Essays on Applied Political Economy

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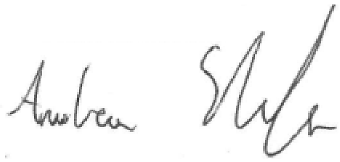
Declaration

I declare that, unless explicitly acknowledged, this dissertation is the result of my own original work and has not been submitted, in whole or in part, for any other degree or qualification at this university or elsewhere. A more comprehensive version of Chapter One is currently under submission at SSRN and is cited in the references of that chapter as Sbarile (2024). A version of Chapter Three has been accepted for publication in Economia Internazionale/International Economics and is cited in the references as Sbarile and Blampied (2024).

Andrea Sbarile



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Preface

The recent global challenges generated by the pandemic crisis, a resurgence of widespread inflation, and an increasingly urgent demand for significant actions against climate change compel policymakers to consider tools and measures that require appropriate identification and counteraction strategies.

Simultaneously, economic research is seeking to adopt new tools for identifying correlation and cause-and-effect relationships, the study of which is especially important in contexts where data are scarce or may result from inaccurate estimation. This becomes particularly complicated in cases such as hyperinflations. In this specific scenario, tools like wavelets (now widely used, especially in the financial sector) have found limited application, considering the economic history (Fratianni et al., 2021 being one of the few exceptions).

On the other hand, evidence regarding the relationship between environmental pollutants and economic growth is not always consistent, making it challenging to identify a political impetus to reverse the climate trend and pollution.

This dissertation aims to analyze, through the lens of political economy, these two themes: the relationship between the causes of inflation (chapter one) and redistributive consequences (chapter three), focusing on stabilization policies and the actual presence of a nonlinear relationship between economic growth and pollution in different income groups. It also aims to provide potential policy indications.

We also aim to bring a case of great historical interest to show how some of these tools can be useful even in the context of an analysis with a relatively limited amount of data.

The first chapter focuses on the study of the German hyperinflation of 1922-1923, framing it in a framework where multiple causes act simultaneously and emerge as determining factors of inflation. This challenges the notion of a singular triggering cause, showing that often, other causes were either considered minor or caused by the same factor.

The fiscal or money views, that have emerged as the prevailing perspective, are two examples of this argument. Heterodox inflation and stabilization framework, despite introducing wages and considers inflation as caused by potentially difficult identifiable causes, considers wages as the main actor on the high and hyperinflation.

These views have been challenged in this study, which contends that inflation is a multifaceted outcome influenced by numerous factors operating at different time and frequency and where it doesn't emerge as a main single cause.

The study, moreover, extends beyond conventional analysis periods by constructing an original weekly dataset spanning from January 15, 1921, to December 29, 1923, incorporating the initial post-stabilization weeks. The interest in the build f a more extended dataset is useful since, as proposed by Mladenović and Petrovic(2010), hyperinflation dynamics could be misspecified if based on low frequency data. Due to the absence of real production data at the required frequency, nominal variables were predominantly used, limiting the application of traditional time series analysis tools that require stationarity. To address this challenge, wavelet tools are employed for spectral and correlation analysis, decomposition, and the examination of predictability. Moreover, causality is tested through multi spatial convergent cross mapping and transfer entropy.

Applied findings indicated that German inflation exhibited long memory persistence, with limited predictability, particularly in the long term. Recurring behaviors at different scales were identified before transitions to new patterns, providing insights into the dynamic nature of inflationary phases. Causal analysis aimed to uncover relationships between nominal variables and the non-stationary component of inflation over different time scales. Wavelet coherence suggested potential wage-price spirals.

The second paper empirically analyzes the presence of the Environmental Kuznets Curve (EKC) in high, medium, and low-income countries. The EKC is currently a widely used tool in environmental political economy and consists of a non-linear relationship whose movement is linked to economic development stages. As countries tend to grow and enter advanced stages of development, they are more likely to seek measures to contain pollutants.

The empirical analysis provides results that support that hypothesis. Across various specifications, the coefficients exhibit expected signs and high significance levels. The focus is on the parameters of interest determining the EKC shape. A pooled OLS without covariate control (a "*naive*" morel), a refinement with control variables and a time trend, fixed effects models and weighted estimations are applied.

Furthermore, an examination of CO_2 and methane emissions was conducted. The findings indicate that the results for CO_2 align with the previously discussed results, indicating a consistent pattern while methane findings, though qualitative, lack robustness. Focusing on income groups, strongly support the EKC for middle-income countries. Low-income countries show a monotonically increasing relationship, consistent with early EKC stages. High-income countries, with a time trend, align with the EKC.

These results contribute insights into the complex interplay between economic development and environmental sustainability, acknowledging the importance of income levels and country-specific dynamics in shaping environmental outcomes.

The third paper studies Argentine inflation between 2004 and 2019 using the lens of political economy. This approach makes it possible to identify inflation as an effective target of certain social classes at the expense of holders of financial assets not indexed to it.

This study extends the political exchange hypothesis proposed by Beetsma and Van der Ploeg (1996) to analyze inflation dynamics in post-convertibility Argentina, with a specific focus on the political equilibriums that have shaped the country since the early 2000s. The model incorporates three interest groups—businesspeople, rentiers, and workers—articulating their preferences regarding inflation, while political parties compete for government representation by aligning with these demands.

In the aftermath of Argentina's 2001-2002 macroeconomic crisis, two distinct political equilibriums emerged, each associated with varying inflation rates. From 2003 to 2015, the Kirchner administration, a businessperson-worker coalition, favored workers and businesspeople but imposed an increasing inflationary tax on rentiers. In 2015, a shift to a businessperson-rentier coalition (Macri's administration) aimed at reducing inflation, favoring rentiers with high real interest rates and businesspeople with tax cuts. The unexpected strength of workers' lobbying power led to a failed stabilization and a subsequent return to power of a businessperson-worker coalition in 2019.

In an era where inflation is regaining dominance in debates, both regarding its nature and methods to prevent further price increases, this contribution asserts that inflation can be used as a means of redistribution in situations where financial wealth is polarized. Furthermore, a developed financial system could mitigate this incentive by providing instruments to protect against inflation. For future stabilization programs, coordination is crucial to ensure the fair distribution of benefits and potential costs among interest groups within the governing coalition, thereby minimizing the risk of coalition dissolution.

Chapter one:

In der Welle des Preises mitschwimmen: a multichannel view of the Weimar hyperinflation[1]

Abstract

German hyperinflation is often associated with the so-called “classical hyperinflations” in which a main cause can be identified as the predominant factor. However, some historical elements suggest the importance of multiple causes as occurred in Latin America “heterodox-type” hyperinflation. The limited availability of data on German inflation could pose a significant challenge in interpreting these historical events. We build a database based on weekly data between 01/15/1921 and 12/29/1923 for inflation (based weighted mean for 68 cities), money base, nominal exchange rate and wages. By employing specific common assumptions of inertial inflation theory and univariate and multivariate analyses through wavelet tools and causality methods (cross mapping and transfer entropy), we argue that Weimar inflation exhibited persistence and that this inflation persistence, when viewed from a multi-channel perspective, resulted from different causes acting on various time scales.

Keywords: hyperinflation, Weimar Republic, wavelet, convergent cross-mapping, fractal analysis, inflation persistence

JEL: N14, C65; C63; C22.

[1] An extended version of this paper is on SSRN. See Sbarile(2024).

1.1 Introduction

The German hyperinflation of 1922-1923 and its subsequent stabilization represent key subjects in macroeconomic history, often categorized as a "classic hyperinflation" (Kiguel and Liviatan, 1995). This classification aligns with hyperinflations and stabilizations prevalent in the 1920s, characterized by discernible origins rooted in budget deficits financed through money creation. The abrupt stabilization, achieved through orthodox measures, addressed fiscal imbalances and instilled public confidence in the central bank's commitment to refrain from excessive money printing. This approach, exemplified by Germany's introduction of the Rentenmark, stemmed from clear deficit roots, notably associated with World War I financing. In contrast, "new hyperinflations" in 1980s South America lacked a singular cause, arising from a blend of domestic and external factors. These hyperinflations manifested as the culmination of prolonged fiscal deterioration, increased financial system fragility, and a tolerance for elevated inflation. The distinction between classical and new hyperinflations underscores the varied trajectories and complexities inherent in different historical contexts.

In the debate on the causes of German inflation, the main schools of thought are the money view, fiscal view, and balance of payments view. The money view (Bresciani Turroni, 1937) sees inflation as a phenomenon caused by an excess expansion of the monetary base, triggering phenomena such as currency depreciation and the wage-inflation spiral. The fiscal view (Sargent, 1982) focuses on the role of expectations and considers hyperinflations as always originating from fiscal imbalances. The balance of payments view (Laursen and Pedersen, 1964) considers expectations of currency depreciation due to Reparations and the value of the Mark as causing capital flow reversals and depreciation, leading to an increase in inflation.

Other approaches have sought to explain German inflation and stabilization from a political perspective, either as a reaction to bad news about reparations and negative political events (Webb, 1986; Lopez and Mitchener, 2021) or as a distributive conflict (Burdekin and Burkett, 1996a). The latter has been used to evaluate both the case of inflation as an unintended result of distributive conflict and the failed stabilization as an attempt by interest groups to shift the costs of stabilization onto others (*war of attrition*, Alesina, 1988) or as the will of government coalitions favoring inflation at the expense of holders of debt and non inflation-linked financial assets (Beetsma and Van der Ploeg, 1996).

A common element in the theories above is the existence of a single cause or, at most, a *primus inter pares* cause, where other minor causes impact but are secondary or are caused by it. Furthermore, as highlighted by Câmara and Vernengo (2002), these approaches tend to limit the impact of wages, which is common in heterodox theories of inflation arising from the experience of new hyperinflations that often are involved in persistent inflation stabilization cycles (Dornbusch et al., 1990).

The approach we refer to involves inertial inflation (De Carvalho, 2019), considering inflation as resulting from a distributive conflict and its persistently high level as a result of an inertial component due to wage adjustment systems (Durevall, 1999) acting as a vehicle for the autoregressive component over time and that remains despite the absence of a shock. Stabilization would occur often through income policies (wage and price freezes, reduction policies in welfare spending) and the adoption of a more restrictive exchange rate regime. German inflation could also exhibit a persistent nature (Fuhrer, 2010), where the average lifespan of the shock is prolonged and is a state commonly assumed by the recents cases of Argentina and Brazil inflations. Additionally, there might be periodicities and factors of long memory (Gadea et al., 2004) and can also be present in hyperinflation cases (Caporale and Gil-Alana, 2003).

For the analysis, I have constructed a weekly frequency dataset with weighted cost-of-living data based on 68 German cities with populations exceeding 10,000 inhabitants between the beginning of 1921 and the end of 1923 to include the initial effects of stabilization. This was done since limitations in data quantity, as highlighted by Mladenović and Petrović (2010), can be misleading in determining hyperinflationary dynamics.

Empirical analysis will be carried out using tools peculiar to econophysics such as wavelet coherence and decomposition, fractal analysis, transfer entropy and multi-spacial convergent cross mapping with the aim of verifying characteristics of persistent inflation (periodicity, cyclicality, fractal dimension, section 3.2 of this chapter) and for the causality relations respect to inflation and its own persistence.

This research has two main purposes. The first is to verify if German inflation is inertial/persistent. The second is to investigate, in light of the multichannel view, the presence of multiple (and concurrent) causes of German inflation or whether there remains a primary cause, as emphasized by the main schools of thought.

The paper is divided into the following sections: Section 2 will provide an historical background, particularly to provide a macroeconomic context and insight into the role of wage bargaining in explaining the various channels that fueled inflation. Section 3 will offer a description of the data used and provide evidence of the univariate component of inflation as inertia/persistence. Section 4 will focus on the multivariate analysis of wavelet coherence and causality between the variables explored in the historical context section. Section 5 summarizes the conclusions.

1.2 Historical background

The historical discourse on wage adjustments relative to the cost of living in Germany predates the 20th century, with trade unions unofficially representing workers. The absence of an official cost-of-living index posed challenges. Teupe(2021) highlights cases where pre-war wages were urged to align with rising prices. Socialist parties noted that, during inflation (*Teuerung*), workers favored price stability or deflation, aiming to maintain real wages. The idea of automatic indexation was proposed in 1909 by socialist leader Adolf Braun but faced criticism and shelving within the labor movement. Wage adjustment difficulties in times of rising prices led to strikes (i.e in 1889, 1912), consolidating trade unions as worker representatives. The main three groups (Bry, 1960, Patch Jr., 1981) were the Free Unions (*Freie Gewerkschaften*), the Christian Trade Union (*Gesamtverband der christlichen Gewerkschaften Deutschlands*) and the Hirsch-Dunker Union,which stood as a form of

extra-parliamentary forces distinguished mainly by socialist, "centrist" and "liberal" ideology, respectively. Between 1896 and 1913, real wage progress for German workers was minimal.
The transformative period of 1914-1918 saw the end of WWI and the abdication of Emperor Wilhelm II, leading to the establishment of a republican government supported by revolutionary workers and soldiers (Kahn Freund, 1981). A peace treaty in 1918 between industrialists and workers resulted in a collective agreement (*Arbeitsgemeinschaftsabkommen*), introducing an eight-hour workday without wage losses. However, ideological divisions emerged, and trade unions, despite official recognition, struggled to cooperate with industrialists. The Weimar Republic's constitution in 1919 brought innovations in workers' rights, however, some imperial characteristics persisted.
Post-war material shortages and inflation exacerbated social conflicts. Rising living costs prompted wage increases, often in the form of cost-of-living bonuses (Sitzler, 1924) including provisions for wage negotiations in collective agreements in cases of substantial cost-of-living increases .
The Federal Ministry of Labour (*Reichsarbeitsministeriums*) through the Wage office (*Tarifamt*), determined the justification for new negotiations. The authority aimed to balance worker wage demands and the centrality of collective agreements (Kunz, 1986). The complex socio-economic landscape during the Weimar era highlighted the intricate relationship between inflation, wage adjustments, and the evolving role of trade unions in representing workers' interests.
There were several proposals for adjusting wages for inflation (for a review, Holtfrerich, 1986 and Kuczynski, 1925), however, each was far from perfect and, moreover, each social group had an interest in imposing a method to gain an advantage in bargaining.
Another important element underlined by Webb (1989, see Table 1) and Brunnermeier et al(2023) is the shortening of the length of the wage payment period. Despite the fall in wage bargaining length, the payment period (the days necessary to have paid the wage) continued for most part of the firsts 1920s without decreasing (exceptions excluded) until the 30 days. Between 1920 and 1922 payment periods didn’t face high changes. In general, authorities undertook a middle-way solution: workers should have accepted a considerable reduction in real wages to maintain the authority of collective agreements but an increase would have coincided with worsened workers’ conditions. Contracts were later discussed, separating wages from other issues; wages were contacted shortly compared to agreements on other issues (*Manteltarif*) that were valid, in general, for one year.

	Coal (Ruhr, white-collar)	Metal (Ruhr, steel)		Electrical and machine building (Berlin, blue collar)	Textiles (Rhineland, white collar)
		Blue-collar	White-collar		
1921/ 1922	30 days	30 days	30 days	-	30 days
1922 Fall	15	-	-		
December	15	-	-	14 days	-
1923 January	15	-	-	14	-
February	10	-	-	14	-
March	10	-	-	28	-
April	10	-	-	28	-
May	10	15	15	14	-
June	10	15	-	7	10
July	10	15,7	15	7	-
August	5	5-7	10	7	10
September	7, 3-4	4-7	7, 5	7	7
October	3-4	7	4-5	-	7, 3-4
November	3-4	7	-	-	3-4

Table 1: Payment period of workers in German industry

The urgency to shorten wage agreement negotiation intervals arose from challenges in estimating a universally accepted cost-of-living index in 1919. The absence of a universally valid instrument complicated negotiations, leading to diverse cost-of-living indexes. Holtfrerich (1986) outlines issues related to index calculation, categorizing them based on the chosen goods bundle. The Statistical Office of the Reich (Statistiche Reichsamt) proposed the inflation figure, including essential goods, clothes, and rent published on *Wirtschaft und Statistik*, a statistical periodical. Regional indexes, like Kuczynski's for Berlin, reflected local consumption patterns, contributing to biased calculations. The period from late 1919 to early 1920 witnessed an unprecedented price surge, complicating inflation impact assessments on the cost of living.

To further highlight the role of inflation on the timing of wage adjustment (and, thus, the dependence of wages themselves on current and past inflation) we can resort to the following exercise. We propose a modification of de Carvalho (2019) wage indexation model and apply it to a time series with variable indexation. Similarly to de Holanda Barbosa and McNelis(1989), de Carvalho's model is useful to consider an indexation equation with fixed length. Given h the dependence of wages to current inflation and $(1 - h)$ as the dependence to lagged inflation:

$$h = 1 - \frac{1}{2T} \rightarrow \begin{cases} T = 1 & Year \\ T = 4 & Quarter \\ T = 52 & Week \\ \quad \dots & \\ T = 365 & Day \end{cases}$$

and T is the number of adjustments considered for a given period. Since if $T = 1 \rightarrow h = 0,\ 5$; $(1 - h) = 0,\ 5 \rightarrow W = 0,\ 5\pi_t + 0,\ 5\pi_{t-1}$, with an yearly indexation, the de Carvalho model concludes that the weight of current and past inflation is equal, while with a quarterly indexation $T = 3 \rightarrow h = 0,\ 875$; $(1 - h) = 0,\ 125\quad W = 0,\ 875\pi_t + 0,\ 125\pi_{t-1}$. Applying this model to our data presents some problems, since we have many changes in adjustment length both inside the single working class and between themselves. So, to avoid this problem and maintaining the formalization and the fitting of de Carvalho, we change the definition of T from the number of indexation agreements to the ratio between the number of time unit in a given time span (in our case the fixed number of weeks in an year, so $N_y = 52$) and the number of time units needed for a new agreement (i.e. the number of weeks between two agreements[2]) and we define respectively as N_y and N_a. So, the previous formulation becomes:

$$h = 1 - \frac{1}{2\frac{N_y}{N_a}} \rightarrow \begin{cases} N_a = 52 & \frac{N_y}{N_a} = 1 & Year \\ N_a = 13 & \frac{N_y}{N_a} = 4 & Quarter \\ N_a = 1 & \frac{N_y}{N_a} = 52 & Week \\ \quad \dots & & \\ N_a \approx 0,143 & \frac{N_y}{N_a} \approx 365 & Day \end{cases}$$

In our sample, the first agreements is arrived after $N_a = 28$, so $T = 52/28 \approx 1,\ 857 \rightarrow h \approx 0,\ 73$; $(1 - h) \approx 0,\ 27 \rightarrow \dot{W} \approx 0,\ 73\pi_t + 0,\ 27\pi_{t-1}$. Figure 1 is the graphical proposition of our version of de Carvalho(2019) model with respect to our observations. We estimate the value of h and $(1\ h)$ for the period of the 15th of January 1921 to the 29th December 1923.

[2] This modified model could be applied also to different span and time for agreement (if the equality between fixed length estimation and the other model is respected). For this case, we apply just weekly agreements and time span of a year to make our results fitting with de Carvalho (2019a).

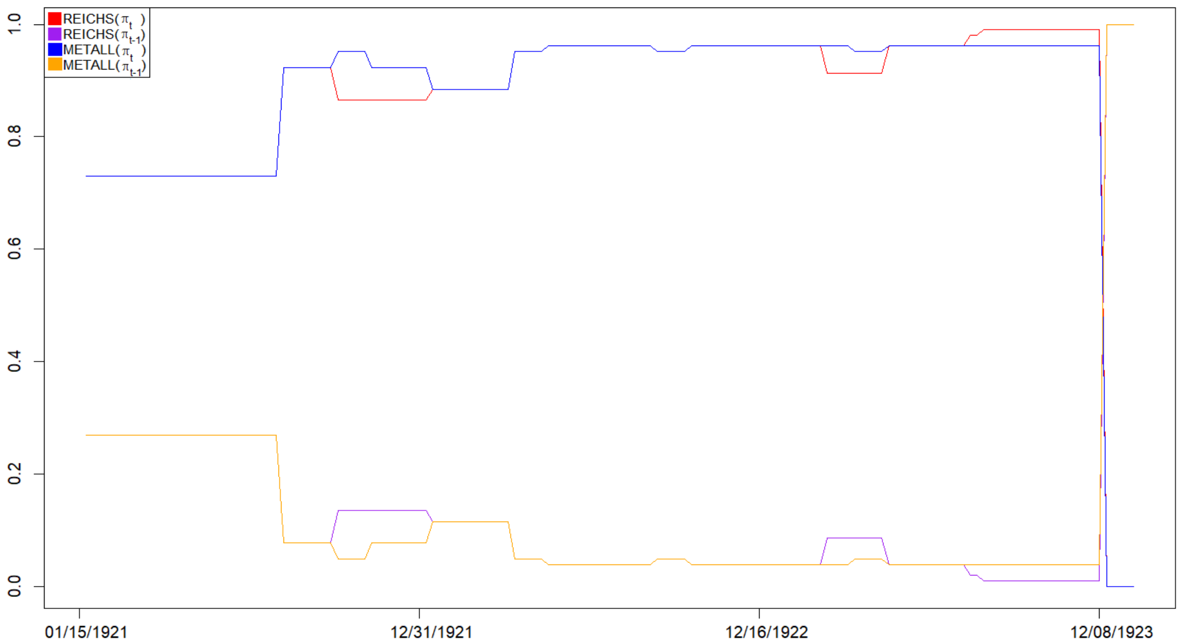

Figure 1: Dependence of nominal wages by current (π_t) and past (π_{t-1}) inflation

In the final months of 1921, particularly concurrent with the publication of the express index, there was a notable surge in the number of agreements and wages for the Reichsarbeiter (REICHS) and Metallarbeiter (METALL) classes. The data suggests a persistent high level of dependence of wages on current inflation, aligning with de Carvalho's findings that shorter intervals lead to increased sensitivity of nominal wages to actual inflation rates, thereby accelerating future inflation rates. This pattern of wage dependence on current inflation did not originate with the 1922 price explosion.

The first breach intensifying wage dependence on current inflation is not precisely identifiable due to data limitations up to January 1921. Nevertheless, in October 1921, hourly wages experienced a substantial increase compared to 1920, influenced by factors such as the rising cost of living and the integration of a "social wage" accounting for family situations and urban living. The reduction in real wage value between 1919-1922 was partly attributed to the introduction of shorter working hours through the collective agreements of 1918.

Post-August 1921, nominal wages began to rise more rapidly as the cost of living increased, while real wages remained stable. This aligns with the corresponding increase in the number of agreements during this period, indicating a correlation between the two. Bresciani Turroni (1929) posits that the inflation-wage spiral commenced in 1920. When incorporating Sitzler's (1924) contract information, the data reveals a heightened dependence on current inflation by wages after 1921 compared to the years 1919-1920.

