and the evolution of comparative advantage". In: CID Working Paper Series (2007).

Herzer, Dierk and Felicitas Nowak-Lehnmann D. "What does export diversification do for growth? An econometric analysis". In: Applied economics 38.15 (2006), pp. 1825-1838.

Hidalgo, Cesar A and Ricardo Hausmann. "The building blocks of economic complexity". In: Proceedings of the national academy of sciences 106.26 (2009), pp. 10570{10575.

Imbs, Jean and Romain Wacziarg. "Stages of diversification". In: American Economic Review 93.1 (2003), pp. 63-86.

IMF. "Sustaining Long-Run Growth and Macroeconomic Stability in Low-Income Countries-The Role of Structural Transformation and Diversification". In: IMF Policy Paper (2014).

IMF. "Real Exchange Rate And Sectoral Competitiveness in Uruguay". In: Uruguay: Selected Issues (2019).

Harvey, David I., Neil M. Kellard, Jakob B. Madsen, and Mark E. Wohar. "The resource curse, commodity prices and economic growth." In *Global Commodity Markets and Development Economics*, pp. 16-49. Routledge, 2018.

Klinger, Bailey and Daniel Lederman. Discovery and development: An empirical exploration of "new" products. The World Bank, 2004.

_____"Export discoveries, diversification and barriers to entry". In: Economic Systems 35.1 (2011), pp. 64-83.

Koren, Yehuda, Robert Bell, and Chris Volinsky. "Matrix factorization techniques for recommender systems". In: Computer 42.8 (2009), pp. 30-37.

Lathia, Neal, Stephen Hailes, and Licia Capra. "kNN CF: a temporal social network". In: Proceedings of the 2008 ACM conference on Recommender systems. 2008, pp. 227-234. Lin, Justin Yifu and Feiyue Li. Development strategy, viability, and economic distortions in developing countries. The World Bank, 2009.

Al-Marhubi, Fahim. "Export diversification and growth: an empirical investigation". In: Applied economics letters 7.9 (2000), pp. 559-562.

Paterek, Arkadiusz. "Improving regularized singular value decomposition for collaborative filtering". In: Proceedings of KDD cup and workshop. Vol. 2007. 2007, pp. 5-8.

Prebisch, Raul. "The economic development of Latin America and its principal problems". In: Economic Bulletin for Latin America (1962).

Sarwar, Badrul et al. Application of dimensionality reduction in recommender system-a case study. Tech. rep. Minnesota Univ Minneapolis Dept of Computer Science, 2000.

_____ "Incremental singular value decomposition algorithms for highly scalable recommender systems". In: Citeseer.

Singer, Hans W. "The distribution of gains between investing and borrowing countries". In: The Strategy of International Development. Springer, 1975, pp. 43-57.

_____ "The Distribution of Gains between Investing and Borrowing Countries". In: The American Economic Review 40.2 (1950), pp. 473-485.