Examining the period from 1921 to 1923, the data confirms that dependence on current inflation is a structural phenomenon in the German economy, stemming from the wage agreement mechanism. In December 1923, a reversal in dependence from current to past inflation occurred. This shift coincided with a wage freeze for the specified worker categories, remaining unchanged for the rest of the month and only being indexed during the initial months of 1924. This adjustment in the indexation scheme made it more challenging to apply

and reversed the inflation dependence during that specific time frame.
Since the beginning of 1920, the Statistical Office computed an index for more than 600 cities, in particular, those with more than 10000 inhabitants, based on a number of foodstuffs as well as for housing. These statistics were not quick enough to estimate for practical purposes, and at the end of 1920 a change was made to the so-called " *express*" data, taking into account current living conditions, a normal ration for a family of five was elaborated, and the costs (*Teuerungszahlnen*) for each month and city were calculated in about 48 and after 71 cities of different sizes and characteristics. Data were collected, initially, every two weeks to obtain a month-based index. Sitzler (1924) underlines that the control over the indexation length was taken into account as a means to reach price stabilization since:

≪*In spite of repeated requests for more frequent data, the publication of a monthly index number as maintained as long as possible, in order to secure the economic advantage of changing wages only once a month, with some consequent stabilization of prices.*≫

The increase in the number of publications (fortnight during July-August and weekly since September 1923) coincided with the rampant decrease of the value of the Mark. Requests for adjustments on wages after WWI were more an " annoying necessity rather than a voluntary struggle for improvement" (Teupe, 2021). Workers could, at least, count on a partial indexation and the demand for inflation (in particular by workers and indebted firms) was more prone to continue with an inflationary policy. However, workers and firms did not desire persistent inflation, since industrial prices were strongly related to wages and the depreciation of the Mark (also in respect to foreign currencies that were more stable, exceptions made for countries in hyperinflation in the same period) represented a critical issue for the whole period after WWI. The increase in the number of adjustments went hand in hand with collective bargaining, and the reduction in unemployment had strengthened the unions' ability to demand adjustments. It also highlighted the political class's inability to act on stabilization efforts, despite the price increases (especially during hyperinflationary phases) causing problems for the workers themselves.
In the backdrop of the German hyperinflation crisis, two critical periods, the 1920-1921 crisis and the onset of 1923, saw a tension between stabilizing inflation and reducing wages. This dilemma compelled capitalists to choose between zero inflation, favored by financial activity holders, and positive inflation, potentially through partially indexed worker wages. The timing of wage collection, typically on Mondays with availability on Wednesdays, made the latter part of the week crucial for measuring fluctuations in the cost of living. Workers advocated for an automatic escalator, prioritizing the index number in wage negotiations. This persisted until the introduction of the gold wages system in response to the Mark's collapse in 1923.
The preference for complete automatic adaptation of wages to maintain real wages clashed with industrial and governmental efforts to curb wage-inflation spirals. Trade unions exploited government resistance to indexation, resisting a sliding scale that would limit their role in negotiations. The Ministry of Labour proposed arbitration courts, aiming to consider wages in relation to the index number at regular intervals. Initially, the flexibility of free negotiation rendered government-sponsored sliding scales unnecessary.

The collapse of the Mark in 1923 necessitated an automatic escalator, with some exceptions implemented earlier. Continuous collective bargaining and wage recontracting were observed, and despite challenges, wage scales for large areas and the whole country were introduced in 1920. The Ministry of Labour initiated wage statistics compilation in February 1920, hoping to inform better wage graduation systems. However, these hopes were unfulfilled due to data obsolescence caused by price and wage volatility.
Efforts to stabilize money and prices in 1920 were influenced by factors like the failure of the Kapp coup, improved trade conditions, capital inflows, and a general fall in international prices. The Reichsbank pursued an accommodating monetary policy since WWI, favoring inflation and fiscal deficit financing. The period from February 1920 to April 1921, termed "relative stability" by some, was marked by the illusion of stabilization in the course of German inflation. Despite the increased Reich's income, expenditure grew rapidly, and deficits were covered by issuing Treasury bills, contributing to the seeds of the Mark's fall. In March 1921, a significant portion of the issued currency was sold internationally, marking a crucial juncture in the lead-up to hyperinflation.
Hefeker (2001) emphasizes that post-war inflation in Germany stemmed significantly from the inability to reform the tax system. A coalition government faced opposition from both nationalists and communists, hindering substantial fiscal reforms. The imposition of hefty reparations worsened the situation. Hefeker argues that it resulted from deep-rooted distributive conflicts (*war of attrition*), preventing necessary fiscal reforms. Despite structural issues, the conditions in 1920-21, marked by relative inflation stabilization and government attempts for economic stability, led to the formation of an "inflation consensus" among rival social groups. The Fehrenbach Government aimed for budget stabilization, a prerequisite for addressing the Reparations issue, advocating expenditure cuts and increased government income, particularly from groups accustomed to having their demands met by the public purse, such as civil servants.
Post-war stabilization in Germany faced significant challenges, with potential paths for war debt repayment outlined by Holtfrerich (1986). Three main approaches were considered: revaluation of the exchange rate through deflation, devaluation for domestic price stability, and debt reduction via continued inflation. However, these strategies encountered opposition from the "inflation coalition," hindering effective budgetary measures and perpetuating social unrest.
The "inflation coalition" (Pittaluga and Seghezza, 2012; Seghezza and Morelli, 2014; Kunz, 1982) composed of various interest groups, presented formidable challenges to the German government's attempts at stabilization. This coalition, driven by the desire for higher wages and a resistance to fiscal reforms, impeded efforts to achieve sound budgetary conditions necessary for economic and monetary stability. Rising wages, particularly in the public sector, became a contentious issue, leading to strikes and social unrest / (Kunz, 1986). Despite the potential benefits of stabilization, which included a reduction in government expenditures and a freeze or reduction in salary levels, the prevailing economic and political conditions led to a continued increase in wages. The period from 1919 to 1920 witnessed a gradual rise in money wages due to a depreciating currency and a tightening labor market. However, this trend was interrupted briefly in the fall of 1920, only to resume in December

1920/January 1921. This fluctuation hinted at the potential for social conflict and demonstrated the challenges of achieving economic stability during this period.
The relative stability of inflation from April 1920 to May 1921 came to an end with the acceptance of the London Ultimatum and the subsequent reparations schedule in May 1921. The faith in Germany's monetary stability faltered, leading to a rise in prices, increased money circulation, and a worsening foreign deficit. As inflation resumed, social discussions intensified, prompting wage movements in August and October 1921. This period culminated in the general strike of February 1922, reflecting three years of endemic social unrest within the Weimar Republic's public service.
The delayed stabilization underscored the political implications of distributional conflicts laid bare during the relatively stable period. Despite the lack of significant changes in political economy by the governments in charge, the delay was preceded by stability in the foreign exchange rate, which constrained Germany's export advantage. The British industry, in particular, advocated for German currency stabilization to avert potential disturbances (Holtfrerich, 1986).
Stabilization conditions were consented to by Germany at the Cannes conference, initiating fiscal adjustments. However, the period from July 1921 saw a cycle of inflation, wage disputes, and exchange rate depreciation. The German government's continuing wage negotiations were viewed as a form of compulsion in response to the emergency state created by falling real wages due to mark depreciation. The imposition of a loan subscription by the Allies further contributed to increased demand for foreign currency and a subsequent rise in money supply.
The fiscal deadlock persisted, exacerbated by Reparations emerging as the critical fiscal issue. Germany attempted to convince the Allies of its inability to pay the demanded annual Reparations, which far exceeded its actual financial capacity. The fiscal constraints and ongoing distributional conflicts set the stage for the subsequent hyperinflationary phase, marking a critical period in Germany's economic and political history.
Some efforts to address the fiscal deficit in post-war Germany faced challenges, with proposals for a tax surcharge encountering resistance. Hefeker (2001) notes that a 20% tax increase on all taxes could have sufficed, but opposition from higher-income individuals, lack of tax indexation to inflation, and French reluctance hindered implementation. The inability to raise taxes contributed to inflation, fueling distributional conflicts. Inflation benefited debtors over creditors and unskilled workers over skilled ones (Holtfrerich, 1986), exacerbating societal divisions. The beneficiaries lacked motivation to end the inflationary war of attrition.
The murder of Foreign Affairs Minister Rathenau in June 1922 triggered fiscal reform attempts and exchange rate stabilization. However, resistance to tax hikes and foreign pressures led to a disrupted collapse. With Rathenau's murder, foreign investors divested Marks, prompting rapid depreciation, inflation, and rising living costs. The Reichsbank accommodated this by creating more money, complicating fixed-rate wage contracts. Workers sought compensation for depreciation, posing challenges for wage adjustments. Two options emerged: a supplementary payment or new wage rates compensating expected cost-of-living increases. The former faced industrial opposition, while the latter risked overcompensating inflation.

During the mark's depreciation collapse, the Reichsbank initially claimed limited resources for effective intervention. Not until late January did a change in strategy occur, culminating in massive February intervention. President Havenstein acknowledged the Reichsbank's passive stance, attributing it to limited resources and political risk. The hyperinflation phase reflected a politically motivated, risky policy with uncertain future payoffs. The Reichsbank's intermittent opposition during the mark support effort further underscored the complexity of navigating Germany's economic crisis.

The period of the German hyperinflation was marked by a contentious struggle over the distribution of burdens arising from stabilization politics. Despite the lack of faith in the efforts of the central bank, some attempts to stabilize the currency were made. In October 1923, Hjalmar Schacht, the later President of the Reichsbank, proposed a plan for mark stabilization. Published in the Berliner Tageblatt, Schacht's plan envisioned an intermediary means of payment pegged to the dollar and issued by a newly established gold bank linked to the Reichsbank.

Under Schacht's proposal, the Reichsbank would issue gold mark banknotes to credit institutions, with 1 dollar equating to 4,2 gold marks. Banks would acquire these notes by exchanging trade bills in marks, eliminating the option of rediscounting bills at the Reichsbank. The exchange rate would mirror the daily mark-to-dollar rate, allowing the Reichsbank to withdraw marks from circulation. Banks were obligated to base their lending policies on this coverage, aligning income from marks with payment obligations to the Reichsbank, measured in gold marks. With the ongoing devaluation of money, debtors faced increasing mark amounts at maturity.

The plan hinged on the assumption that stabilizing the mark would also stabilize the Mark-Dollar exchange rate. The restriction of the money supply in marks aimed to contribute to domestic price stability in payment transactions. Credit was granted selectively, favoring investments and commodity transactions with returns sufficient for meeting obligations. The debtor's ability to fulfill obligations, measured in gold marks, was crucial (van der Hek, 2020).

Income policies, while not the central focus of the stabilization plan, played a supportive role. The Stresemann government's policies included limiting indexation time for certain worker categories and suspending privileges like the quarterly pay system. Public criticism of the latter had intensified during the summer of 1923, particularly after the economically advantageous prepayments resulting from the July 1923 Indexation Agreement.

Schacht's proposal reflected a multifaceted approach to stabilization, intertwining monetary, exchange rate, and income policies. The intricate balance sought to rectify the economic turmoil wrought by hyperinflation and address structural issues in the financial system. As the Weimar Republic grappled with the aftermath of hyperinflation, these measures aimed to restore confidence in the currency and establish a foundation for economic stability.

Fiscal stabilization was a way to respect, through the influence on people's income, the constraints of the public expenses due to social policies. Emblematic, in this case, is that, during the Cabinet council (*Kabinettssitzung*) of the 7th of November 1923 (Erdmann and Vogt, 1996, Dokumente Nr. 227,9. "*Begrenztheung der Erwerbslosenfürsorge im besetzten Gebiet*"), the Minister of the Finance (*Reichsminister der Finanzen*), Hans Luther:

≪As far as the Rentenmark was concerned, it had to be absolutely clear that the issuing of the Rentenmark would be a total failure if the Reich's enormously inflated expenses were not contained to a tolerable level on the day of issuance. Above all, this required the cessation of unemployment benefit payments in the occupied territory>>.

During the same *Kabinettssitzung*, the urgency to fix a defined date for the emission of the new Rentenmark was underlined by different ministers, because the absence of this data, in the words of the Minister of Economics of the Reich (*Reichswirtschaftsminister*),

≪if the Government would not make a positive decision and thus give new strength to the Rentenmark, the consequences would not be predictable≫.

The Rentenmark in this view played a relatively more contained role (at least, with respect to the wage agreement) since just trade unions both financially and from the point of view of the bargaining power (caused by the high unemployment rate after the decreasing of the capacity to affect wage agreements after the institution of scale arrangements in July), gave to the entrepreneurs the possibility to reduce the wages, on the grounds that only by such a reduction the German industry would be enabled to meet foreign competition. At the same time the employers endeavored to extend the working day, and eventually obtained from the Government the decree of November 1923, which, although it did not abolish the principle of the eight-hours day, it suspended its application in practice (Webb, 1989; Bresciani Turroni, 1929). We can be pretty sure that the stabilization of the Rentenmark (continued in 1924 with the Dawes plan e under the leadership of the same Schacht) was a success.
Obviously, some inertial effects of inflation remained also after the introduction of the Rentenmark (in particular in December 1923), but, as the same publication of the Statistical office of the 10th of April 1924 in "*Wirtschaft und Statistik*" where it was underlined that:

≪A comparison of the course of inflation in the individual months shows the same picture with regard to both the cost of living (overall) and food: in January the price level fell uninterruptedly, whereby food alone fell to a significantly greater extent; the month of February brings the turnaround in the opposite direction, while March brings stability of the price level in the second half of the year≫.

To conclude, the role of wages and labor policy seem to have been clearly considered to have a strong impact on price setting. Moreover, the same Statistische Reichsamt in the "*Wirtschaft und Statistik*" published on 14th of January 1924:

≪As a result of the acute price fluctuations, the industry was forced to abandon the principle of pricing according to cost price plus charge and switched in part to sliding prices that rose in line with wages (Lohnklausel) and in part to sales that were entirely subject to change. However, since the final price remained uncertain, the change in prices was later often brought into a certain relationship with the wage increase and a maximum amount expressed as a percentage of the basic prices was provided for.>>

1.2.1 Is inertia enough to explain the Weimar case?

What has been discussed so far has allowed us to identify the role of wages within German inflation. Wages, rather than merely transmitting monetary shocks, effectively served as a cause of inflation. This situates inflation within a cost-push framework, particularly where businesses, in line with distributive conflict models, transferred wage shocks onto inflation. They then utilized the exchange rate lever to mitigate the negative effects on competitiveness. Despite criticism at the time from economists such as Bresciani Turroni and von Mises (for a review, see Humphrey, 1998), this perspective appears fitting with historical evidence.

The relationship between the adjustment time of wages and payment times with inflation, initially proposed by Barro (1970) and later by inertial inflation theory (Vera, 2013), adds the aspect of wages highlighted by Robinson(1938). As we will see in the next section, Weimar inflation is persistent (more than inertial), and therefore, some characteristics of heterodox inflation models find confirmation in what has been discussed so far. However, inertial inflation has several limitations.

Lopes (1985) suggests that if an economic operator engages solely in transactions where prices are denominated in foreign currency and maintains the price of the service or product fixed in terms of that currency, their real income becomes independent of the inflation rate, influenced only by movements in the real exchange rate. This implies that the agent essentially reduces the size of their readjustment interval to zero, making their average real income equal to the peak real income, irrespective of the inflation rate. However, this view faces criticism, particularly in the context of German hyperinflation, where the asynchronies between inflation and nominal exchange rates contributed to the divergence between real and nominal exchange rates, making this reference difficult to use and especially unable to explain stabilization given that wages continued to adjust to domestic prices via *Terueungszahlen* than through the exchange rate. Lopes' argument assumes, hence, that inflation would not affect the time of conversion between local and foreign currency. This perspective does not consider the impact of logistical challenges in cash flow recording for companies, the evolution of domestic prices, and the time required for currency conversion decisions.

Moreover, Lopes suggests that when a currency is devalued to the point of being unusable, the relevant inflation rate for the average economic agent becomes less representative. The argument implies that the relevant inflation rate can decrease long before the stabilization of inflation in terms of legal tender. However, this perspective overlooks elements such as distributive conflict and internal motivations within the German economy.

The theory of inertial inflation, critiquing rational expectations, fails to account for certain factors, aligning partially with the balance of payments view. The fixing of the exchange rate, which occurred concurrently with initial disinflation in Germany, played a crucial role in stabilizing the economy without the need for a monetary reform. Lopes' work appears to overlook the reasons behind the decrease in inflation. Stabilization, according to this view, seems like happening because of the limiting of the vicious cycle without explaining why it works without monetary reforms and changes in expectations and why an anti-inflation coalition rose. The convergence of economic agents toward a preference for stabilization in

late 1922 remains so unexplained. Stabilization is mainly despicable as a combination of both orthodox and heterodox models, but neither the model of Vera(2013) where the government intervenes to limit credit and thus the quantity of money nor the above-described model of Lopes(1985) are sufficient.
Since inertialists poses that inflation is mainly caused by wages transmitting the autoregressive component through the time, themselves could be considered as a *primum inter pares* theory. In the absence of a convincing framework we must first verify whether, statistically, German inflation behaves as inertial inflation or persistent inflation. In addition to examining elements associated with inertial inflation, a perspective that considers a comprehensive model incorporating both the exchange rate, the monetary base and the wages can provide insights into the complex dynamics of Weimar inflation. Notable works integrating these variables include Tullio (1995), Sommariva and Tulio (1987), and Burdekin and Bukett (1996a; 1996b). Aligning conceptually with Burdekin and Bukett (1996a), this approach emphasizes a model that encompasses the endogenous determination of wages, highlighting government deficit finance, the collapse of the exchange rate, and the monetary transmission of the wage-price spiral are all pivotal factors contributing to the price surge.

1.3 Applied analysis

During the tumultuous period of 1919-1923, data collection faced significant challenges, with varying frequencies for different categories, indexes, and aggregates. The onset of hyperinflation in July 1922 heightened the urgency for data collection, crucial for social classes adjusting wages and authorities implementing policies. *Wirtschaft und Statistik*, the primary source, transitioned from monthly to weekly frequency in 1923 due to the pressing need for timely information and in order to maintain the coherence with respect to the observation of the period October-December 1923 that was published at weekly frequency..
Data estimations by Kuczynski(1925), though weekly, focused solely on Berlin, limiting its ability to capture the evolution across a broader sample. Recognizing the importance of describing wage adjustments to compensate for rising living costs, the Lebenskostenindex emerged as a preferred indicator, collected at a high frequency and covering a large sample of cities, as suggested by Holtfrerich(1986).

1.3.1 Inflation data

The dataset, compiled from *Teuerungszahlen* issues in Wirtschaft und Statistik between February 1921 and April 1924, incorporates data for 48 cities until July 1921 and 68 until December 1923. To ensure homogeneity in the sample's inflation impact on the German population, a weighted index was calculated based on city populations reported in the same tables as *Teuerungszahlen*. Berlin, with a population ranging from almost 2 million in 1921 to nearly 4 million in 1922-1923, remained a consistent focal point in the sample, representing 15-18% of the entire German population.

Figure 2 illustrates the evolution of *Teuerungszahlen*, providing insight into the weighted cost of living index. Challenges in data continuity arose due to changes in the cities included between consecutive periods, with adjustments made to maintain homogeneity. In March 1922, modifications were introduced and labeled as "*neu Index*" further influencing the dataset. Below Figure 2 shows the costs of living used to calculate the weighted value of inflation.

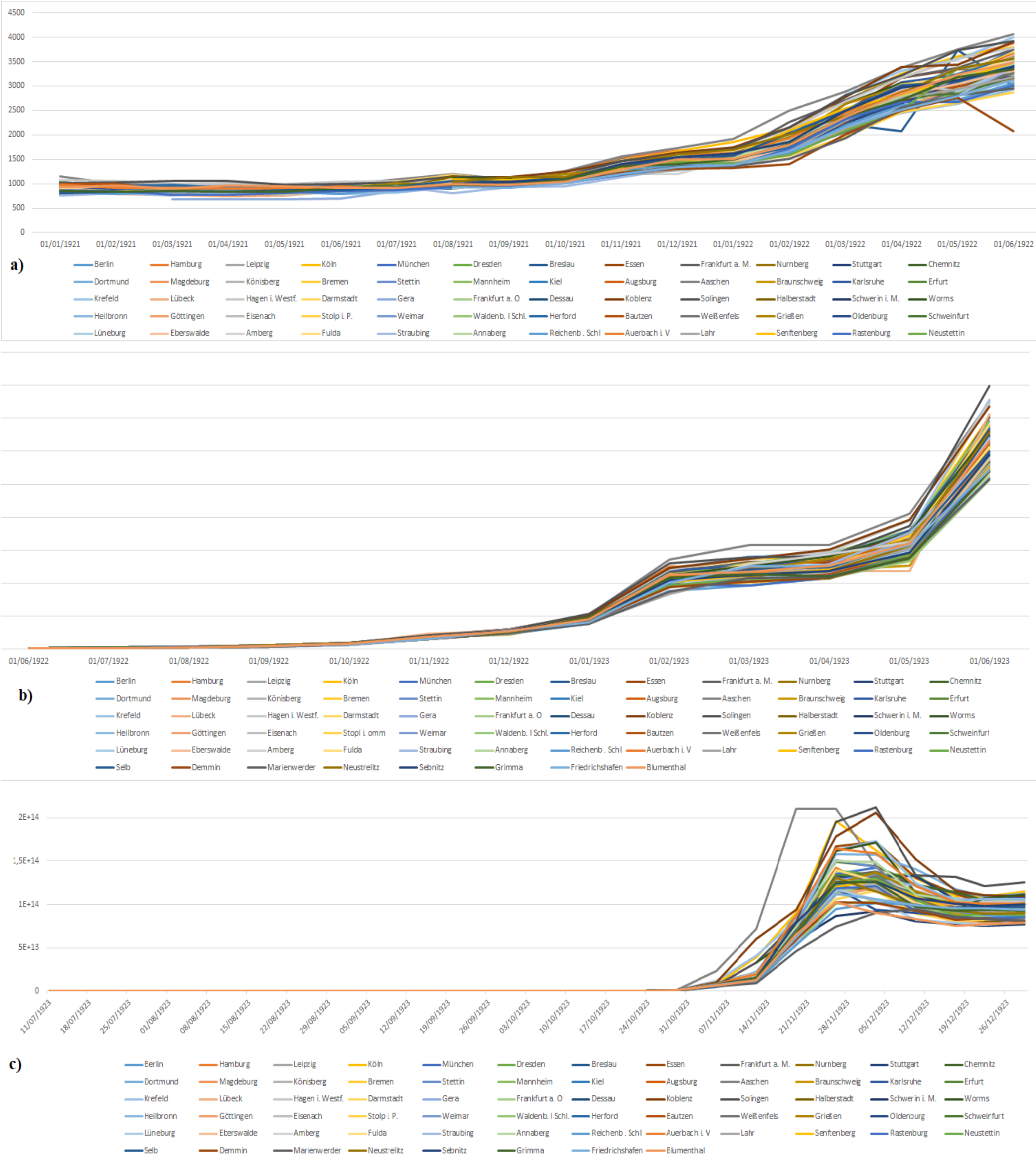

Figure 2: Nominal cost for inflation calculation (*Teuerungszahlen*) for 47 (until August 1921) and 68 (until December 1923) cities higher than 10000 inhabitants in Germany[3].

[3] Source: *Wirtschaft und Statistik*, various issues. Panel a) describes the *Teuerungszahlen* for the pre-hyperinflation period (January 1921-June 1922). Panel b) covers the period of escalating prices following the disruptive depreciation of the Mark, encompassing the first attempt at inflation stabilization (July 1922-June 1923) and its subsequent failure. Panel c) encapsulates the hyperinflation phase and the successful stabilization of the Rentenmark (mid-July 1923 to the end of December 1923). Note: Panel c) is distinct as it does not rely on monthly data for its construction.

1.3.2 Persistence and periodicity of inflation

Fuhrer(2010) suggests estimating inflation persistence by analyzing empirical properties of inflation time series without a structural interpretation. Statistical models commonly used for persistent inflation, such as autocorrelation functions, variance ratio, and unit roots tests, provide insight into these properties. Figure 1a (see Appendix) displays the autocorrelation of inflation, revealing a slow decline in significance after 14 weeks, indicating non-stationarity. Evans(1978) observed similar results in monthly time series. Tables 1a-1b show the unit root tests and the presence of a structural break in the time series in May 1923. Table 1c tests the variance ratio showing a significant decline in the random walk component, aligning with stationary processes. Variance ratio tests, as suggested by Edwards and Lefort (2002), indicate a decreasing trend despite hyperinflation, especially during stabilization policies or price declines. Salcedo-Sanz et al.(2022) argue that for non-stationary time series, the semivariogram is more effective in assessing long-range correlations following the equation:

$$\gamma[k] = \frac{1}{2(N-k)} \sum_{n=1}^{N-k} (x[n+k] - x[n]) \tag{1}$$

Where x[n] is the space sequence of the time series x(t), N is the length (in our case N=155) and k is a time lag variable.

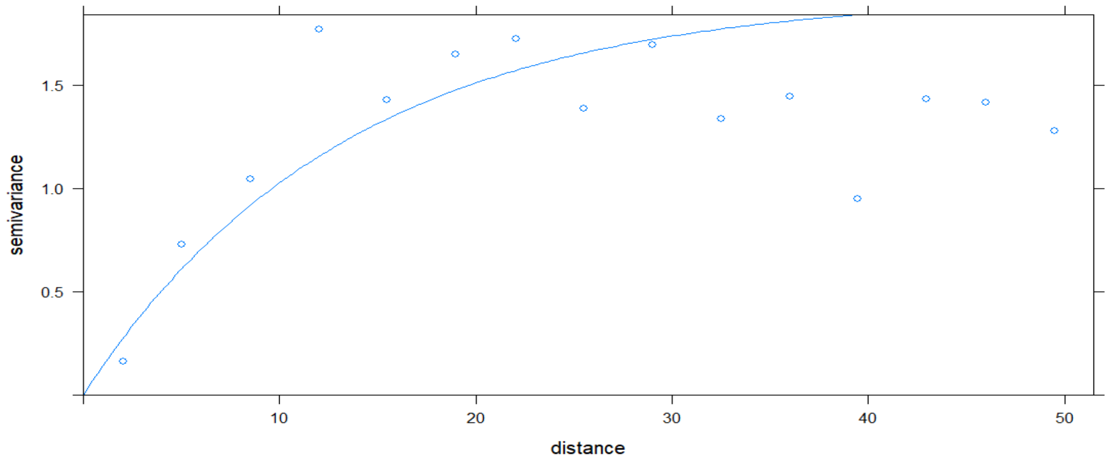

Figure 3: semivariogram of inflation time series

Despite our dataset presenting more observations with respect to many other monthly studies about German hyperinflation, the division attributable to structural break (in particular in trend) makes our inflation constrained since a dataset about 32 observations is difficult to manage with respect to our original sample. Another common tool used in persistence analysis is the Hurst's exponent (Caporale et al., 2018). A theoretical explanation is proposed here. Hurst introduced the first method for long-term persistence characterization, known as Rescaled Range (R/S) analysis (Weron, 2002). R/S analysis can be described as follows:

$$y(n) = \sum_{t=1}^{n} x(t) \tag{2}$$

Where y(n) consists of non-overlapping segments of length s in number $N_s = N/s$. A range $R_{m,s}$ is used to describe the dispersion of these values, looking at the maximum and minimum Y_j values within each segment m of length s. It is defined as:

$$R_{m,s} = max\left[y_m^s(n)\right] - min\left[y_m^s(n)\right] \tag{3}$$

For each segment m of length s the variance of the original time series $x(t)$ values in that segment is computed as:

$$S_{m,s} = \sigma_x[x_m^s] \tag{4}$$

where this expression indicates taking the standard deviation over each segment of length s in the time series $x(t)$. The mean value of the R and S are respectively $R_s = 1/N_s \sum_{m=1}^{N_s} R_{m,s}$ and $S_s = 1/N_s \sum_{m=1}^{N_s} S_{m,s}$. The ratio (R_s/S_s), exhibits a power-law scaling as a function of segment length s:

$$\left(\frac{R_s}{S_s}\right) = \left(\frac{s}{2}\right)^{HE} \tag{5}$$

The Hurst's exponent (HE) quantifies time series correlation, indicating whether it's uncorrelated (H=0.5), persistent (H>0.5), or anti-persistent (H<0.5). This exponent reveals the regularity and dependency structure in data over time. Employed to assess time series, a higher HE implies greater long-term dependence, indicating likely data persistence or trend-following. In financial, climate, or economic analysis, a high HE suggests persistent trends. Plakandaras et al. (2015) and Fernandes et al. (2020) use this parameter to examine inflationary data persistence, similar to the Alijani et al. 's (2021) approach for identifying fractal behavior in time series.

Simple R/S HE	0.7573
Corrected R over S HE:	0.8996
Empirical HE	0.9594
Corrected empirical HE	0.8033
Theoretical HE	0.6431

Table 2:HE specification

All HE > 0.5 confirming strong inflation persistence. To address potential specification issues in nonstationary series, we employ fractal dimension analysis. Fractal dimension serves as a measure of time series complexity and regularity, indicating long-term persistence. We apply the Higuchi method (HDF, Wanliss and Wanliss, 2022; Kesić and Spasić, 2016), designed for the curve's fractal dimension in a plane. Higuchi's technique calculates segment lengths at various scales, providing insights into the fractal properties of potentially non-periodic and nonstationary data. This approach enhances robustness in evaluating inflation persistence, complementing Hurst's exponent analysis.

Let's take the usual historical series $x(t) = x(1), x(2), ..., x(155)$ in our case. From the starting time sequence, a new self-similar time series was calculated as $X_{\Gamma}^{j}: x(j) + x(j + \Gamma), x(j + 2\Gamma),..., \{x[j + int[(155 - \Gamma)/\Gamma]\Gamma\}$ for $j = 1, 2,..., \Gamma$ where j is initial time; Γ is the time interval, $\Gamma = 1,\ldots,\Gamma_{max}$; Γ_{max} is a free parameter, and $int(r)$ is the integer part of the real number r. The "length" of the curve $L_j(\Gamma)$ was computed for each of the k time series or curves X_{Γ}^{j}:

$$L_j(\Gamma) = \frac{1}{\Gamma}\left\{\left[\sum_{t=1}^{int\left(\frac{155-j}{\Gamma}\right)} [x(j + t\Gamma) - x(j + (t - 1)\Gamma]\right]\frac{154}{int\left(\frac{155-j}{\Gamma}\right)}\right\} \tag{6}$$

where $154/int[(155 - j)/\Gamma]$ is a normalization factor[4]. $L_j(\Gamma)$ was averaged for all j forming the mean value of the curve length $L(\Gamma)$ for each $\Gamma = 1,\ldots,\Gamma_{max}$ as:

$$L(\Gamma) = \sum_{j=1}^{\Gamma}\frac{L_j(\Gamma)}{\Gamma} \tag{7}$$

An array of mean values L(Γ) was obtained and the Higuchi fractal dimension (HFD) is estimated as the slope of least squares linear best fit from the plot of ln(L(Γ)) versus ln(1/Γ), or:

$$HDF = \frac{ln[L(\Gamma)]}{ln\left(\frac{1}{\Gamma}\right)} \tag{8}$$

The HFD involves segmenting the original curve into smaller windows, either overlapping or non-overlapping, akin to the Hurst exponent calculation. HFD values are computed for each window, providing insights into the complexity of the curve. Larger fractal dimension values indicate increased complexity and persistence in the data. The graph depicts the fractal dimension (log_L) against the value of (log_k), illustrating that as the scale of observation increases, self-similarity decreases, implying less complexity at larger scales.

4 The number 154 in the equation is due to the fact that in the original formula there is N-1.

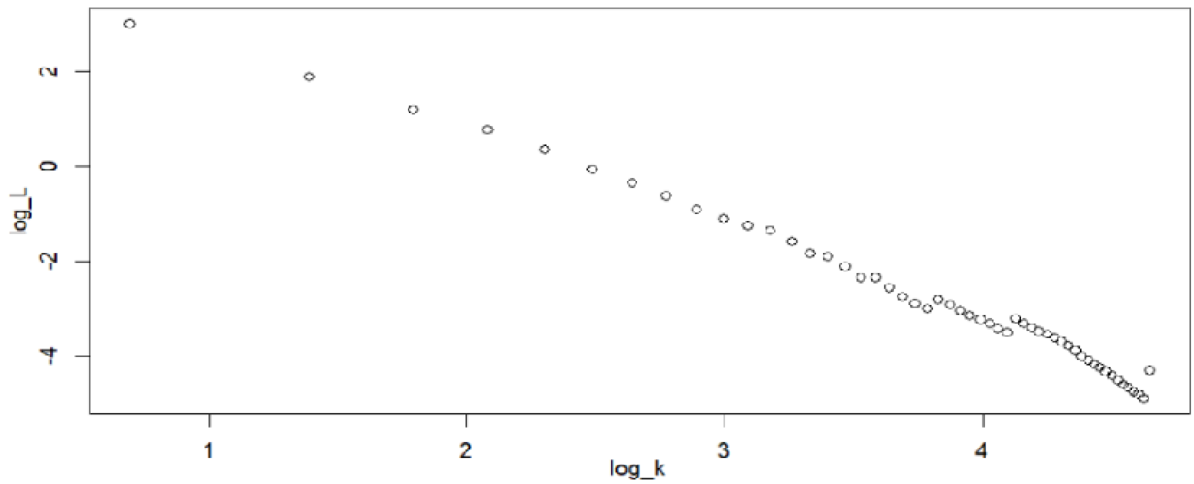

Figure 4: HDF for inflation

Higuchi's fractal dimension results indicate that as the value of Γ (representing the scale of observation) increases, the fractal dimension tends to decrease. Different Higuchi fractal dimension estimation are proposed in the following table:

Γ	HDF
4	1.615285
8	1.633268
12	1.68734
24	1.803678
36	1.894617

Table 3: HDF at different Γ

The time series exhibits overall persistence, and German inflation does not behave inertially but persistently. This means that inflation values are autocorrelated over the long term, and shocks dissipate slowly. Accumulated shocks, such as those related to exchange rates and reparations between September 1921 and July 1922, contribute to this persistence. Causality will be addressed later. The presence of lower complexity and non periodic patterns in the time series remains an open question. Aggregate measures as HE and HDF do not provide a conclusive answer.

On another hand, spectral analysis and Fourier transformation encounter difficulties in handling non-stationary data. The autocorrelation function, as depicted in Figure 4a, suggests a time series with memory rather than a purely inertial inflation, aligning with the 'long memory' process described by Reisen et al (2003), where shocks have prolonged impacts.

To address periodicity and identify persistent elements, wavelet decomposition is employed, drawing on methods presented by Ysusi (2011) and Chen and Cheng (2018). Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT) are utilized, with CWT providing insights into the time series' periodicity and DWT assisting in decomposing patterns into short, medium, and long-run components. The scalogram and windowed scale index from CWT are particularly valuable in detecting periodicity. This approach allows for a more nuanced understanding of the time series, revealing heterogeneous characteristics across frequencies and periods. Similar methods have been employed in geological time series analysis by Chen and Cheng (2018) to identify strong persistent long-run cycles.

Wavelets, as wavelike functions, play a crucial role in this analysis. Unlike Fourier transforms, which use harmonic basis functions, wavelet transforms employ time-localized basis functions, providing a representation with both time and frequency domain components. This approach aims to overcome limitations in classical models of inflation persistence and uncover persistent elements and periodicity in the Weimar inflation time series.

The wavelet function $\psi_{u,s}(t)$ is defined as:

$$\psi_{u,s}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right) \quad (9)$$

The u parameter specifies the location of the wavelets, s is the scale or dilation factor that controls the breadth of the wavelet and t is the location in time. where s is a scaling and τ is a translation parameter controlling its location. The scale parameter indicates how stretched or dilated the wavelet is while retaining the same wavelike shape. Larger values of s increase the width of the wavelet, and therefore more of the observed time series is considered, but granularity of the observation is reduced meaning a higher-level view of the time series is taken. Low scales will allow for analysis of (higher frequency) short-term dynamics of the time series under consideration, whereas high scales will allow for analysis of (lower frequency) long-term dynamics. If the wavelet and time series follow a similar pattern at a specific temporal location and scale, then a large transform value is generated. If the wavelet function is applied in a continuous fashion this is referred to as continuous wavelet transform. The continuous wavelet transform (CWT, Figure 5, panel a) of a time series x(t) is a function of two variables, $W_x(\tau, s)$ is defined as

$$W_x(\tau, s) = \int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{s}}\psi^*\left(\frac{t-\tau}{s}\right) dt \quad (10)$$

where ψ^* is the complex conjugate of ψ. The Morlet wavelet has been used here. It is made up of a normalization factor, complex sinusoid. and Gaussian bell curve. It is essentially a sine wave multiplied point by point by a Gaussian. All wavelet functions used in the transformation are derived from the mother wavelet through translation (shifting) and scaling (dilation or compression), modifying s and τ in ψ (Chinarro et al, 2015). The use of a Morlet Wavelet with Gaussian envelope in the presence of an explosive process such as bubbles is confirmed by Fruehwirt et al(2021). The Morlet wavelet is defined as follows:

$$\psi^M(t) = \frac{1}{\pi^{\frac{1}{4}}}e^{i\omega_0 t}e^{\frac{-T^2}{2}} \quad (11)$$

where T is dimensionless time, and ω_0 is the dimensionless frequency. Morlet is one of the most used for numerical purposes because it can be treated as an analytic wavelet and sine peak frequency, the energy frequency, and the central instantaneous frequency of the Morlet wavelet are all equal facilitating the conversion from scales to frequencies. The CWT of equation (10) allows us to obtain the frequency components (or details) of x(t) corresponding to scale s and time location u, thus providing a time-frequency decomposition of the same time series. The scalogram (S) of x(t) at a given scale s > 0 is given by.

$$S(s) := \int_{-\infty}^{\infty} \left| Wx(t,\ u, s)^2 du \right|^{\frac{1}{2}} \tag{12}$$

The wavelet power spectrum, or scalogram, serves as a function capturing the energy of the CWT applied x(t) at a specific scale. However, when applying CWT to a finite time series, boundary effects arise, impacting the accuracy of transform values at the series' beginning and end. These effects intensify with scale, leading to the cone of influence, an area prone to unreliable results. The scalogram's definition, inspired by Bolos et al (2020), aids in identifying the most significant scales contributing to the time series' total energy. The windowed scalogram (WS, Figure 5, panel b) can be defined, reprising equation 12, for a specific time interval as follows:

$$WS(t, s) = \int_{t-R}^{t+R} \left| Wx(t,\ u, s)^2 du \right|^{\frac{1}{2}} \tag{13}$$

where R is the time radius. Normalized WS is, in short, a finite time interval restricted version of the scalogram of the CWT of a time series. Equation 13 calculates windowed scalograms of a signal for specified scales using time windows centered at time t with a time radius R. The radius should balance obtaining information on non-stationary time series events without sacrificing accuracy. In our case, following Bolos et al (2020) for the methodology, $R = (b - a)/20$, where a and b are the first and last observations respectively so $R \equiv 8$. The normalized windowed scalogram reveals the energy distribution of all scales, representing frequency components for each time window. Another tool, the scale index, measures non-periodicity, quantifying the chaos in a time series through its wavelet scalogram within a finite interval $[s0,\ s1]$. The most representative scale, s_{max}, corresponds to the maximum value of the scalogram WS:
If the scalogram S(s) never becomes too small compared to $S(s_{max})$ for $S > s_{max}$, then the signal is "numerically non-periodic" in $[s_0,\ s_1]$ .The scale index of a time series x in the scale interval $[s_0,\ s_1]$ is given by the quotient

$$i_{scale} = \frac{S(s_{min})}{S(s_{max})} \tag{14}$$

However, this tool lacks consideration of time location, limiting its effectiveness. As it provides a global or average estimate of signal chaos, it may not capture diverse degrees of non-periodicity in non-stationary series we apply the windowed scale index (wi, Figure 5 panel c), that preserves time location. This tool maintains scale index properties, measuring non-periodicity for a time series centered at a specific point within a given time radius. The windowed scale index for a time series f in the scale interval $[s0,\ s1]$ centered at time t combines the tools proposed in equations 13 and 14:

$$wi_{t,s} = \frac{WS(t,s_{min})}{WS(t,s_{max})} \tag{15}$$

Figure 5 provides insights from wi.

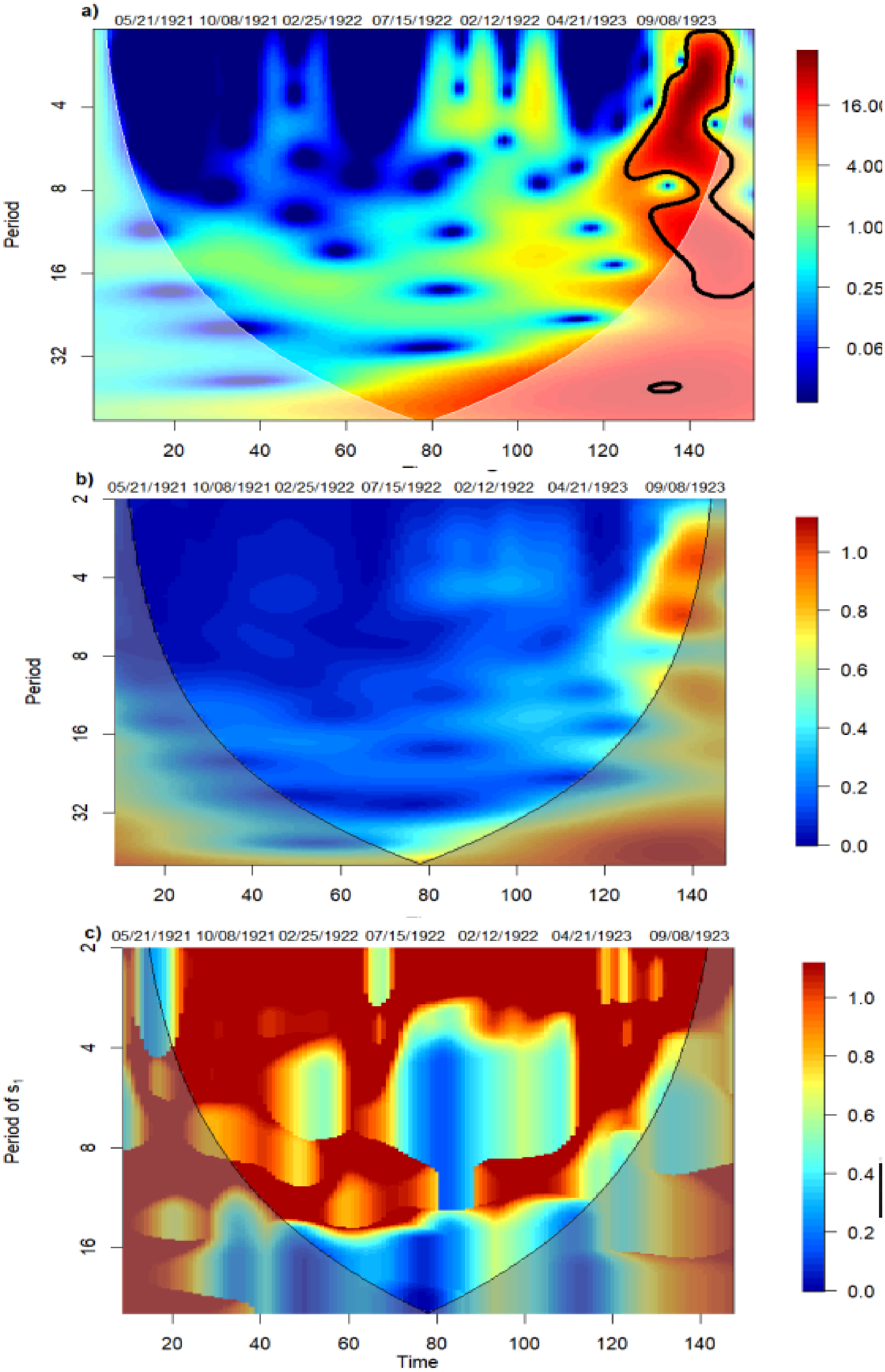

Figure 5: wavelet power spectrum (panel a). windowed scalogram(b) and windowed scale index (c)of the inflation time series[5]

[5] Black area is p.value at 95%, the opaque area is the cone of influence.

Panel a) reveals a significant area signifying the onset of the second phase of hyperinflation in late 1923. The graph exhibits reduced periodicity associated with increased power, indicating a lack of periodic behavior in the time series. Short-term fluctuations during the hyperinflation's initiation in July 1922 and the subsequent inflation slowdown in early 1923 are evident. However, standard wavelet spectrum statistical significance tests are questioned, and despite employing various methods, periodicity in the time series is not found. Panel b) illustrates the windowed scalogram, confirming non-periodicity and aligning with panel a), although with limitations on power scale. Panel c) introduces the windowed scale index, depicting high entropy, especially from August 1921 to July 1922 and from late April 1923 to year-end. Notably, during hyperinflation (July 1922 to April 1923), uncertainty is primarily a short-term phenomenon, contrasting with the later stabilization attempts. The abandonment of stabilization plans in May 1923 led to increased non-periodicity and entropy, gradually decreasing afterward, reflecting the failed stabilization's pattern.
In summary, wavelet tools reveal that German inflation lacks a periodic behavior and exhibits a high degree of entropy, suggesting unpredictability throughout the considered period (exceptions made for some scale and time period).
We will employ other wavelet tools in order to check for the presence of periodic cycles and/or seasonality in time series (it will be moreover useful in Section 4). The first is a pyramid algorithm useful to decompose time series into different levels and successively translating and convolving the mother wavelet using low-pass and high-pass filters. That is the multiresolution analysis (MRA, Percival and Walden, 2000) following the equation:

$$x(t) = \sum_{J=1}^{J} (D_j + S_j) \tag{16}$$

where the time series is expressed as the sum of constant vector S_j and D_j each of which contains a time series related to variation in x(t) at a certain scale where D is the detailed decomposition (useful for cyclicity or seasonality) and S is the smooth decomposition for long run periods (to approximate the trend of the time series).
Another wavelet tool was earlier mentioned and is the DWT (Rhif et al, 2019 provide a clear description of this wavelet). The DWT is a discrete set of the wavelet scales and translations. DWT decomposes the signal into a mutually orthogonal set of wavelets. This specificity represents the main difference between DWT and CWT. In fact, the DWT employs a dyadic grid, where the mother wavelet is scaled by power two $a = 2^j$) and translated by an integer ($b = k2^j$), where k is a location index running from 1 to 2 −jN (N is the number of observations) and j runs from 0 to J (J is the total number of scales). DWT is expressed by the next equation:

$$\psi_{j,k,t}{}^{d} = 2^{-\frac{j}{2}} \psi(2^{-j} t - k) \tag{17}$$

while the DWT wavelet coefficients are obtained from the following expression:

$$W_{k,j} = W(2^j, k2^j) = 2^{-\frac{j}{3}} \int_{-\infty}^{\infty} x(t)\psi(2^{-j} t - k)) \tag{18}$$

while the scaling coefficients

$$W_{k,j} = W(2^j,\ k2^j) = 2^{-\frac{j}{3}} \int_{-\infty}^{\infty} x(t)\varphi(2^{-j}t - k)) \tag{19}$$

The DWT (Alarcon-Aquino and Barria, 2009) supports different mother wavelets, such as the simplest Harr model or the Daubechies orthogonal wavelets family based on the number (1<N<20) refers to the wavelets and scaling parameter used for decomposing the signal. Our time series cannot be decomposed with DWT since this wavelet supports only dyadic (power of 2) time series. To overcome this problem, we will employ the Maximal overlapping DWT (or MODWT) that is, as DWT, a subsampling of the CWT at a dyadic scale but, respect to DWT, MODWT can deal with every length of a time series and not only with the multiple of 2^j (Percival and Walden, 2000, p.16). Moreover, MODWT allows for a more flexible time–frequency representation of a signal using variable-length windows (Rhif et al, 2022). The redundancy (contrary to orthonormality of the DWT) of the MODWT facilitates alignment of the decomposed wavelet and scaling coefficients at each level with the original time series, thus enabling a ready comparison between the series and its decomposition. derived using the MODWT (Cornish et al,,2006). Decomposing a time series using the MODWT to J levels theoretically involves the application of J pairs of filters. The J th level equivalent filter coefficients have a width width $(2^J - 1)(L - 1) + 1$, where L is the width of the J= 1 base filter. The filtering operation at the j th level consists of applying a wavelet (high-pass) filter $\hat{h}_{j,t}$ to yield a set of wavelet coefficients

$$\hat{W}_{J,t} = \sum_{t=0}^{(2^J-1)(L-1)} \hat{h}_{j,t} x_{t-J-1} \tag{47}$$

while the scaling coefficients where $\hat{g}_{j,t}$ is the scaling (low-pass) filter

$$\hat{y}_{J,t} = \sum_{t=0}^{(2^J-1)(L-1)} \hat{g}_{j,t} x_{t-J-1} \tag{48}$$

The study employs multiresolution analysis (MRA-MODWT), following methodologies used by Ysusi (2011), Stachura (2014), and Habimana (2019), with J=5 to capture long time horizons over the 32 weeks, almost equivalent to a year. For robustness checks, two additional wavelet filters, Daubechies 4 and Haar, are used in addition to the least asymmetric (LA(8)) wavelet. The analysis aims to identify persistent patterns and trends in inflation by decomposing the series.

The results reveal that the persistent pattern for inflation is not evident in both short-term cyclicity/noise (D1) and seasonality (D3). The cyclical component of inflation in D1 appears dependent on the phase of inflation, with clearer patterns observed between October-December 1921 and July-February 1922. However, in the later phase (May-December 1923), the amplitude of cycles complicates the identification of a persistent pattern. Similarly, for detail D4 (seasonality), a recognizable pattern is present until July 1922, after which the explosion of hyperinflation disrupts predictability.

Comparing D1 and D4 helps understand the identifiable phases of Weimarer hyperinflation in the short and medium run decomposition of the time series. The long-term trend, identified with S5 (higher than 32 weeks), reveals fluctuations. Initially declining until May 1921, the trend experienced growth with a decrease from the end of January to the end of June 1922.

The exchange rate crises in June 1922 mark a return to positive growth. Another decrease occurs between the end of 1922 and the beginning of June 1923, followed by a new phase of hyperinflation. Haar and D4 filters show a decrease in trend at the end of October 1923, corresponding to the stabilization of November 1923.

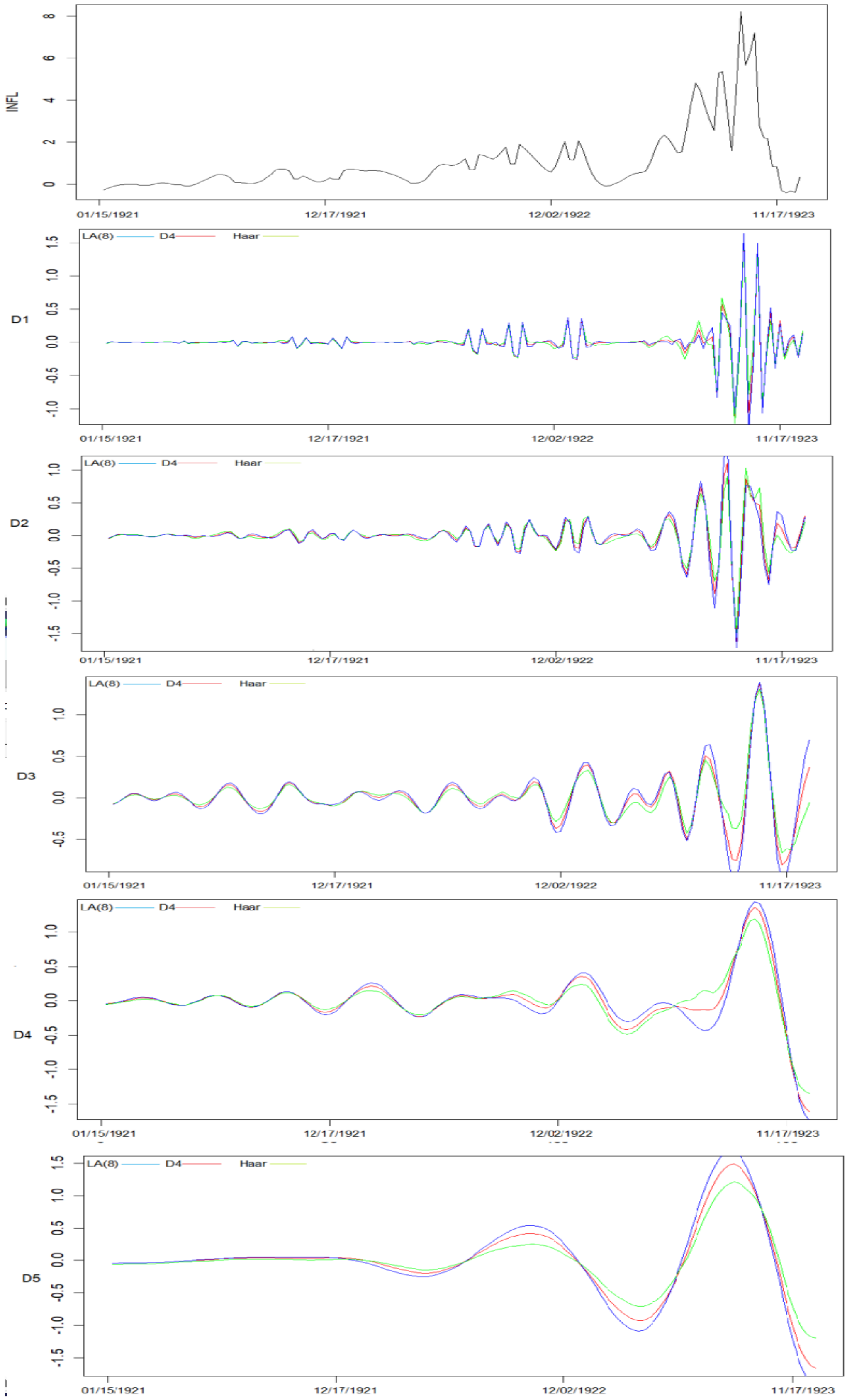

Figure 6: MRA-MODWT for inflation time series

In conclusion, various wavelet tools are employed to overcome challenges in classical statistical tests for hyperinflation data. These tools identify the characteristics of the time series, emphasizing the absence of a clear random walk behavior or persistent patterns in cyclicity, seasonality, and periodicity during the Weimar hyperinflation. Caution is advised in drawing conclusions, as the interpolation of the series may introduce repeated patterns not attributed to the decomposition but to the interpolation itself, necessitating further studies.

1.4 Multivariate analysis and causality

For this last empirical part, I want to address the research question about "*what causes inflation and its own persistence?*" and try to give a final answer to one of the questions proposed in Section 1 about the multichannel nature of German inflation.

A notable gap exists in the collection of weekly or higher-frequency data regarding hyperinflationary data and monetary aggregates don't make an exception. While *Wirtschaft und Statistik* covered prices and wages comprehensively, a similar approach to financial and monetary situations was not consistently present, representing a limitation in understanding monetary dynamics during this critical period.

In terms of data availability for the hyperinflation period from 1919 to 1923, there are challenges due to variations in data collection frequency across different categories. With the onset of hyperinflation after July 1922, the urgency of collecting data increased significantly for both social classes and authorities. *Wirtschaft und Statistik*, the primary publication for statistical data, transitioned from monthly to weekly frequency in 1923 to address this demand. However, despite the increased frequency, some limitations persist.

For our analysis, we prioritize the *Lebenskostenindex* as the most reliable indicator of the cost of living, considering its high frequency and coverage across a large sample of cities. The dataset includes Teuerungszahlen from various issues of *Wirtschaft und Statistik* between February 1921 and April 1924, covering 48 to 68 cities. To ensure homogeneity in the sample, we calculate a weighted index based on city populations.

In contrast, monetary aggregates lack sufficient high-frequency data. We resort to an approximation proposed by Holtfrerich(1986), based on interpolated weekly data between January 1921 and December 1923. Nominal exchange rates, crucial for our analysis, are sourced from *Zahlen zur Geldentwertung*, with monthly data interpolated to weekly using cubic spline.

Wage data, critical for understanding compensatory adjustments during hyperinflation, are sourced from Wirtschaft und Statistik, focusing on two categories: civil servants without executive functions (*Reichsarbeiter Klass C*) and industrial workers (*Metallarbeiter*). These wages, considering skilled (*gelernt*) and low-skilled (*ungelernt*) married workers, undergo logarithmic transformation and first differencing for analysis.

Despite these efforts, the scarcity of high-frequency data poses challenges. The analysis aims to unravel the impact of wage adjustments, labor rights, and distributive conflict within the historical context, incorporating these aspects into a theoretical model that combines inertial inflation and cost-push factors, addressing concerns related to stabilization.

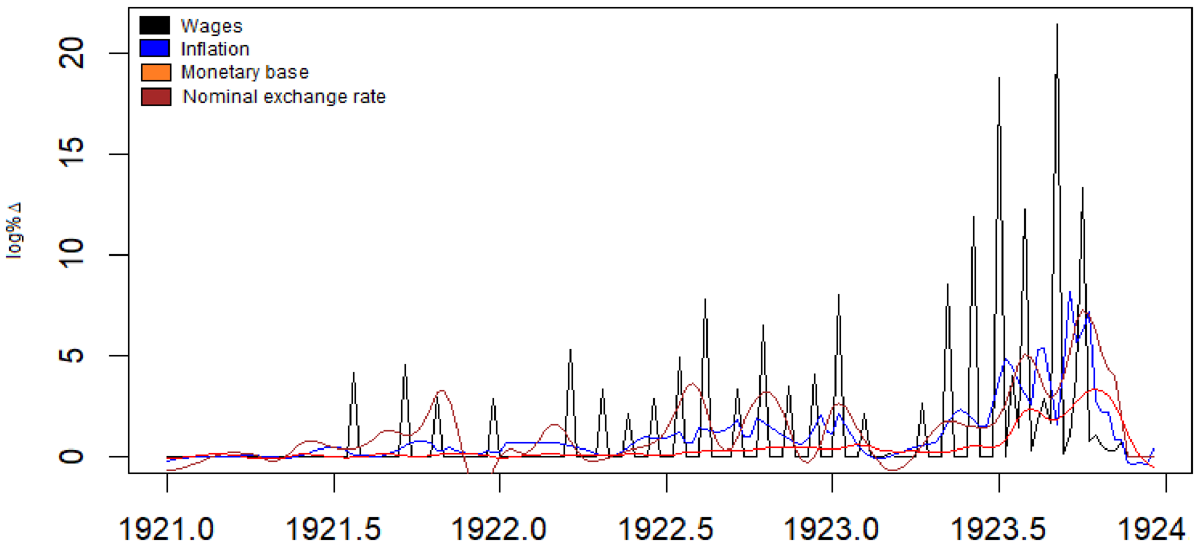

Figure 7: model variables during Weimar hyperinflation (1/15/1921-12/29/1923)

In addressing the model's variable selection, despite the fiscal deficit and expectations are generally considered as key contributors to the hyperinflation, their inclusion is hindered by data unavailability or inconsistencies. Using floating debt (*Schwebende Schulde*) as a proxy for the fiscal deficit encounters challenges due to uncertainties in its actual value during the reference months. Discrepancies in historical data sources introduce risks of overestimation or underestimation, particularly given the lack of precise initial values. An attempt was made to use data from van der Borght (1920), who estimated the *Schwebende Schulde* at slightly over 78 billion Goldmarks in July 1919. However, when we reference data from the week of November 7, 1923, a debt value of 71 trillion is reported. This represents approximately 3% of the value reported in the 1923 document. Such discrepancies introduce a risk of both overestimating and underestimating the deficit. The complex nature of historical fiscal data, as highlighted by Jessen (1923) and Bresciani Turroni(1937) and the lack of comprehensive tax information introduces more difficulties in estimation. Consequently, the study opts for variables involving less speculation to ensure robustness in the analysis.
Similarly to the expectations since the lack of data beyond August 1923 (Einzig, 1937; Braggion et al., 2023). Despite recent efforts revealing inflation expectations based on exchange rates (Seghezza and Morelli, 2020), the data became biased post-August 1923 due to stabilization influences. While alternative data sources exist, including weekly data, the constraints and limitations, such as data availability and potential biases, guide the choice of variables. In this context, the study employs wavelets, an effective tool for analyzing non-stationary time series, to explore relationships between nominal variables. Despite the scarcity of wavelet applications in hyperinflation contexts, the methodology has proven valuable in analyzing explosive phenomena, speculative bubbles, cryptocurrencies, and non-stationary economic time series (Tiwari et al., 2019, Fratianni et al., 2021; Oddo and Bosnjak, 2021, Wang, 2023). The concepts of cross wavelet and wavelet coherence are introduced to extend the univariate power spectrum to compare multiple time series,

providing a robust framework for analyzing complex relationships among variables, thereby enhancing our understanding of hyperinflation dynamics.
We can define the wavelet cross spectrum WCS(t,s) as the expectation value of the product of the corresponding $W_x(t, s)$and $W_y(t, s)$(Maraun and Kurths, 2004)

$$WCS_{xy}(t, s) = W_x(t, s) + \overline{W_y(t, s)} \tag{16}$$

where the overscript $\overline{}$ is the complex conjugate continuous wavelet transform of the observed time series y(t,s). Since WCS(t,s) is complex valued it can be decomposed into amplitude (that show the intensities of the frequency of the time series) and the phase (Φ_{xy}):

$$WCS_{xy}(t, s) = |WCS_{xy}(s)| e^{i\Phi_{xy}(t,s)} \tag{17}$$

where

$$\Phi_{xy}(t, s) = tan^{-1}\left(\frac{\Im[S(s^{-1}W_{xy}(t,s)]}{\Re[S(s^{-1}W_{xy}(t,s)]}\right) \tag{18}$$

is the phase difference and describes the delay between the two signals at time t on a scale s and S is a smoothing operator[6]. Wavelet coherence (WC) is introduced. WC is defined as a value in the interval [0,1] by the following equation:

$$WC_{xv}(ts) = \frac{\left|[S(s^{-1}W_{xy}(t,s))]\right|^2}{S\left((s^{-1}\left|W_x(t,s)\right|^2)S(s^{-1}\left|W_y(t,s)\right|^2\right)} \tag{19}$$

The phase differences defined in equation (3) are really useful in order to describe the Phase of time series x(t) and y(t), when converted to an angle in the interval [−π, π]. An absolute value less (larger) than π/2 indicates that the two series move in phase (anti-phase, respectively) referring to the instantaneous time as time origin and at the frequency (or period) in question, while the sign of the phase difference shows which series is the leading one in this relationship. A graphical representation of this phase diagram is shown in figure 8:

[6] Done using a weighted running average (or convolution) in both the time and scale directions (Fruehwirt et al, 2021).

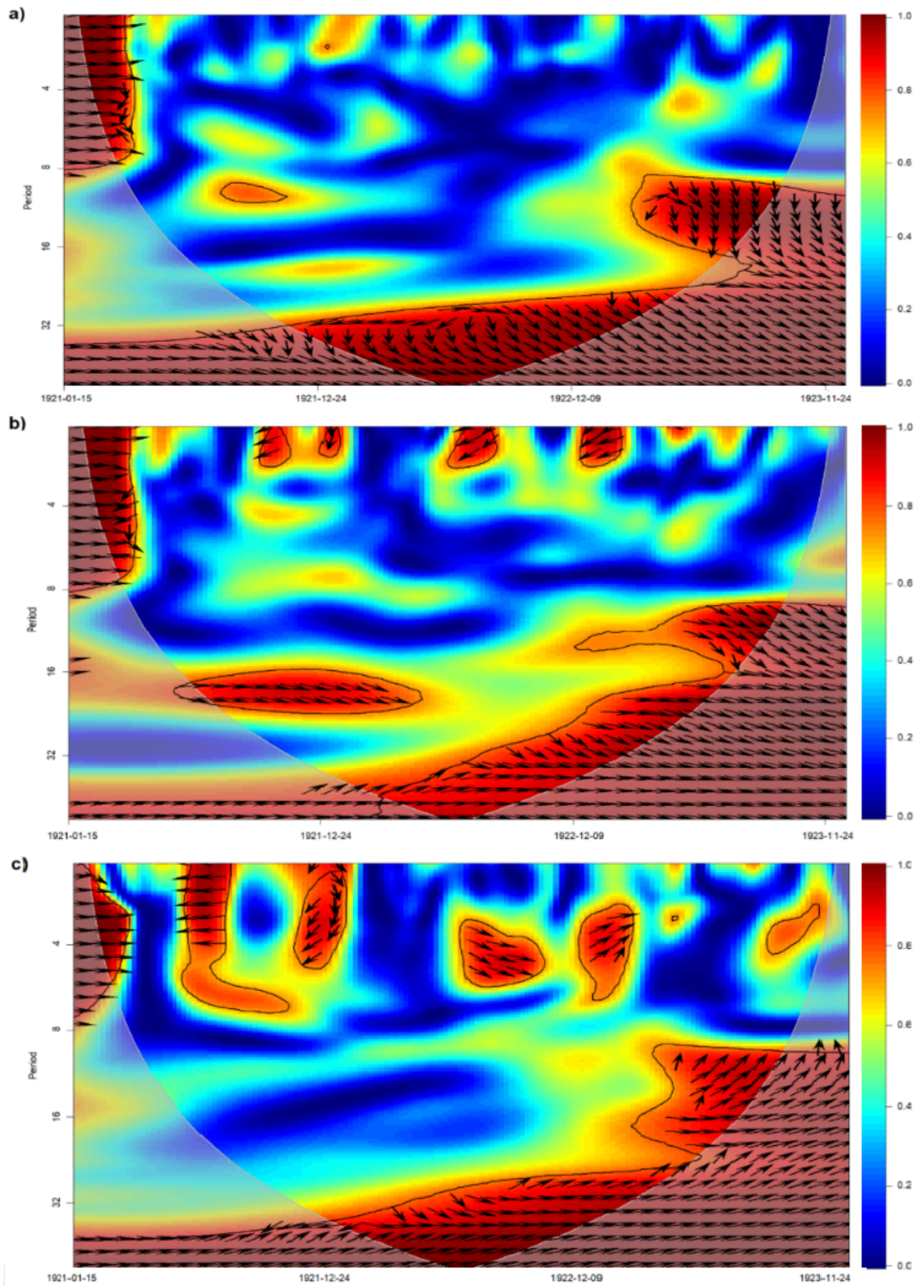

Figure 8: wavelet coherence for money supply (panel a) nominal exchange rate (b) and nominal wages(c) growth rates against inflation[7].

The wavelet coherence analysis unveils dynamic relationships among key variables during the Weimar Republic's hyperinflation, shedding light on causal links and dispelling certain economic hypotheses. The study focuses on the monetary view, employing wavelet coherence to explore the connections between money supply growth (proxied by M1), the nominal exchange rate, and wages, thereby testing the quantity theory of money and assessing causality.

[7] The areas inside the bounded regions are significant while holding the significance level at 95%, while the opaque area is the cone of influence previously described.

In the examination of M1 and inflation (Figure 8, panel A), a predominant long-run link, with inflation often leading, challenges the assertion that hyperinflation hinges solely on money supply growth. The relationship between the monetary base and inflation contradicts cost-push arguments, indicating that the monetary base is primarily driven by inflation, except during the initial failed stabilization in early 1923.

The nominal exchange rate (Figure 8, panel B) exhibits anti-phase relationships with inflation, serving as a leading variable in short-term crises. However, in the long run, the causality between the exchange rate and inflation undergoes a reversal, particularly after the first hyperinflationary phase. The study underscores the nuanced interplay of variables over time, with notable changes in phase relationships during key events such as currency crises.

Wages (Figure 8, panel c) emerge as a dynamic variable, displaying phase changes and driving inflation in both short and medium terms. The complex relationship between wages and inflation challenges a simplistic wage-inflation spiral hypothesis, indicating a more intricate interdependence. The wavelet coherence identifies instances where wages drove inflation, countered by periods of inflation influencing wages, revealing the multifaceted nature of hyperinflationary dynamics.

The causality analysis unveils the temporal evolution of relationships, offering insights into the sequence of events leading to hyperinflation. The exchange rate initially drives inflation, but this causality reverses with the onset of hyperinflation. Wages maintain a consistent driving relationship with inflation, highlighting their role in shaping the hyperinflationary trajectory.

Contrary to expectations-based explanations, the study finds little evidence of significant reactions in relationships during the period of changing expectations. This challenges the notion that shifts in expectations played a decisive role in hyperinflationary dynamics during mid-August 1923.

In summary, the wavelet coherence analysis provides a nuanced understanding of hyperinflation, revealing the intricate dynamics among key variables. The findings challenge conventional economic hypotheses, highlighting the need for a comprehensive and dynamic approach to studying hyperinflation during the Weimar Republic.

The study delves into the complex dynamics of inflation, employing wavelet analysis to scrutinize potential causal relationships among key variables and inflation itself. Recognizing the intricate interplay among these variables, the research aims to unravel the multifaceted nature of German hyperinflation. The wavelet coherence (WC) and multiple wavelet coherence (MWC) methods are employed to explore lead-lag relationships, providing nuanced insights into the temporal dimensions of these intricate dynamics.

The analysis considers nominal levels to ensure consistency with previous research and mitigate potential biases in historical time series, especially regarding real wages and the real exchange rate. The study challenges conventional portrayals of German hyperinflation as predominantly driven by identifiable factors like monetary expansion, fiscal deficits, balance of payments, or expectations. Drawing parallels with instances of "new hyperinflation" in other economies, the research posits that German hyperinflation may result from multiple influential factors, each exerting its influence in a nuanced manner.

The findings reveal variability in the temporal dimensions of relationships among variables. Money supply appears to exert influence primarily in the medium to long term, while the

fiscal deficit demonstrates a noteworthy short-term relationship, particularly during the initial phases of the dataset. The study contributes to a comprehensive understanding of hyperinflation dynamics by shedding light on the multifaceted nature of the phenomenon.
The choice of wavelet coherence is deemed valuable as an alternative to more commonly used time series models like VAR/VECM and ARFIMA. The study acknowledges other successful tools for identifying causality, ranging from classical Granger causality tests to sophisticated methods like convergent cross-mapping, transfer entropy, and Bayesian approaches. To address stationarity concerns, the study employs decomposition methods similar to those used in previous research, allowing the isolation of periodic components of the variables under consideration.

Scales	MB	EX	W
D1	-0,18**	-0,16*	-0,16*
D2	-0,11	0,11	-0,26***
D3	-0,01	0,47***	0,49***
D4	0,69***	0,74***	0,76***
D5	0,6***	0,00	0,00
S5	0,3***	0,4***	0,41***

Table 4: Spearman correlation matrix (with inflation) between MRA-MODWT results

The analysis reveals varying correlations between inflation and other variables at different scales. In the short term, the correlation becomes negative, shifting to positive in the medium to long term for money supply and exchange rates. Wages display a negative correlation in the short to medium term but turn positive in the medium to long term. The relationships between periodic inflation components and other variables are not stable across scales, emphasizing the need to explore causal relationships at different scales and understand the role of these variables in the persistence of German inflation.
The study faces challenges, including non-stationarity and a limited number of observations in the dataset. To conduct a more comprehensive analysis, the research applies both raw and filtered data. The Hodrick-Prescott filter is utilized to extract the non-stationary (persistent) part of inflation, enabling analysis without the constraint of stationarity. While various tools for causal inference exist, the non-stationary nature of the data guides the preference for non-parametric tools. Transfer entropy and EDM models are considered, as employed in prior works, to address the challenges posed by limited samples and non-stationary data.
Shannon Transfer Entropy is introduced as a non-parametric tool for causal inference, quantifying information gained from a specific state of a random variable averaged over all possible states. The tool is selected for its suitability in analyzing relationships among financial and macroeconomic variables. This choice aligns with a growing body of literature

implementing similar approaches to understand complex causal relationships in various domains. We can calculate the average number of bits required to optimally encode independent draws as follows:

$$H_x = -\sum_j p(x) log_2 p(x) \quad (20)$$

Shannon's formula quantifies uncertainty, which increases with the number of bits required to optimally encode a sequence of realizations from the time series x. To assess the information flow between two processes, Shannon entropy is integrated with the concept of the Kullback-Leibler distance (KLD, Kullback and Leibler, 1951), while assuming that the underlying processes evolve over time according to a Markov process (Schreiber, 2000).

The KLD enables the measurement of information transfer between two processes and is employed to gauge the disparity between two probability distributions, assuming that one of them approximates the other. As elucidated by Schreiber (2000), the Kullback entropy denotes the surplus number of bits needed for encoding when a different probability distribution is employed. In the bivariate scenario, the Kullback entropy is recognized as the formula for mutual information. Moreover, considering another discrete random variable Y with probability distribution p(y), the corresponding Kullback entropy (mutual information) of the two random variables X and Y, with their joint probability distribution defined by $p_{XY}(x, y)$ is:

$$M_{XY} = \sum_{x,y} p_{XY}(x, y) log\left(\frac{p_{XY}(x,y)}{p(x)p(y)}\right) \quad (21)$$

and the summation encompasses all possible states y and x that can be assumed by the variables Y and X, respectively. This quantity measures the departure from the independence of the two random variables and can be viewed as the reduction in uncertainty about one variable when the other variable is known. When applying these measures in the context of time series analysis, Schreiber (2000) introduced a dynamical structure by considering transition probabilities.

The relative measure for quantifying information flows is derived under the assumption that the dynamical structure of a discrete random variable I corresponds to a stationary Markov process of order k. This assumption implies that the probability of observing y at time t+1 in state y, conditional on the previous k observations, is governed by the transition probabilities defined by this Markov process conditional on a previous observations, is $p(y_{t+1}|y_t,..., y_{t-a+1}) = p(y_{t+1}|y_t,..., y_{t-a})$. The average number of bits required to encode an additional time series observation when the previous states are known is:

$$h_Y(k) = -\sum_i p(y_{t+1}, y_t^{(k)}) log\ p(y_{t+1}|y_t^{(k)}) \quad (22)$$

where $y_t^{(k)} = (y_t ,..., y_{t-k+1})$ (analogously for process X at Markov order l). In the bivariate case, the information flow from process X to process Y is assessed by quantifying the deviation from the generalized Markov property $p(y_{t+1}|y_t^{(k)}) = p(y_{t+1}|x^{(l)}_t, y_t^{(k)})$. relying on the KLD. The formula for Shannon transfer entropy (TE) is:

$$TE_{X\to Y}(k,l) = \sum_{x,y} p(y_{t+1}, y_t^{(k)}, x_t^{(l)}) log\left(\frac{p(y_{t+1}|y_t^{(k)}, x_t^{(l)})}{p(y_{t+1}|y_t^{(k)})}\right) \quad (23)$$

where $TE_{X\to Y}$ measures the amount of information flow from process X to Y and the information flow from Y to X, can be derived analogously. Nevertheless, in the case of our relatively short sample, a direct application of TE is prone to significant misestimations attributable to finite sample effects. Therefore, we opt for the use of Effective Transfer Entropy (ETE), as introduced by Marschinski and Kantz (2002), a bias correction of the TE that is:

$$ETE_{X\to Y}(k,l) = TE_{X\to Y}(k,l) - T_{X_{shuffeled}\to Y}(k,l) \quad (24)$$

where $T_{X_{shuffled}\to Y}(k,l)$ indicates the transfer entropy using a shuffled version of the time series X. Shuffling implies randomly drawing values from the observed time series X and realigning them to generate a new time series, which destroys the time series dependencies of X as well as the statistical dependencies between X and Y. As a result, $T_{X_{shuffled}\to Y}(k,l)$ converges to zero with increasing sample size and any nonzero value of $T_{X_{shuffled}\to Y}(k,l)$ is due to small sample effects.

To derive a consistent estimator, shuffling is repeated and the average of the resulting shuffled transfer entropy estimates across all replications serves as an estimator for the small sample bias, which is subsequently subtracted from the Shannon to obtain a biased corrected effective transfer entropy estimate. We apply this method on both inflation (INF) and inflation persistence (INFP) time series as the relation with the monetary base (MB), exchange rate(EXC) and wages(W).The MRA-MODWT for all the time series are in Appendix.

	D1	D2	D3	D4	D5
MB→INFP	0.0142 (0,16)	0.0732** (0,007)	0.0378* (0,013)	0.0358* (0,02)	0.0195 (0.0767)
EXC→INFP	0.0099 (0.1633)	0.0612** (0.01)	0.0000 (0.8067)	0.0000 (0.55)	0.0572* (0.010)
W→INFP	0.0709*** (0.00)	0.0485* (0.02)	0.0958*** (0,00)	0.0328* (0.0467)	0.0621 (0.0033)
INFP->MB	0.0579** (0,007)	0.0226 (0,07)	0.0792*** (0,00)	0.0575** (0,007)	0.0483* (0,01)
INFP→EXC	0.0176 (0.12)	0.0498** (0.0067)	0.0428** (0.0067)	0.0568** (0.0067)	0.0606*** (0.00)
INFP→W	0.0662*** (0.00)	0.0832*** (0,000)	0.0802*** (0,00)	0.0139 (0.1433)	0.0000 (0.33)
MB→INF	0.0271 (0,08)	0.0727*** (0,00)	0.1154*** (0,00)	0.0326* (0,0167)	0.0078 (0,20)
EXC→INF	0.0400* (0,037)	0.0557** (0,006)	0 (0,62)	0 (0,233)	0.0114 (0,143)
W→INF	0.0711** (0,007)	0.0449* (0,023)	0.1593*** (0,00)	0.0849*** (0,00)	0.1452*** (0,00)
INF->MB	0.0559*** (0,007)	0.0180 (0,137)	0,1639*** (0,00)	0.0900*** (0,00)	0.0433* (0,01)
INF→EXC	0.0242 (0,07)	0.0583*** (0,00)	0.0312 (0,05)	0.0757*** (0,00)	0.1174*** (0,00)
INF→W	0.0665*** (0,00)	0.1*** (0,00)	0.06*** (0,00)	0 (0,837)	0 (0,287)

Table 5: Effective Shannon transfer entropy

Our findings present a nuanced picture of the relationships between variables, with some displaying statistical significance at different time scales, though the magnitude of information transfer is moderate. Regarding the persistence of inflation, money supply and exchange rates exhibit stronger information transfer in the short term, especially in the D2 scale, while wages exert a more substantial influence in the short to medium term (D1-D3). Raw inflation's short-term impact appears weak, similar to the limited influence of the exchange rate across all scales except D2. Notably, money supply and wages demonstrate the greatest transfer of information in D2-D3 and D3-D4-D5, respectively. While this evidence doesn't definitively establish causality, it indicates information transfer, even if not implying direct causation. The nature of these relationships changes across time scales, evident in lead-lag dynamics.

To delve deeper into causal relationships, we employ multiscale convergent cross mapping (MCCM), an approach accommodating our varied scales. MCCM, an enhancement of convergent cross mapping (CCM), discerns causal relationships within dynamical systems. The fundamental concept is that causation is evident when the states of the causal variable can be reconstructed from the time series data of the affected variable. The response process, prevailing over the forcing process, forms the core of CCM. By verifying the accuracy of using the attractor manifold of the affected variable to estimate states of the causal variable, CCM assesses causal interactions. In our case, the application of MCCM aligns with the theoretical frameworks set forth by Liu et al. (2019) and Tsonis et al. (2018), providing a robust methodology to explore causal relationships between variables X and Y.

To ascertain whether X causally influences Y, the core concept of CCM involves verifying the accuracy of using the attractor manifold M_Y, constructed from lagged coordinates of time series Y, to identify nearby points in M_X, which is constructed from the X variable. If this verification holds true, then the Y series can be utilized for estimating X, and vice versa. Consider now the same two time series X and Y of length L=155 (as our effective sample),

$$X = \{X(1),\ X(2),\ X(3),...,X(155)\} \tag{25}$$

By forming the lagged coordinate vectors of X and Y, the shadow attractor manifold M_X and M_Y can be reconstructed as follows

$$\begin{gathered}\overline{X}(t) =< X(1), X(t - \tau). X(t - 2\tau)..., X[t - (E - 1)\tau] > \\ \overline{Y}(t) =< Y(t), Y(t - \tau). Y(t - 2\tau)..., Y[t - (E - 1)\tau] >\end{gathered} \tag{26}$$

where t ranges from 1 + (E-1) to t = 155, E represents the embedding dimension, which defines the size of the time window, and the time lag τ is a positive value. Starting from the first lagged coordinate X(t) and proceeding to the last, X(t − (E − 1)τ), we encounter E-dimensional points. The smallest bounding simplex is constructed from the E + 1 closest neighbors, enabling it to encompass E-dimensional points. Consequently, there is a fundamental numerical constraint on the potential embedding dimension E. If there are n observations, then E must be less than or equal to n-1, as the analysis necessitates n − 1 observations to characterize the historical dynamics and at least one observation to assess the estimated values. The cross-mapped estimation of $Y(t)$ is denoted as $\widehat{Y}(t)|M_X$, which signifies the utilization of M_X to estimate $Y(t)$ for the purpose of detecting the causal relationship YX. Similarly, the cross-mapping from Y to X is defined in a comparable manner. We define $\widehat{Y}(t)|M_X$ as follows

$$\widehat{Y}(t)|M_X = \sum w_i Y(t_i) \tag{27}$$

for $i = 1, 2, E - 1$ where w_i is the weighting calculated by the distance between $\overline{X}$ and its ith neighbor on M_X, and $Y(t_i)$ are the values of Y; the formula for the weighting is as follows:

$$w_i = \frac{u_i}{\Sigma u_j} \tag{28}$$

where $u_i = exp\left(-\frac{d[\bar{X}(t),X(t_i)]}{d[\bar{X}(t),X(t_1)]}\right)$ and $d[\bar{X}(t), X(t)]$ denotes the Euclidean distance between two vectors. A library containing L points from M_X can be utilized to generate estimates for L points in the original time series Y. Subsequently, the Pearson correlation coefficient ($\rho_{Y\hat{Y}t}$), which assesses the capacity of the L cross-mapped estimates derived from X to accurately describe the L true values in Y, can be computed. More specifically, the CCM correlation is computed as follows:

$$\rho_{Y\hat{Y}t} = \rho(Y(t), \hat{Y}(t)|M_X) \tag{29}$$

The Pearson correlation coefficient, which ranges from 0 to 1, serves as an indicator to quantify the strength of influences from Y to X. Therefore, if Y has a causal impact on X, then $\hat{Y}(t)|M_X$ will converge to *Y*(*t*), and$\hat{X}(t)|M_Y$ should converge to *X*(*t*).

The application of Convergent Cross Mapping (CCM) in causal analysis is robust but requires longer time series data for meaningful results. To overcome this constraint, Multispatial CCM introduces extensions, addressing brevity through spatial replication. Clark et al. (2015) proposed this innovative approach, combining CCM with bootstrapping, demonstrating effectiveness with as few as five observations. The method involves iterations, repeating the CCM algorithm for 'n' samples drawn from 'n' spatial replicates (we used 300 iterations), providing accurate estimates of uncertainty surrounding predictive power.

MCCM is applied to unravel causal relationships, yielding valuable approximations. Figures 9a and 9b summarize the findings, with solid lines representing means of predictive power and shaded regions indicating mean values plus or minus one standard deviation. Short-term causal relationships are non-significant, understandable given persistent inflation's medium-to-long-term nature. Robust causal relationships emerge in the medium term (D3), with highly significant connections between all variables and inflation. In D3, the monetary base exhibits the highest correlation (around 0.8), followed by the exchange rate (approximately 0.6) and wages (about 0.4). Inflation significantly affects the monetary base and wages, while the exchange rate has no significant impact.

In D3 with raw inflation, the relationship with the monetary base remains, but wages no longer cause raw inflation. The opposite causal direction indicates wages impact inflation persistence, not its seasonal fluctuations. In the medium to long term (D4), the relationship with the monetary base reverses, with inflation significantly influencing it. The exchange rate maintains consistency with D3, and wages exhibit a significant bivariate relationship with inflation persistence. The monetary base causes raw inflation, and the reverse relationship is observed, applying similarly to other variables at this scale, where the exchange rate has no significant impact.

For the long term (D5), all variables significantly impact and are influenced by inflation persistence, with correlation coefficients close to 1. The monetary base and exchange rate have a more substantial impact than wages, which, in turn, predominantly causes inflation. This pattern holds for both raw and structural inflation. The analysis demonstrates that German inflation is not primarily driven by a single component but exhibits changing information flows across different time periods. This multichannel view aligns with Burdekin and Burkett's (1996) perspective, challenging theories commonly applied to the Weimar context. The memory component in this scenario is not solely driven by inertia and indexation, distinguishing it from cases like Brazil. The study contributes insights to refine interpretations and enhance understanding of German inflation dynamics.

1.5 Conclusions: *primus inter pares* or multichannel?

Weimar inflation is an extremely complex phenomenon whose causes, implications and consequences are still being debated today[8]. Over the last century, numerous attempts have been made to include it within theoretical frameworks useful also for giving policy directions. In spite of this, economists and historians seem to have found the fiscal or money view to be the most generally agreed upon conclusion, and it is still considered to be the example of orthodox inflation and stabilization.

This view, in some respects is, to paraphrase an expression by Robbins "the foster-child of the lack of data," since, as shown by Mladenović and Petrović (2010) analyses on hyperinflationary data can lead to errors and misunderstandings of the phenomenon.

This study challenges the notion of inflation having a singular primary cause and posits that it is a complex outcome influenced by multiple factors operating at different scales. To investigate this, a weekly dataset spanning from 15th January 1921, to 29th December 1923, was constructed, extending beyond the typical analysis period to include the initial post-stabilization weeks.

The dataset predominantly relies on nominal variables due to the absence of real production data at the required temporal frequency. Although real variables were occasionally used, the challenge of exclusively relying on nominal variables limited the application of conventional time series analysis tools which require stationarity. To overcome this limitation, wavelet tools were employed for spectral and correlation analysis, decomposition, and the examination of predictability.

Empirical findings indicated that German inflation exhibited long memory persistence, with wavelet estimates revealing limited predictability, particularly in the long term. Recurring behaviors at different scales were identified before transitions to new patterns, providing insights into the dynamic nature of inflationary phases.

Causal analysis aimed to uncover the relationships between nominal variables and the non-stationary component of inflation over different time scales. Wavelet coherence, exploring lead-lag relationships, suggested potential wage-price spirals. The study attempted to align German inflation with the framework used to study inertial inflation, commonly applied to hyperinflations in Latin American countries. However, the findings indicated that Germany did not experience purely inertial inflation, but rather persistent inflation. To explain the underlying causes of persistence, wavelet coherence and causality tests, including transfer

[8] About the consequences of the rise of the Nazi regime, see Galofré-Vilà(2023).

entropy and multispatial convergent cross-mapping, were applied. These tests revealed a multichannel view of German inflation, where all variables had an impact, and the significance of relationships varied based on the time horizon identified through MRA-MODWT.

I have attempted to provide some explanations using applied models as evidence that further methods and studies are needed to investigate hyperinflation episodes and in order to give a sort of “theoretical” explanation. However, I am aware of the limitations (highlighted in the course of the chapter) and how additional analyses are necessary to overcome these constraints.

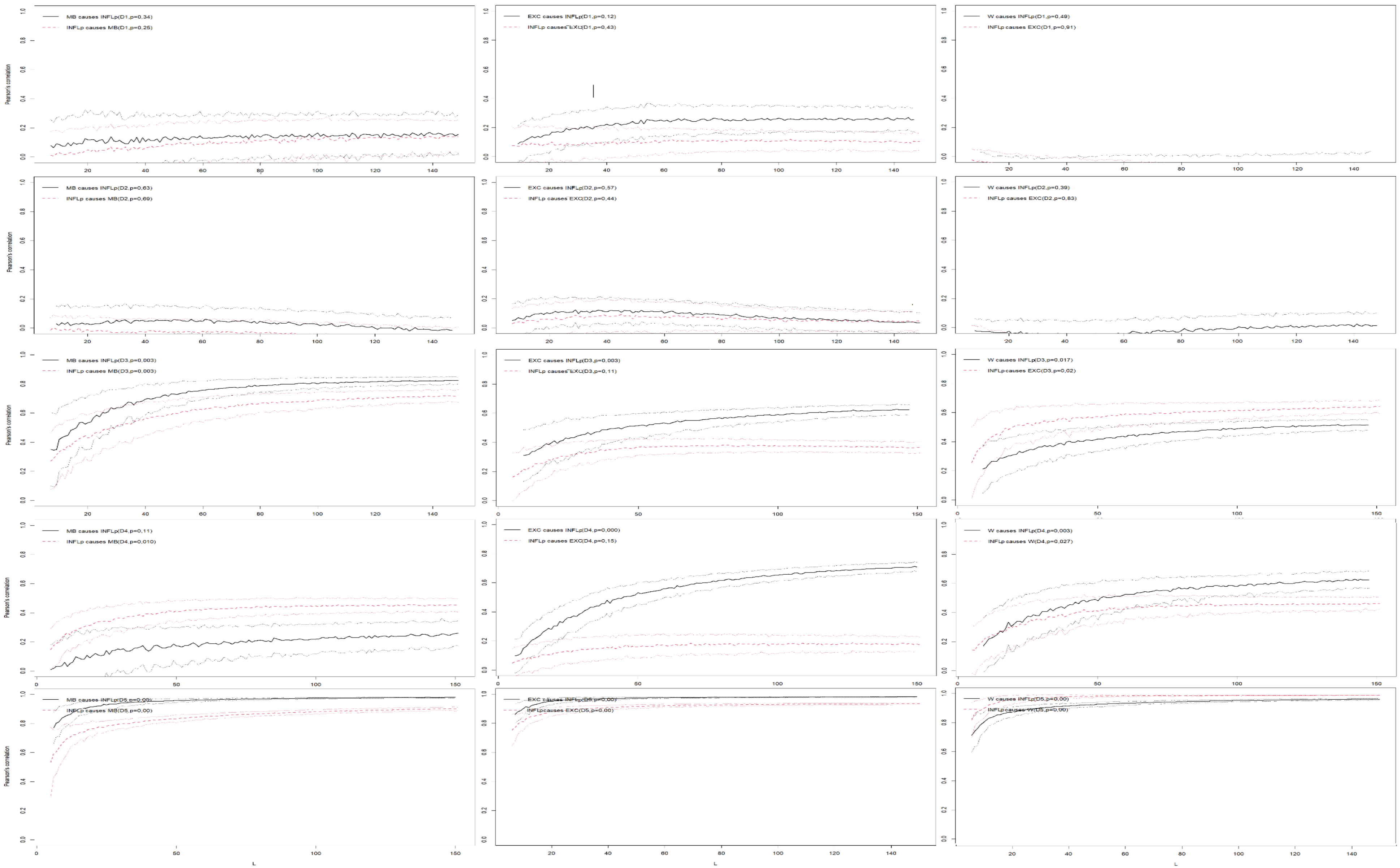

Figure 9a: MCCM for inflation persistence

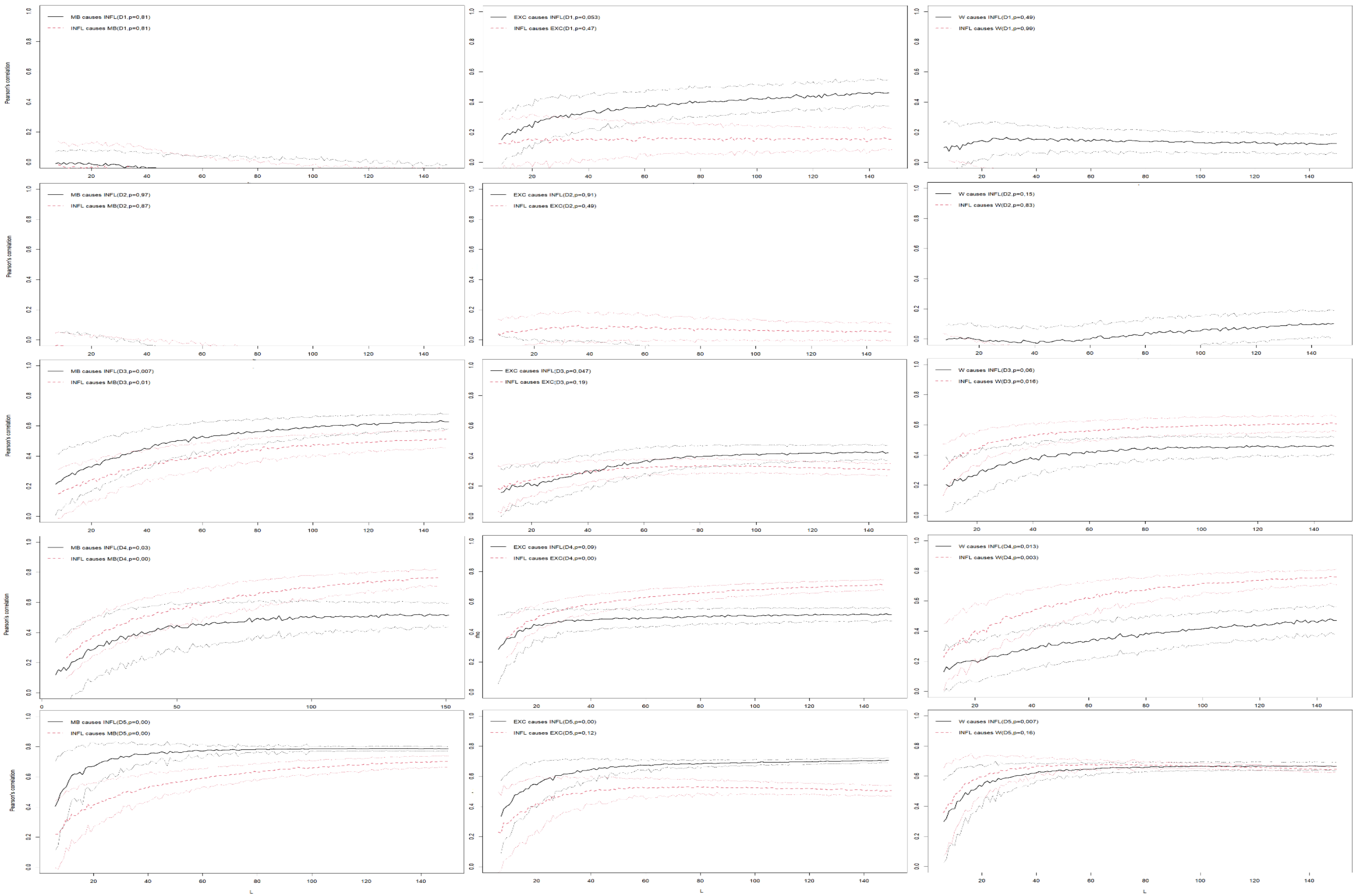

Figure 9b. MCCM for raw inflation

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Appendix

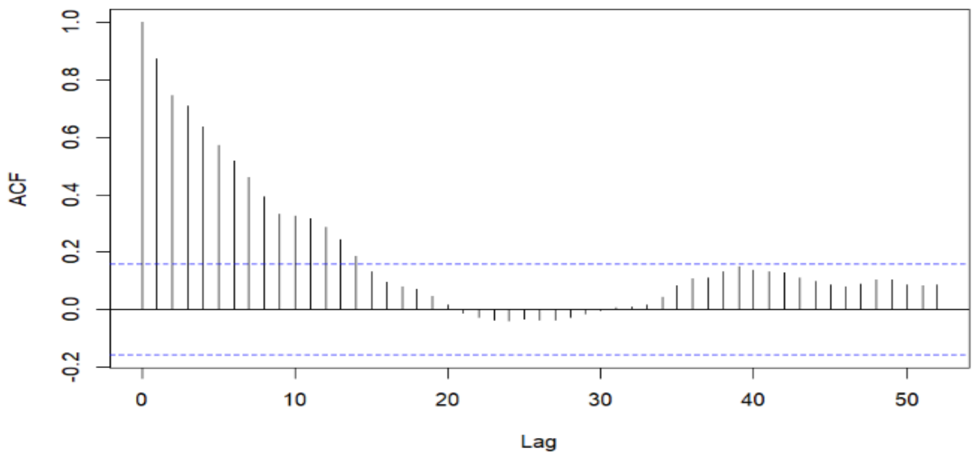

Figure 1a: autocorrelation function of Weimarer hyperinflation (lags in weeks on x-axis)

	ADF	PP	KPSS	Zivot -Andrews
None	-1.710192 (0.032008)	-2.422253*** (0.032197)	/	/
Intercept	-2.310620 (0.042337)	-3.172197*** (0.038948)	0.794410*** (0.117302)	-4.348656*** (7/7/1923)
Trend	/	/	/	-2.915223 (26/11/1921)
Intercept and trend	-2.908854 (0.066584)	-3.872896*** (0.047972)	0.071045*** (0.002139)	-2.947980 (29/10/1921)

Table 1a: Univariate unit root tests for inflation (standard deviation in parenthesis[9])

[9] *,**,*** significant respectively at 10%, 5% and 1%.

	ADF	PP	KPSS	Zivot-Andrews
None	-0.443618 (0.030545)	-1.052282 (0.030334)		
Intercept	-1.724374 (0.048739)	-2.394653 (0.042074)	0.871339*** (0.048301)	-5.889607*** (1/06/1923)
Trend	/	/	/	-4.831406*** (10/28/1922)
Intercept and trend	-2.481173 (0.072950)	-3.357197 (0.051973)	0.101311*** (0.001078)	-6.051179*** (8/12/1922)

Table 1b: unit root tests for subsample 1/15/1921-5/19/1923

Period	Variance ratio (std.errors)
2	1.101485 (0.090536)
4	0.835860 (0.169377)
12	0.414430 (0.339425)
24	0.272671 (0.496114)
36	0.161297 (0.614167)
52	0.111360 (0.742979)

Joint Tests	Value	df	Probability
Max |z| (at period 12)*	1.725182	122	0.4112
Wald (Chi-Square)	11.75363	6	0.0677

Table 1c: variance ratio for sample before breakpoint of 5/26/1923

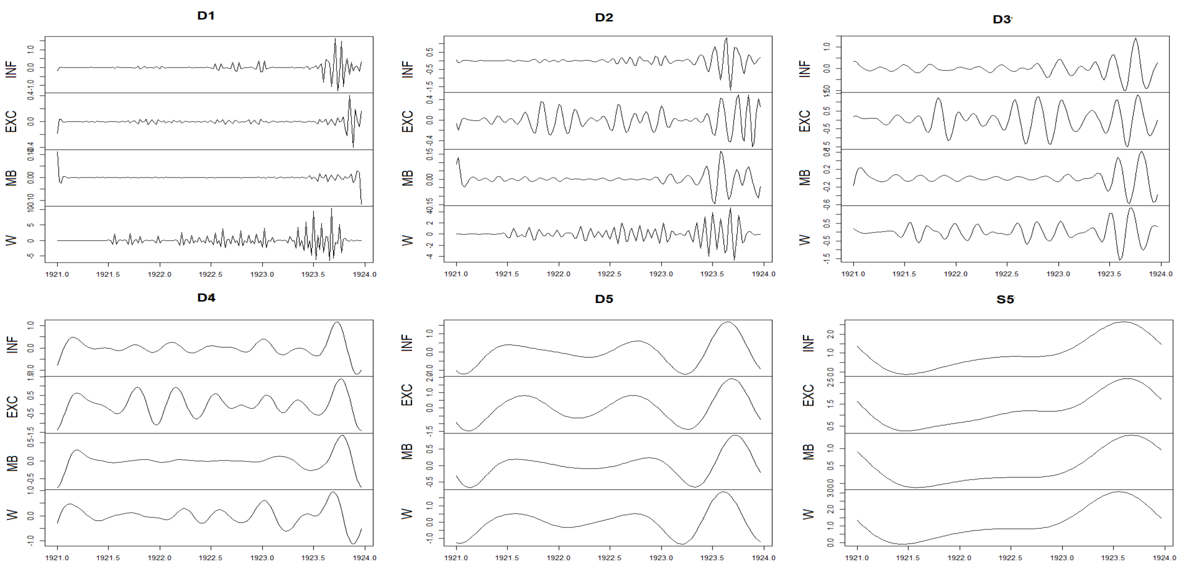

Figure 1b MRA-MODWT for inflation (INF), exchange rate(EXC), money base(MB) and wages(W)

Chapter two:

The EKC around the world: does the income group matter?

Abstract

The Environmental Kuznets Curve (EKC) hypothesis posits an inverted U-shaped relationship between environmental degradation and economic growth. Despite variable findings regarding the impact and nature of this relationship, the EKC remains a valuable tool for empirical studies and policy recommendation. In this study, we test the EKC for 139 countries categorized into low, middle, and high-income groups over the period 1990-2018 using weighted fixed effects and pooled OLS (POLS) regressions. We control for various time-varying pollutant, economic, and demographic variables to mitigate omitted variable bias. Our findings provide support for the EKC hypothesis across all three income groups. We discuss the policy implications, emphasizing the role of market forces that need to be directed towards achieving conditions that enable the overcoming of the EKC income threshold.

Keywords: Environmental Kuznets Curve, fixed effects model, pooled OLS, income groups.
JEL: C10, Q50, C23; Q53

2.1 Introduction

Human economic activity, particularly industrialization, deforestation, and the use of fossil fuels, generates pollution in various forms, including greenhouse gasses, particulate matter, and ground-level ozone. These pollutants not only directly threaten human health but also indirectly contribute to broader environmental and health risks through their role in driving climate change. Moreover, pollution poses significant threats to the health and stability of various ecosystems.

Direct health risks from pollution arise primarily from exposure to fine particulate matter and ground-level ozone. Particulate matter can penetrate deep into the respiratory system, leading to cardiovascular and respiratory problems, while ground-level ozone can cause lung inflammation and respiratory irritation (Ebenstein et al., 2017; Pope et al., 2009). Vulnerable populations, such as children, the elderly, and low-income communities, are often disproportionately affected by these pollutants, exacerbating existing health disparities (Currie and Walker, 2019).

Indirect health risks arise from the broader impacts of pollution-driven climate change. For instance, shifts in weather patterns and increasing extreme weather events can disrupt agricultural productivity, leading to food insecurity and malnutrition, which can further weaken immune systems and increase susceptibility to disease (Schlenker & Roberts, 2009; Deschênes & Greenstone, 2007). Additionally, rising sea levels and extreme weather events can displace populations, creating overcrowded living conditions, poor sanitation, and increased disease transmission. Furthermore, competition for dwindling resources, such as food and water, can contribute to economic instability and social unrest, with potentially far-reaching consequences for global health and security.

Pollution also poses significant threats to ecosystems, disrupting the balance of natural habitats, affecting biodiversity, and impairing ecosystem services that are essential for human survival, such as clean air and water, food supply, and disease regulation. For example, ocean acidification, driven by increased carbon dioxide levels, can harm marine life and disrupt the food web, while deforestation can lead to habitat loss and reduced biodiversity, affecting ecosystem resilience and stability.

On the global level, anthropogenic emissions are widely recognized as the principal contributors to global warming. The rapid increase in concentrations of greenhouse gasses, especially carbon dioxide, methane, and nitrous oxide in the atmosphere since the onset of the Industrial Revolution has led to a significant rise in global average temperatures (Hansen et al., 2007). Numerous scientific studies and assessments, such as those by the Intergovernmental Panel on Climate Change (IPCC), have consistently underscored the dominant role of human activities in recent climate change, indicating that the current warming trend is extremely likely to be the result of human influence (IPCC, 2014). Addressing the consequences and causes of this warming will likely be one of the most formidable challenges of the next century, as countries will try to balance economic growth with protecting the environment (Stern, 2008).

In the context of the environmental challenges described above, the concept of the Environmental Kuznets Curve (EKC) has attracted considerable attention in the literature. The EKC hypothesis suggests that the relationship between economic development and environmental degradation follows an inverted-U shape. According to this hypothesis, environmental degradation initially increases with economic development but eventually decreases as a country's income level surpasses a certain threshold (Grossman & Krueger, 1991; Kuznets, 1955). This non-linear relationship implies that economic growth initially exacerbates environmental problems, but after reaching a certain level of development, further growth could lead to improvements in environmental quality.

The EKC hypothesis is appealing because it suggests the possibility of achieving a dual goal: economic development and environmental preservation. If the EKC holds true, it implies that countries can "kill two birds with one stone" by pursuing policies that promote both economic growth and environmental protection. The idea is that, as countries develop economically, they may experience increased demand for environmental quality, improved environmental regulations, technological advancements, and a shift from pollution-intensive industries to cleaner sectors, all of which can contribute to reducing environmental degradation (Stern, 2004; Dinda, 2004).

The empirical validity of the EKC hypothesis, however, has been a subject of ongoing debate. Table 1a in the Appendix provides a review of the literature. While some studies have found evidence supporting the existence of an inverted-U shaped relationship between economic development and various environmental indicators (Shafik & Bandyopadhyay, 1992; Panayotou, 1993), others have challenged these findings and argued that the relationship may be more complex, exhibiting different shapes or even varying across countries and pollutants (Stern et al., 1996; Carson, 2010). Moreover, it is crucial to note that even if the EKC is valid for some pollutants or environmental problems, it does not necessarily apply to all environmental issues, such as global climate change, where the impacts of pollution may be more long-lasting and difficult to reverse (Dasgupta et al., 2002).

Considering the ongoing challenges posed by pollution, climate change, and ecosystem degradation, and the potential implications of the EKC hypothesis for achieving sustainable economic development, it is essential to further investigate the relationship between economic growth and environmental quality. In this study, we contribute to the existing literature by empirically testing different versions of the EKC using the most up-to-date data. Overall, we find relatively robust support for the EKC hypothesis, but at the same time we stress that market forces alone do not seem capable to address the environmental problem.

The remainder of the paper is organized as follows. Section 2 briefly discusses the EKC theory. Section 3 illustrates data and methods. Section 4 presents the results, Section 5 further discusses them, and Section 6 concludes.

Numerous studies have examined the EKC hypothesis through multi-country models, both at the national and group levels, using various econometric techniques and environmental degradation variables This type of model represents most of the literature on the EKC to date. However, the relevant literature has yielded mixed results (Shahbaz and Sinha(2019)). Some studies have found an inverted U-shaped relationship between economic growth and environmental degradation indicators, while others have not found evidence. Additionally, some have identified a linear or N-shaped relationship between the variables in question. These discrepancies are summarized in Table 1.

It's worth noting that CO2 is widely employed as an environmental indicator in nearly all the studies listed in Table 1. Other studies follow the trends of SO2 and energy consumption and/or coal consumption as proxies for the environmental indicator. Another indicator used to estimate the EKC hypothesis is the Ecological Footprint (EF). Following this point, Acar and Asici (2015), Asici and Acar (2016), Charfeddine and Mrabet (2017) and Farhani et al. (2014) confirm the EKC hypothesis.

Several other studies do not confirm the inverted U-shaped relationship, as in Bagliani et al. (2008), Caviglia-Harris et al. (2009), Hervieux and Darne (2015), and Pablo-Romero and Sanchez-Braza (2017). Relatively to the opposition to the EKC, in the same groups of countries we can find some relevant differences. For example, as evidenced by Narayan and Narayan(2010), if the long-run income elasticity is smaller than the short-run income elasticity that means that a country has reduced its emissions with income growth, and this could allow us also to make distinctions between countries belonging to the same development group.

Also in the most recent literature, we do not have a single result regarding the validity of the EKC. Liu and Lai (2021) support the EKC with factors like population, trade openness, and urbanization. Satrovic et al. (2021) find an inverse U-shaped connection in Gulf Cooperation Council countries. Abid and Sekrafi (2021) validate the EKC in developed countries but not in developing ones. Le (2021) extends the STIRPAT model and identifies an N-shaped relationship with income. Espoir and Sunge (2021) support the EKC in African countries. Agozie et al. (2022) find both inverted U-shaped and N-shaped EKC relationships. Also, Huo et al(2022) confirm an inverted U-shaped relationship between GDP and EF that validates the EKC hypothesis for the MINT sample.

In terms of low, middle and high income countries, the result obtained through different models, the story is the same, we do not have common results. For example, someone proposes the rejection of the U-shaped EKC for low and lower-middle-income country groups but verifies this relationship for upper-middle and high-income country groups, as shown in Al-Mulali et al. (2015). A similar result was proposed by Azam and Khan(2016) where EKC is shown in low middle.income countries while fails to find any support for the validity of an EKC hypothesis for upper middle income and high-income countries. Similarly. Allard et al(2018) have evidenced the presence of the EKC in all income groups, except for the upper-middle-income countries. Differently, Ulucak and Bilgili(2018) find that EKC hypothesis is confirmed by all the income groups countries and similar also in Nasreen, S., & Anwar(2015).Adedoyin et al(2021) fount that EKC is valid for all the three income groups, while Adedoyin et al (2022), on the other hand, found that the hypothesis holds only in the high-income clusters (following the World Bank definition).

Relative to the methodology, pooled OLS (POLS) and fixed effects model are often used in the research about the EKC. Besides the aforementioned Ulucak and Bilgili(2018) , Ciarlantini et al(2023) used POLS to confirm the presence of a tourism-induced EKC hypothesis, however the results did not validate this model for any of these countries. Maneejuk and Yamaka(2020) used, among the others, POLS to show the existence of the EKC hypothesis in the OECD. Recently, Jeetoo et al(2023) in order to find evidence of EKC and pollution haven in Sub-Saharan Africa used spatial econometric models and POLS with individual fixed effects.

As shown by Wang et al(2017) and Zhang et al. (2019) panel fixed effects regression is a good instrument to examine the nexus between income and CO_2 emissions (these two studies are about the sectoral manufacturing environmental impact). Another global panel was used by Usman and Jahanger(2021) panel quantile regression (PQR) and fixed effects approach for tickling the distributional and unobserved country-specific heterogeneity. Similarly, to the above cited Ulucak and Bilgili(2018),we will propose an econometrics model with both POLS-fixed effects.

2.2 Theoretical discussion

The EKC hypothesis takes its name from the contribution of Simon Kuznets, who observed an inverted-U relationship between income levels and income inequality in his 1955 paper "Economic Growth and Income Inequality" (Kuznets, 1955). While Kuznets never discussed environmental issues, decades later his idea was extended to the environmental context, where other researchers began to explore the potential non-linear relationship between economic development and environmental degradation. Indeed, the EKC was popularized by the seminal work of Grossman and Krueger (1991), who found evidence of an inverted-U shaped relationship between economic growth and several measures of air pollution using cross-sectional data. This discovery led to increased attention on the EKC hypothesis and inspired a growing body of empirical and theoretical research.

The theoretical treatment of the model anticipated in section 2 is fundamental for both the policy evaluator and the researcher. Theoretical contributions on the EKC are concentrated in the late 1990s-beginning of 2000s to reach up to the contributions of Dinda (2005), which have become the most used, as demonstrated by the more recent Özcan and Öztürk (2019). As reported by Grabarczyk (2017), theoretical contributions include Andreoni and Levinson (2001), Arrow et al. (1995), Brock and Taylor (2005, 2010), Cropper and Griffiths (1994), Dinda (2004), Jones and Manuelli (2001), Selden and Song (1995) or Stokey (1998). Following Kijima et al (2010), Figueroa and Pasten (2013) and Pasten and Figueroa (2012) we provide a theoretical model of the EKC. We assume that the representative agent preferences are given by the following utility function:

$$U = U(C, P) \tag{1}$$

where $U(\cdot)$ depends on consumption C and on pollution P and is increasing in C and decreasing in P. Moreover is assumed to be strictly concave in both arguments or $U_C = \partial U/\partial C > 0; U_P = \partial U/\partial P < 0; U_{CC} = \partial^2 U/\partial C^2 < 0; U_{PP} = \partial^2 U/\partial P^2 > 0$.

Moreover, the production function $f(\cdot)$ is given by:

$$C = Y = f(K, P) \tag{2}$$

where aggregate consumption C is equal to aggregate income Y, K is a comprehensive definition of capital (both physical and human); and P is the flow of pollution generated and used in the productive process. This model is, hence, compliant with the pollution in the production function model as in Tahvonen and Kuuluvainen (1993). It is assumed that environmental quality Q is a linear function of pollution and e D is the best environmental quality attainable, so $Q = D - P$. The optimal choice of the agent is:

$$h(C,P) = -\frac{U_C(C,P)}{U_P(C,P)} = f_P(K,P) \tag{3}$$

where $f_P = \partial f/\partial P$. The marginal rate of substitution between pollution and consumption $h(C,P)$ is equal to marginal product of pollution $f_P(K,P)$ or, for a given K, $h(C,P)$ represents supply and $f(K,P)$ the demand for pollution. The equilibrium level of pollution is given by the intersection of two curves. The height to pollution supply $h(C,P)$ is the willingness to pay for a marginal reduction in pollution (or the willingness to pay for a marginal improvement in environmental quality). The height to the pollution demand is the marginal product of pollution (the opportunity cost of a marginal improvement in environmental quality).

If the willingness to pay for a better environment grows slower than its opportunity cost as income grows, then equilibrium pollution increases as income grows, otherwise equilibrium pollution decreases. A scheme of the EKC is in the following figure:

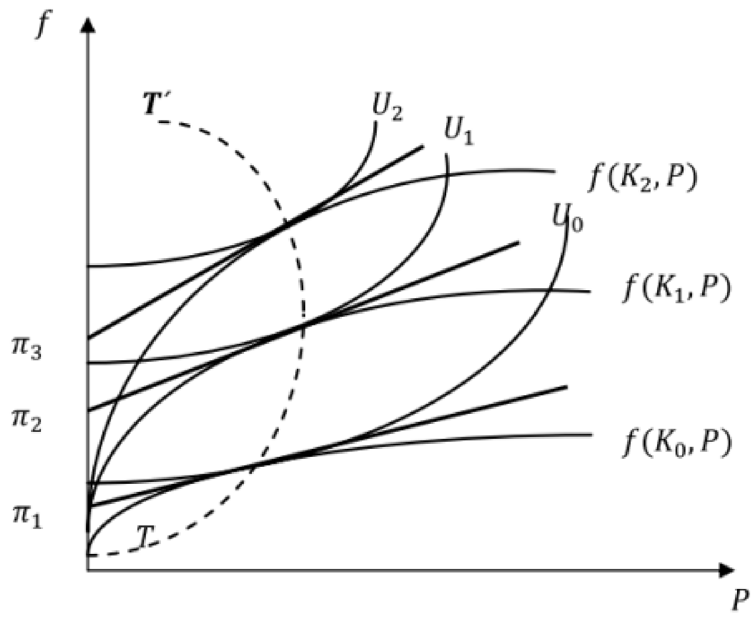

Figure 1:derivation of the EKC[10]

The EKC is determined by the points of tangency of functions U_i and f_i in which their slopes are equal to the relative price π_i between a clean environment and consumer goods. The EKC describes the conditions under which the segmented expansion path TT' is a consequence of economic growth. These prices, if EKC exists, rise with the rise of consumption (and hence, income). If function $h(\cdot)$ is positive and differentiable and preferences exhibit a diminishing marginal rate of substitution between C and Q indifference curves between consumption and pollution are convex and thus the following expression holds:

$$\left.\frac{d^2C}{dP^2}\right|_{U=\bar{U}} = h(C,P)\,h_C(C,P) + h_p(C,P) > 0 \tag{4}$$

[10] Source: Pasten and Figueroa(2012)

The slope for the consumption path can be found by differentiating (2) and (3) with respect to K:

$$\frac{dC}{dK} = \frac{f_{PK} f_P + f_K (h_P - f_{PP})}{f_P h_C + h_P - f_{PP}} \tag{5}$$

The sign of the pollution path:

$$\frac{dP}{dK} = -\frac{f_K h_C - f_{PK}}{f_P h_C + h_P - f_{PP}} \tag{6}$$

is ambiguous and depends by the value of:

$$h_C f_K - f_{PK} \gtreqless 0 \tag{7}$$

where $h_C f_K$ is the marginal effect of economic growth on the willingness to pay for improved environmental quality and f_{PK} is the marginal impact of growth on the opportunity cost of the growth process.

> 0	$= 0$	<0
Pollution is decreasing with economic growth.	Pollution neither increases or decreases with economic growth.	Pollution is increasing with economic growth

Table 1: signs of the pollution path

At its core, the EKC hypothesis suggests that environmental degradation initially increases with economic development but eventually decreases after reaching a certain income threshold. This non-linear relationship is underpinned by several economic theories that emphasize the interactions between income levels, pollution, and the environment. In fact, scholars identified multiple mechanisms at play.

First, the upward-sloping segment of the EKC is primarily driven by a scale effect. In fact, as an economy grows, there is an expansion in production and consumption that leads to increased emissions and waste. A typical example is a developing country experiencing rapid economic growth, where the expansion of various industries and increasing consumption creates a domino effect of environmental challenges. Industrial activities intensify, leading to higher resource consumption and pollution, impacting air quality and public health. Concurrently, economic prosperity drives up the demand for food, prompting agricultural intensification. As farmers employ more fertilizers and pesticides, runoff pollutes rivers and lakes, causing ecological disruptions and loss of biodiversity. The growing economy also fuels urbanization, necessitating more land for infrastructure, housing, and commercial spaces, which, in turn, accelerates deforestation. This results in biodiversity loss and increased carbon emissions. Furthermore, as people's incomes rise, consumption patterns change, leading to a surge in waste generation, for example from non-biodegradable packaging materials. This waste accumulation contributes to land and sea pollution. In this scenario, the scale effect is evident as the country's economic growth triggers a cascade of interconnected environmental challenges.

Importantly, the scale effect is often at the root of environmentalists' concerns associated with the so-called “neo-liberal growth paradigm”. This paradigm, characterized by an emphasis on free-market capitalism, deregulation, and globalization, often prioritizes economic growth without adequately considering its environmental consequences. Many environmentalists argue that the pursuit of unchecked economic growth, without implementing policies to mitigate its environmental impact, can lead to long-term ecological and social costs, advocating for a more sustainable and inclusive growth model that takes into account the environmental and social dimensions of development.

Second, the environmental impact of economic development is influenced by the change of the mix of economic activities. In fact, economies typically move from agricultural to industrial and, at a later stage, to services, leading to a change in the mix of goods and services produced by the economy. The environmental impact of such “composition effect” on the environment is non-monotonic, depending on which sectors expand, which sectors contract, and how sectors interact. For instance, a move from an agriculture-based economy to manufacturing might increase environmental degradation due to industrial pollution. Yet, a subsequent transition to a services-oriented economy could reduce this impact, given the generally lower environmental footprint of service sectors. Thus, predicting environmental outcomes based solely on structural changes requires a nuanced understanding of the intricate interplay between different economic sectors and their respective environmental impacts. However, assuming that countries follow the usual development stages and that industry has a greater environmental impact than agriculture and services, the composition effect will initially produce a negative effect on the environment. Its effect, however, will turn to positive with the subsequent expansion of the tertiary sector. Thus, the composition effect is central to the EKC theory, as it plays an important role in altering the trajectory of the 'pollution function' over different development stages.

Third, the environmental impact of economic activities is influenced by technology and technological progress. At its core, technology can be considered as a function that transforms production inputs into outputs. Technological progress, on the other hand, involves the discovery of new and more efficient combinations of inputs to get the desired output. Once these combinations are identified, they are mapped or codified, ensuring that they can be transferred, adopted, and utilized broadly. This is how new technologies develop and spread. However, it's important to note that not all technological advancements inherently promote a more efficient use of environmental resources. Indeed, the direction of technological advancements is typically influenced by the relative economic value of inputs. Consequently, if other factors of production (e.g., capital or labor) are relatively more valuable than environmental resources at a given time, technological innovations might prioritize optimizing their use over preserving the environment. This underscores the nuanced relationship between technological evolution and environmental conservation, where the inherent value placed on different resources can shape the trajectory of progress. Thus, following this economic reasoning, the net effect of technical change on the environment will crucially depend not only on resource availability, but also on countries’ preferences. And this consideration lies at the base of the main argument of the EKC theory, namely that when incomes rise and people manage to meet their basic needs, they will start to value more the so-called environmental good. However, before starting this discussion, it is interesting to

conclude the discussion on the linkages between technology and use of natural resources by mentioning the so-called Jevons paradox. As noted by the classical economist, even when innovations lead to increased efficiency in environmental resource use, it doesn't always translate into decreased consumption. Still, over time, advancements such as energy-efficient appliances, precision agriculture, and water-saving technologies have shown in many fields the potential of technology to balance economic and environmental concerns (Greening et al., 2000).
So, as proposed by Ozcan, and Ozturk (2019, p.68), the reverted U-shaped EKC development phases could be described by, considering a as regressors:

$$P = a_0 + a_1 Y + a_2 Y^2 + \varepsilon \quad (8)$$

- if $a_1 = a_2 = a_3 = 0$, no growth-pollution association;
- if $a_1 > 0, a_2 = a_3 = 0$, linearly increasing/decreasing growth/pollution relation.
- if $a_1 > 0, a_2 < 0, a_3 = 0$, inverted U-shaped EKC.
- $a_1 < 0, a_2 > 0, a_3 = 0$, U-shaped/monotonically increasing growth-pollution association

As income levels rise, people often start to care more about the environment around them. This change in what society values can push businesses and markets towards making choices that are more oriented toward environmental sustainability. For example, if a majority of consumers prefer products that are produced in an environmentally friendly way, companies will likely adjust their practices to meet that demand. At the same time, citizens will also advocate for stricter environmental regulations and policies, and the tightened regulatory landscape will provide stronger incentives to adopt or develop greener technologies. This transition and emphasis on sustainable technologies become increasingly pronounced over time, amplifying the “technological effect” where advancements in technology correlate with improved environmental outcomes. The Environmental Kuznets Curve theory reflects this dynamic, positing that after achieving a certain income level, economies have the potential to grow while simultaneously fostering a healthier environment. Such transitions are facilitated by the synergy of changing public values and technological evolution, both geared towards environmental preservation. Along these lines, Acemoglu et al. (2012) argue that, when motivated by the appropriate incentives, economic entities can indeed align their technological advancements with environmental well-being.

2.3 Empirical strategy

2.3.1. Data description

To empirically test the EKC theory, we leverage a rich cross-country panel dataset extracted from the World Bank's World Development Indicators (WDI). This comprehensive repository provides various environmental indicators across numerous countries over a significant time span, alongside data on GDP per capita and relevant control variables, thereby facilitating an extensive analysis of the relationship between economic growth and environmental degradation.

The analysis encompasses data spanning from the year 1990 to 2018, a period characterized by significant global economic growth and transformations. This time frame is selected based on the WDI's data availability regarding environmental indicators. With a coverage of 139 countries, the dataset guarantees a substantial breadth to the analysis. However, it should be noted that the panel is unbalanced, as not all variables are available for every country in every time period.

The primary dependent variable in this study is the total greenhouse gas emissions per capita, measured in CO2 equivalent units, which encapsulates the cumulative impact of various greenhouse gasses including CO2 and methane, among others. This parameter can be considered a proxy of countries' environmental impact. Moreover, to deepen the analysis and test the robustness of the empirical findings, we also use other environmental indicators. These are: (i) CO2 emissions per capita, that is a direct measure of the most significant type of greenhouse gas emission attributed to human activities. CO2 emissions are particularly significant given their established role as a primary driver of global warming and proxy of countries' carbon footprint. (ii) *Methane emissions per capita*, given that methane has a greater global warming potential than CO2 on a molecule-to-molecule basis.

As formalized in the following subsection, the main regressor is GDP per capita, that we compute as the ratio between countries' GDP measured in (thousands of) constant 2015 dollars and total population, GDP per capita squared. This metric serves as a reliable indicator of a country's average level of income and its potential correlation with environmental degradation.

The presence of omitted variable bias could pose a significant challenge. One approach to mitigate this is to enhance the basic model by incorporating several covariates, thereby gaining a more comprehensive understanding of the interplay among the variables. This strategy has been suggested as a potential solution to address this issue (Ozatac et al., 2017). To mitigate the risk of omitted variable bias, we also integrate several control variables into our model. These include a country's oil and coal rents, expressed as a percentage of GDP, which help to gauge the economic impact of these sectors and their potential influence on environmental indicators. Similarly, we account for the physical characteristics of the countries under scrutiny, including surface area measured in square kilometers, and the proportion of land designated as arable or covered by forests, both of which can have implications for the nation's carbon footprint and environmental health. Moreover, we consider demographic factors such as total population and population density, which can affect pollution levels and the extent of environmental degradation. The proportion of the population residing in urban areas is also factored in, given the often higher pollution levels in densely populated urban regions. Additionally, the age-dependency ratio is included to explore potential correlations between demographic structures and environmental outcomes. These variables collectively provide a nuanced perspective, enabling a multifaceted analysis of the dynamics between economic growth and environmental sustainability.

The trend of total greenhouse gas emissions is illustrated in Figure 1. In the period analyzed, total emissions have nearly doubled. This increase is primarily driven by middle-income countries, whose emissions have nearly doubled since 1990. In contrast, total greenhouse gas emissions from high-income countries have remained relatively constant. Finally, even though emissions from low-income countries have surged significantly (about a 50% increase), they still constitute a minor portion of total emissions, resulting in a relatively low environmental impact.

To obtain a more comprehensive picture, however, it is also necessary to examine the trend of emissions per capita. As illustrated in Figure 2, while the overall environmental impact of middle-income countries is about two times higher than that of their high-income counterparts, the individual footprint of people residing in those countries is less than half of those living in high-income ones. Indeed, the increase in the population of middle-income countries, which was much more pronounced than in high-income ones (over the last three decades, about +50% vs. +20%), represents a significant factor behind the substantial increase in their greenhouse gas emissions. In low-income countries, on the other hand, the population has more than doubled. However, in 2018, they constituted only 8.4% of the world population, and therefore their impact, both in absolute and relative terms, remains limited. Moreover, as discussed subsequently, this group of countries is where the environmental footprint of each dollar of income has decreased the fastest (in absolute terms).

Finally, to complete the picture, Figure 3 shows the dynamics of greenhouse gas emissions per (constant) dollar of GDP. Consistently with the predicates of EKC theory, the environmental impact of each dollar of GDP is negatively correlated with a country's level of income. Indeed, in 2018, the average amount of greenhouse gasses emitted per dollar of GDP in high-income countries was less than half of that produced in middle-income countries, and about a fifth of what was produced in low-income countries. Additionally, there is a noticeable decreasing trend: between 1990 and 2018, emissions per dollar have reduced by about 45%. This might imply the development and adoption of “greener” technologies. However, this might not necessarily have been the case, as the change could also be attributed to within- and between-country composition effects (within: an increase in the significance of the tertiary sector in all countries; between: higher-income countries outsourcing polluting activities to lower-income ones).

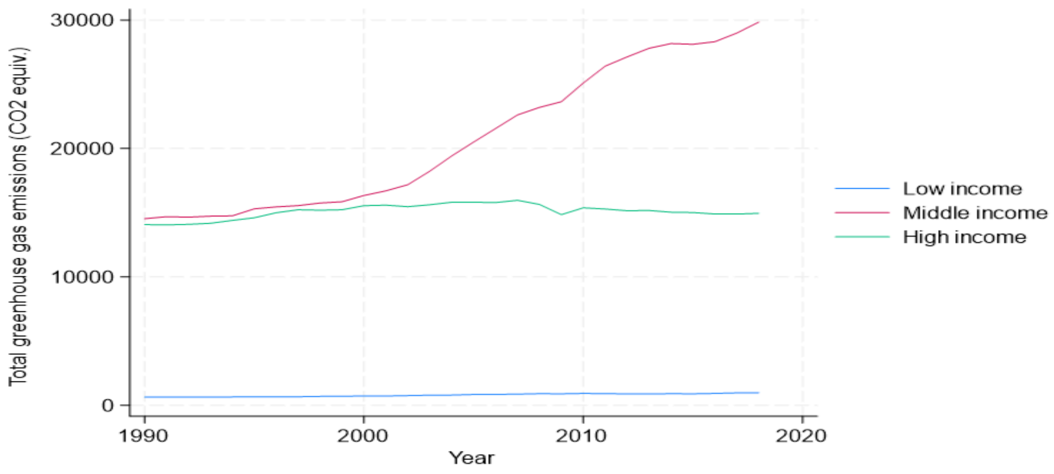

Figure 2: :total greenhouse gas emissions

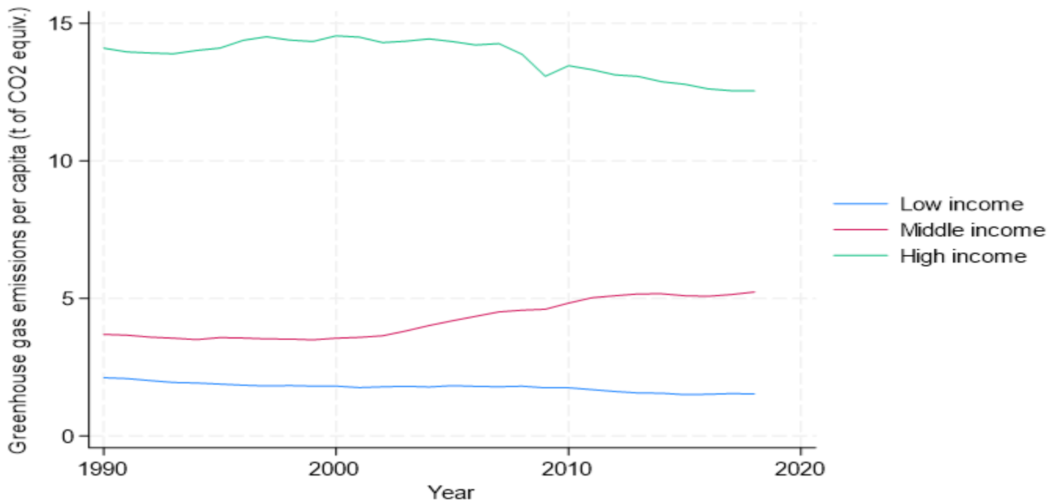

Figure 3:greenhouse emissions per capita

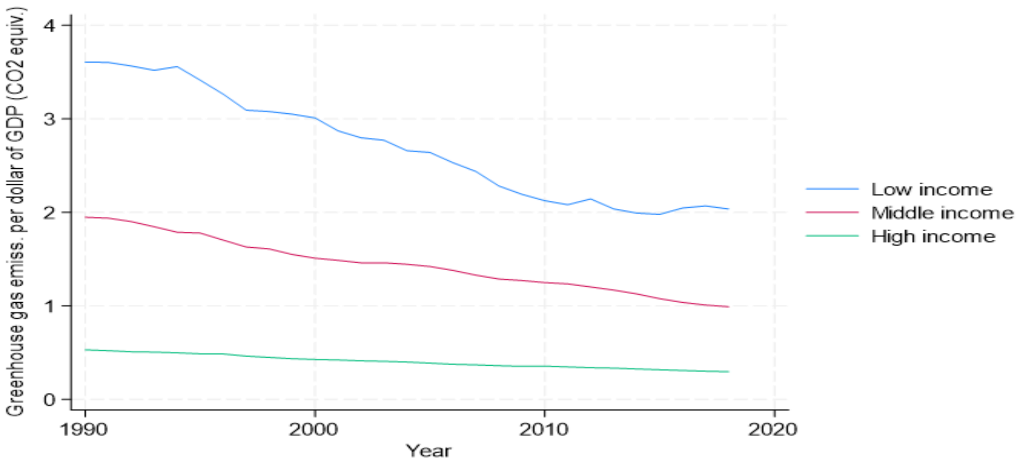

Figure 4:greenhouse emissions per dollar of GDP

2.3.2 Empirical model

As expressed above, POLS and fixed effects models have been used on several occasions to estimate EKC as in Ulucak and Bilgili(2018), Hussain and Dey(2021) and Farooq et al, 2022). In particular, models with fixed effects for a similar purpose have already been used in works such as the mentioned Ganda, 2019; Satrovic et al..2021; and Abid and Sekrafi, 2021). In order to test the EKC theory, we estimate different versions of the following generic empirical model

$$y_{it} = \alpha + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \gamma' x_{it} + \xi_i + u_{it} \quad (1)$$

Where y_{it}, the dependent variable, is a measure of environmental impact (in per capita terms) of country i at time t. $GDPpc_{it}$ indicates GDP per capita expressed in constant 2015 US dollars. The vector x_{it} represents a set of time-varying country-level control variables. They include $\xi_i$the percentage of and is a set of country fixed effects. The inclusion of country-level controls and fixed effects aims at mitigating the risks arising associated with omitted variable bias.
To test the ECK, we are interested in estimating the sign and the statistical significance of beta regressors. In particular, if the standard EKC holds true, we would expect to find $\beta_1>0$ and $\beta_2 < 0$, with a turning point in correspondence of a level of income of $-\beta_1/2\beta_2$ Higher polynomials of $GDPpc_{it}$ may be included to test other shapes of the relationship between income and environmental degradation.

2.4 Results

The baseline results of the empirical analysis are reported in Table 1 and, overall, they corroborate the EKC hypothesis. Indeed, across all the specifications, and exhibit the expected signs and are both highly significant, with p-values below 0.1% in almost every case (standard errors are clustered at the country level). Except in a few cases, even if the interpretation of coefficients associated to the control variables may be worth of interest, we will focus the analysis on the discussion of the estimates of the parameters of interest, i.e. the regressors which determine the shape of the EKC.
In column (1), we present what might be called a "naïve estimator", which is an estimation of the parameters of interest obtained with a pooled OLS (POLS) without controlling for any covariates, and this has been included as a reference point for the other specifications. By predicting an EKC turning point at about 46k dollars per capita, this naïve estimation leads to results that are not very far from those obtained with more robust specifications and discussed in the following.
In columns (2) and (3), we report another POLS estimation, this time including all the control variables mentioned in the previous section, and aimed at mitigating omitted variable bias concerns. Moreover, in column (3), we also include a time trend. The estimates of both

models align with the EKC hypothesis, pinpointing a turning point in the income range of 47-48k dollars per capita and accounting for about ¾ of the total variability in greenhouse gas emissions. Differently from fixed effects models of columns (4)-(7), the introduction of the time trend – whose coefficient, however, is negative and highly significant - does not meaningfully impact the POLS estimates of the EKC, as the estimates of beta coefficients are very similar across the two models (can't reject the null at 1%).

Fixed effects estimates are documented in columns (4)-(7). The models represented in columns (6) and (7) are weighted based on countries' populations, and in columns (5) and (7), we have also incorporated the time trend among the regressors. From a qualitative viewpoint, all fixed-effects models are consistent with the anticipated existence of the EKC, even though they vary substantially in terms of quantitative predictions.

On one hand, the data indicates that weighted estimations are associated with a significantly lower turning point. Specifically, these models anticipate a decrease in greenhouse gas emissions upon reaching an income per capita level of about 40-45k dollars, which is approximately 15k dollars lower than the threshold projected by unweighted models. This finding is notable as it suggests a more potent EKC relationship in larger countries which, all other factors being equal, account for a larger portion of total greenhouse gas emissions.

On the other hand, the inclusion of the time trend "pushes further away" the estimated turning point. This result deserves some discussion. The negative and significant coefficient of the time trend suggests that, regardless of GDP per capita dynamics, the average level of greenhouse gas emissions per capita is on a declining trend over time. What could be the underlying cause of this trend? It is plausible that the time trend coefficient captures, at least in part, the influence of technological advancements that enhance resource efficiency. While greener technologies are predominantly pioneered by frontrunner countries, advancements do trickle down, as previous-generation technologies become readily accessible and affordable for follower nations. If it is so, a point of discussion is whether it is appropriate to include the time trend among regressors. Indeed, as the pace of technical progress is likely to be a function, among other things, of the level of income of rich countries, it raises a problem of endogeneity of the effect of technological progress. While we prefer to be agnostic on this, we believe that it's useful to include both results and, as we are likely to partial out some of the contribution of the technological effect, treating the estimates incorporating the time trend as a lower boundary for the EKC.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP p.c.	0.6078***	0.4840***	0.4737***	0.2423***	0.4560***	0.6455***	0.9074***
	(0.0700)	(0.0527)	(0.0540)	(0.0703)	(0.0911)	(0.1040)	(0.1119)
GDP p.c. ^ 2	-0.0066***	-0.0051***	-0.0050***	-0.0023**	-0.0037***	-0.0083***	-0.0100***
	(0.0011)	(0.0009)	(0.0010)	(0.0009)	(0.0011)	(0.0013)	(0.0013)
Oil rents		0.1577***	0.1583***	0.0224°	0.0187°	-0.0116	-0.0129
		(0.0403)	(0.0399)	(0.0120)	(0.0102)	(0.0128)	(0.0117)
Coal rents		0.5479**	0.5672**	0.0216	0.0264	0.1927***	0.2174***
		(0.2034)	(0.2023)	(0.0544)	(0.0543)	(0.0323)	(0.0304)
Land		0.7512***	0.7251***	-2.4910	-2.4507	-4.6183	-4.4743
		(0.1434)	(0.1431)	(2.3446)	(2.0949)	(3.8031)	(3.3190)
Arable land		-0.0213	-0.0244	0.0783**	0.0667*	0.1192**	0.0752°
		(0.0179)	(0.0179)	(0.0295)	(0.0309)	(0.0446)	(0.0401)
Forests		-0.0479***	-0.0489***	-0.0569	-0.0541	0.0750*	0.0707*
		(0.0128)	(0.0128)	(0.0502)	(0.0510)	(0.0330)	(0.0300)
Age-dependency ra		-0.0636***	-0.0721***	-0.0616**	-0.0819***	-0.0512***	-0.0689***
		(0.0151)	(0.0164)	(0.0191)	(0.0193)	(0.0139)	(0.0200)
Log(Population)		-0.9323***	-0.8779***	-2.9387°	-0.2099	-1.9287*	2.2662°
		(0.1830)	(0.1827)	(1.4882)	(1.8997)	(0.7756)	(1.2952)
Pop. Density		-0.0007***	-0.0008***	-0.0005	-0.0014*	-0.0002	-0.0002
		(0.0002)	(0.0002)	(0.0005)	(0.0006)	(0.0008)	(0.0009)
Year			-0.0644***		-0.0899***		-0.1124***
			(0.0168)		(0.0240)		(0.0309)
Constant	2.2658***	22.9734***	151.9125***	59.8562*	194.8074***	56.5731*	:01.4844**
	(0.3533)	(3.7137)	(34.5000)	(26.8473)	(37.8023)	(23.4562)	(47.5026)
Observations	3,890	3,823	3,823	3,823	3,823	3,823	3,823
R-squared	0.5102	0.7474	0.7538	0.1716	0.2342	0.7013	0.7493
Number of Countri	139	139	139	139	139	139	139
Country Fixed Effects				Yes	Yes	Yes	Yes
Weighted						Yes	Yes
Turning point	46.1	47.3	47.8	51.7	61.7	38.7	45.3

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05, ° p<0.1.

Table 2: Baseline results

In qualitative terms, the primary findings of the analysis remain robust to changes in the indicator of environmental impact. Table 2 reports the fixed effects estimates when the dependent variables are CO2 emissions per capita (measured in tons) and methane emissions per capita (also measured in tons of CO2 equivalent). Notably, while the findings of CO2 emissions per capita align both qualitatively and quantitatively with those presented in Table 2 (a correlation that is not entirely surprising given that CO2 emissions comprise a significant fraction of total greenhouse gas emissions), the results obtained with methane emissions are slightly less robust. In the unweighted versions, however, these coefficients maintain a 10% level of significance, a threshold that is sometimes deemed as worthy of consideration in studies characterized by small sample sizes. In order to get further insights into the EKC relationship, we also repeat the empirical analysis on three non-overlapping sub-samples, which are identified on the basis of the World Bank's income group classifications. The results, shown in Table 3, refer to weighted estimates, although it should be noted that the unweighted estimates are largely similar. We can see that, overall, the empirical evidence strongly supports the EKC only for the group of middle income countries. In contrast, for low-income countries, the models estimate a monotonically increasing relationship between income and emissions. This is in line with the initial phase of the EKC theory, where economic development is tied to increased resource exploitation and pollution, and environmental concerns give way to the necessity of economic growth. Considering that all countries in this subsample are characterized by very low levels of income per capita (about 800 dollars in 2018), it is not surprising that, albeit negative, is not significant (the p-value is ranging between 23% and 45%, depending on the specification). On the other hand, the high-income group are consistent with the EKC theory only when the time trend is incorporated, otherwise suggesting a negative quadratic relationship between income and environmental footprint. This result may be due to the opposite reason of that of low-income ones. The finding of a negative quadratic relationship between income and environmental impact in high-income countries could imply that high-income countries (where average income was about 42k dollars in 2018) have perhaps passed the stage where growth has a noticeable effect on environmental degradation, and some of them may even be in a stage in which, at the margin, an increase in income has a positive net effect on the environment.

	CO2 emissions per capita				Methane emissions per capita			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP p.c.	0.1782**	0.3541***	0.5774***	0.8073***	0.0461°	0.0756°	0.0325**	0.0503***
	(0.0547)	(0.0638)	(0.0984)	(0.1050)	(0.0274)	(0.0450)	(0.0106)	(0.0128)
GDP p.c. ^ 2	-0.0015*	-0.0026***	-0.0072***	-0.0086***	-0.0005°	-0.0007°	-0.0007***	-0.0008***
	(0.0007)	(0.0007)	(0.0012)	(0.0012)	(0.0003)	(0.0004)	(0.0002)	(0.0002)
Oil rents	0.0050	0.0020	-0.0204°	-0.0215*	0.0178*	0.0173*	0.0113**	0.0112**
	(0.0080)	(0.0075)	(0.0111)	(0.0104)	(0.0085)	(0.0080)	(0.0042)	(0.0041)
Coal rents	0.0561	0.0601	0.2059***	0.2275***	-0.0167°	-0.0160°	-0.0124	-0.0107
	(0.0528)	(0.0527)	(0.0278)	(0.0305)	(0.0096)	(0.0096)	(0.0115)	(0.0106)
Land	-2.4015	-2.3683	-5.4762	-5.3498	-0.1621	-0.1565	0.4443	0.4541
	(2.2308)	(2.0175)	(3.9722)	(3.5320)	(0.2362)	(0.2619)	(0.3692)	(0.3949)
Arable land	0.0525*	0.0429°	0.1059*	0.0673°	0.0264**	0.0248**	0.0105°	0.0075
	(0.0220)	(0.0228)	(0.0409)	(0.0367)	(0.0084)	(0.0084)	(0.0059)	(0.0065)
Forests	-0.0343	-0.0320	0.0705*	0.0668*	-0.0250*	-0.0246*	0.0035	0.0033
	(0.0380)	(0.0382)	(0.0320)	(0.0311)	(0.0118)	(0.0121)	(0.0085)	(0.0082)
Age-dependency ratio	-0.0495**	-0.0662***	-0.0427***	-0.0582***	-0.0076	-0.0104*	-0.0050°	-0.0063*
	(0.0151)	(0.0156)	(0.0117)	(0.0171)	(0.0047)	(0.0046)	(0.0028)	(0.0030)
Log(Population)	-1.7742°	0.4719	-1.3153*	2.3672*	-1.0940**	-0.7167	-0.5171**	-0.2316
	(1.0637)	(1.3885)	(0.6396)	(1.1113)	(0.3670)	(0.4840)	(0.1670)	(0.2938)
Pop. Density	-0.0012**	-0.0019***	-0.0006	-0.0006	0.0002°	0.0001	0.0002	0.0002
	(0.0004)	(0.0005)	(0.0006)	(0.0010)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Year		-0.0740***		-0.0986***		-0.0124		-0.0076
		(0.0188)		(0.0275)		(0.0090)		(0.0052)
Constant	37.7676	.48.8553**	47.2193*	.74.4008***	20.1723**	38.8332**	8.8488*	18.7105**
	(19.2881)	(29.4550)	(21.7101)	(43.6142)	(6.5095)	(14.1295)	(3.9619)	(6.8359)
Observations	3,821	3,821	3,821	3,821	3,823	3,823	3,823	3,823
R-squared	0.1759	0.2466	0.7211	0.7673	0.1313	0.1415	0.2005	0.2111
Number of Countries	139	139	139	139	139	139	139	139
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted			Yes	Yes			Yes	Yes
Turning point	60.1	68.2	40.3	46.7	44.5	53.6	24.6	32.4

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ° p<0.1.

Table 3: Estimation for CO2 and methane emissions

	Low-income countries		Middle-income countries		High-income countries	
	(1)	(2)	(3)	(4)	(5)	(6)
GDP p.c.	1.4946*	1.0213**	1.1767***	1.5414***	0.2236	0.4714*
	(0.6414)	(0.3651)	(0.1333)	(0.1264)	(0.1405)	(0.1826)
GDP p.c. ^ 2	-0.1619	-0.0628	-0.0457***	-0.0504***	-0.0028°	-0.0044*
	(0.1339)	(0.0882)	(0.0108)	(0.0078)	(0.0015)	(0.0017)
Oil rents	-0.0060	0.0002	-0.0019	-0.0066	0.0062	0.0182
	(0.0126)	(0.0071)	(0.0121)	(0.0104)	(0.0193)	(0.0201)
Coal rents	-0.0739*	-0.0261	0.1278***	0.1080***	0.8953°	0.6645°
	(0.0334)	(0.0293)	(0.0322)	(0.0210)	(0.4468)	(0.3827)
Land	-0.1807	-0.4880°	-23.6095	-15.2429	-12.8154***	-11.8298***
	(0.2114)	(0.2496)	(27.2228)	(13.5077)	(1.8673)	(2.3292)
Arable land	0.0131	0.0256°	-0.0057	0.0113	0.0072	-0.0724
	(0.0096)	(0.0126)	(0.0272)	(0.0236)	(0.0805)	(0.0816)
Forests	0.0302	-0.0094	0.0456**	0.0134	-0.2462	-0.0952
	(0.0192)	(0.0272)	(0.0151)	(0.0143)	(0.1998)	(0.1920)
Age-dependency ratio	0.0215	0.0018	-0.0168	-0.0668***	-0.0919	-0.0256
	(0.0171)	(0.0073)	(0.0190)	(0.0136)	(0.0587)	(0.0801)
Log(Population)	-0.0260	2.7364*	-0.9402	2.8962**	-4.1926	0.8257
	(0.2534)	(1.2012)	(0.9030)	(0.9949)	(4.5570)	(4.8514)
Pop. Density	0.0001	0.0005	-0.0030°	0.0005	0.0002	-0.0008°
	(0.0024)	(0.0021)	(0.0018)	(0.0017)	(0.0005)	(0.0005)
Year		-0.0959*		-0.1463***		-0.1264°
		(0.0408)		(0.0240)		(0.0715)
Constant	-1.6704	146.6981*	132.0355	312.1821***	138.6862°	285.4224*
	(4.9121)	(62.3900)	(130.9938)	(75.9056)	(78.3939)	(134.7712)
Observations	671	671	2,038	2,038	1,114	1,114
R-squared	0.3640	0.5075	0.8689	0.9108	0.5420	0.5845
Number of Countries	26	26	73	73	40	40
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes	Yes	Yes
Turning point	4.6	8.1	12.9	15.3	39.4	53.1

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ° p<0.1.

Table 4: Estimation for income groups

2.5 Discussion

Transitioning to green technological paradigms poses a set of challenges. From a strictly economic viewpoint, the initial costs of migrating from well-established technologies to newer, environmentally friendly alternatives can be significant. Industries steeped in traditions of using non-renewable resources face hurdles like capital reallocation, workforce retraining, and potential complete restructuring (Acemoglu et al., 2012).

Political dynamics can pose significant obstacles. Industries tied to these non-renewables frequently wield considerable political clout, using lobbying and campaign financing to defend their vested interests, thus hampering the introduction of robust environmental policies. In addition, countries abundant in fossil fuel resources often resist change due to the substantial economic benefits and geopolitical power that these resources confer (Mitchell, 2012).

A crucial factor in this complex equation is globalization and international competition. Developing countries might opt for cheaper, albeit more polluting, technologies to catch up with their developed counterparts (Frankel & Rose, 2005). This strategy can guarantee quicker economic growth at the expense of environmental conservation. At the same time,

advanced economies, being at the technological frontier, may perceive themselves at an unfair disadvantage if they adopt green technologies that elevate production costs, thereby making their goods less competitive on the global market (Copeland & Taylor, 2004).
Furthermore, societal perceptions play a significant role. In many high-income countries, the population may be used to certain consumption patterns and may resist change, especially if it is felt it may pose limitations to people's lifestyle or inflate costs. Achieving a balance between policy goals and public sentiment is thus pivotal (Grossman & Krueger, 1995).

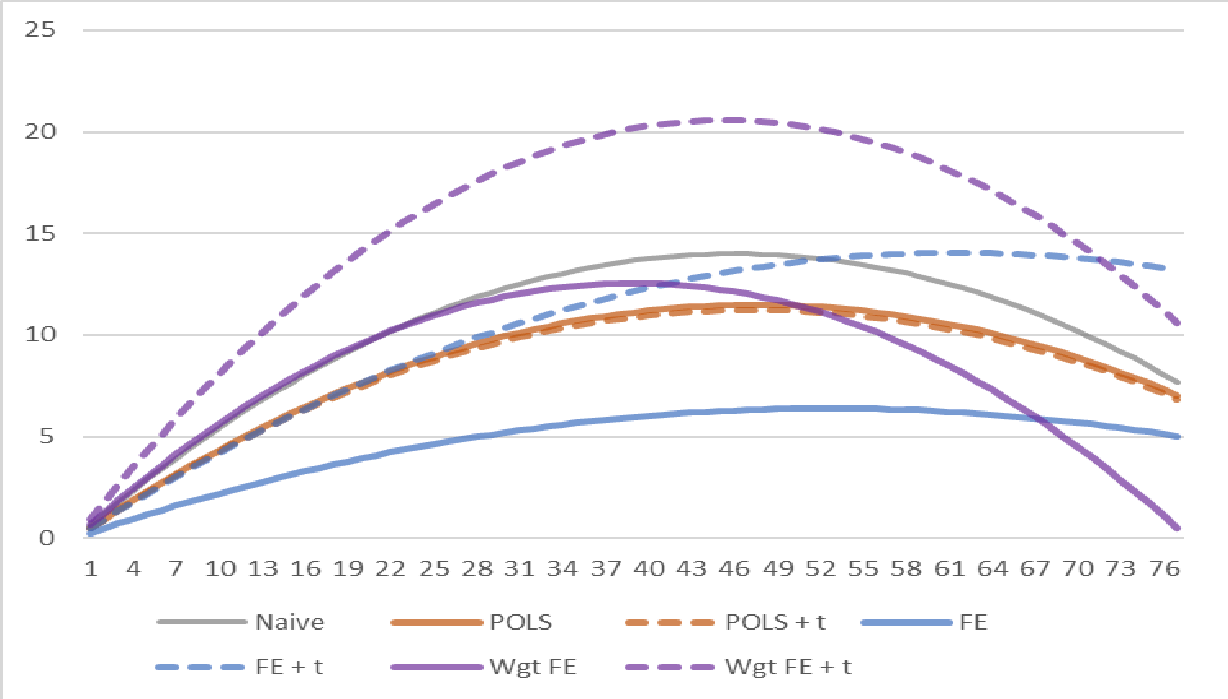

Figure 5: EKC by baseline models

Lastly, the necessity for international coordination presents another layer of complexity. With countries at different stages of development and with varying priorities, fostering universal cooperation on environmental initiatives is a daunting task. Some nations may advance rapidly in green transitions, while others might lag, seeing economic advantages in the old paradigm (Barrett & Stavins, 2003).
By finding results which are largely consistent with the EKC hypothesis, our analysis suggests that, all things being considered, market forces can be conceived as a part of the solution of the environmental challenge, a challenge in which, paradoxically, they played an instrumental part. It's indeed paradoxically that the very drive for higher living standards, which market forces facilitate, has come at the expense of environmental quality. However, while our empirical findings echo the tenets of the EKC, they also suggest that it would be overly simplistic to assume that merely allowing market forces to operate would be sufficient to address the environmental problem. Indeed, as shown in Figure 4, all our EKC estimates share two common traits: a notably high turning point and, after that, a rather modest declining gradient. For instance, using the more "optimistic" weighted fixed effect model as a reference[1],we observe that for the world's average per capita income to merely enter the

descending segment of the curve, it would need to quadruple from its 2018 level, while going back to the 2018 level of per capita emission would require an increase by about six times. These targets, in fact, seem far off on the horizon, even without accounting for global population dynamics, which would further worsen the scenario.

Thus, in order to make significant progress within 2050, efforts need to be made in order to further "bend the curve". This means, on the one hand, that governments need to strengthen the existing market incentives behind the EKC. Probably, in order to be effective, what is truly needed is a coordination effort between governments. Such collaboration is challenging because of the strong inherent incentives to free-ride, exacerbated when autocratic regimes spot opportunities for political leverage. On the other hand, from a bottom-up perspective, civil society needs to become more aware of the environmental risk, and try to adopt more environmentally-friendly behavior. This, in fact, will contribute to create an economic demand for "green" products and services, thus strengthening the market incentives of firms, and a political demand for "green" policy and public goods. On this topic, however, it is important to highlight the problem of greenwashing – both from companies and political organizations – may create a departure between what is perceived as "green" (goods, services, policies) and what actually is green.

2.6 Conclusions

In this analysis, we acknowledge the dual nature of market forces. On one hand, these forces drive economic growth and improved living standards, but on the other, they have historically contributed to environmental degradation. By using latest data to study the relationship between income and environmental dynamics, we find empirical evidence that supports the EKC hypothesis in the three income groups founding support for the evidence proposed by Adedoyin et al(2021), Ulucak and Bilgili(2018) and Nasreen and Anwar(2015).

However, while many discussions about the EKC sometimes present it as a silver bullet solution, implying that as countries get richer, they naturally solve their environmental issues, our analysis temper this optimism. In fact, we underscore that, according to our findings, reaching the "turning point" where environmental degradation begins to decrease with further economic growth can be distant and challenging for the large majority of countries. Thus, merely relying on economic growth could be a slow and insufficient strategy to address the environmental challenge. This, of course, is a critical point, especially in the current context of pressing global issues like climate change, which requires a multi-faceted approach encompassing active interventions from policymakers, aimed at incentivizing green technologies and promoting green regulations, and a raise in environmental awareness at all levels of societies.

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Appendix

Authors	Countries/groups	Date	Environmental variables	Main variables	Econometric methodology
Narayan and Narayan(2010)	43 developing countries	1980-2004	CO_2	GDP	Panel ECM
Farhani et al(2014)	10 MENA countries	1990-2010	CO_2	Human evelopment index, GDP, energy onsumption, trade openness, manufacture value added, rule of law	Fully modified and dynamic OLS
Ganda(2019)	23 OECD countries	2001-2012	CO_2, GHG	GDP, Net savings, DI, domestic credit	GMM
Liu and Lai(2021)	134 countries	2001-2018	CO_2	GDP, energy consumed in imported waste, FDI, population, trade openness, industrial output, urbanization	Life Cycle Assessment

Chakraborty and Mazzanti(2021)	34 developed/ developing countries	1971–2015	CO2	GDP, renewable energy, total oil consumption.	Simulated Sampling Procedure, C-Lasso method
Satrovic et at(2021)	GCC	1990-2019	CO2	GDP, electric power consumption, Urban population, democratic accountability index	Fully modified OLS, least squares dummy variable, pooled mean group.
Le(2021)	ASEAN+6	1995-2012	GHG, CO2, CH4, N2O.	Income, energy consumption, population , FDI, trade openness, urbanization, financial development, industrialization, human capital,	STIRPAT model
Espoir and Sunge(2021)	48 African countries	1996–2012	CO2	GDP, trade openness, renewable energy consumption, governance index, population density	Pooled OLS, Fixed and Random effects, GMM.
Agozie et al(2022)	BRICS	1990-2019	CO2	Economic complexity index, FDI, Renewable energy consumption, urban population, natural resources.	Fully Modified OLS, AMG

Wang et al (2022)	36 European countries	2000-2018	CO2	GDP, trade openness, urban ɔopulation, energy intensity, FDI, ₹enewable Energy generation.	Durbin panel model
Liu et al (2019)	125 counties (low, middle-upper, high income economies)	2000-2014	CO2	GDP. Export product diversifcation, ʹerfndahl–Hirschman index	fixed effects, Driscoll–Kraay estimation
Majeed(2020)	20 upper-income, 36 middle-income, 20 low-income countries.	1961-2018	EFP	GDP, trade openness, iocapacity, human capital	fixed effects, quantile ɛgression, cross section dependence
Hussain and Dey (2021).	30 countries (developed emerging, developing economies)	1990-2016	CO2	HDI, GDP	Fixed effects, POLS
Ulucak, R., and Bilgili, F. (2018)	ow, middle, high income	1961–2013	Ecological footprint	GDP, openness,, human capital, biocapacity	continuously updated fully modified (CUP-FM)-bias corrected (CUP-BC) models

Table 1a: Multi countries models

Chapter three:

Stop and go…and stop: inflation, political exchange and failed stabilization in post-convertibility Argentina

with Nicolas Blampied[11]

Abstract

A widely held belief suggests that inflation disproportionately affects low-income individuals, creating a puzzle for some researchers. This puzzle arises because, despite the perceived negative impact on the lower-income demographic, they tend to support governments that actively promote inflation. However, this apparent contradiction can be resolved when considering scenarios where the government supports a progressive redistribution of the inflationary tax. This paper introduces a model grounded in the *political exchange hypothesis*, where three interest groups – businesspeople, *rentiers*, and workers – express their demand for inflation. Political parties engage in competition to attain governmental power by representing the demands of these groups. The model illustrates that the inflation rate in post-convertibility Argentina, even when excessively high, aligns with the preferences of a coalition in power comprising businesspeople and workers. This coalition derives a portion of its income from the inflationary tax imposed on financial rentiers. Although a stabilization attempt commenced in December 2015 following a shift in the political landscape (Macrì's election), it encountered setbacks. The subsequent change in coalition and its failure are also elucidated through the lens of the model.

Keywords: Inflation; redistribution; interest groups; political economy; stabilization; Argentina

JEL: E31, E63, E65

[11] The paper is the result of a collaborative effort. My contribution mainly involves the description of data and the economic and political history of Argentina. In Section 4 of this chapter, my particular attention was given to the section on workers' lobbying, as well as the overall review. A simplified version with a draft of applied analysis using wavelet coherence has been accepted for publication in Economia Internazionale/International Economics, see Sbarile and Blampied (2024).

3.1 Introduction

Following the significant macroeconomic crisis in 2001-2002, Argentina transitioned from its currency board exchange rate system to a managed floating regime. Despite a decade of price stability, inflation reemerged in the 2000s, though at rates lower than those seen in the 1980s. Between 2002 and 2015, inflation exhibited an upward trend, and budget surpluses turned into deficits in 2011, progressively worsening thereafter. Efforts to curb inflation during the Macri administration (December 2015- December 2019) proved unsuccessful, leading to an acceleration of inflation instead.

Over the past two decades, various attempts have been made to identify the causes of inflation. Some prevalent arguments focused on *fiscal dominance*, the consequences of financing fiscal imbalances through money creation, the distributive conflict between workers and businesspeople encapsulated in the cost-push hypothesis, and the effects of a lack of commitment, among other widespread ideas. However, these narratives fell short of explaining the persistent and escalating inflation rate during the analyzed period or the deliberate delay in stabilization. Our perspective posits that a political economy framework is essential, centering the analysis on the political exchange among diverse interest groups with distinct demands for inflation and the emergent political parties striving to address these demands.

It is often assumed that inflation disproportionately affects low-income individuals, leading to an apparently contradictory phenomenon where this group frequently supports governments prone to inflation. The rationale behind this support becomes clearer when considering the progressive redistribution of the inflationary tax. This tax is collected from the entire population, albeit not uniformly, and is allocated to support specific interest roups. The *political exchange hypothesis* posits that in economies with high financial polarization and fixed-interest rates financial portfolios, inflation functions as a tax burden on holders of financial wealth (*rentiers*). Consequently, a coalition in power with worker constituencies may favor inflation, redirecting the inflationary tax collected from *rentiers* toward workers. Pittaluga and Seghezza (2012a), based on the work of Beetsma and Van der Ploeg (1996), constructed a model to explain delays in stabilization in European countries during the 1920s and 1980s. Their model illustrates that the likelihood of stabilization rises when a political coalition in power, favoring rentiers (center or center-right government), supplants a left-wing government.

In this paper, the Argentinian case is addressed following a political exchange hypothesis model. Moreover, the baseline model is enriched by including asymmetric information and the possibility that workers carry out lobbying activities. The inflation regime depends on the constituencies of the political equilibrium achieved and their attitude toward inflation.

In our perspective, the model elucidates the persistent and escalating inflation in post-convertibility Argentina, the shift in Argentina's political coalition at the end of 2015, and the stabilization effort undertaken by the Macri administration. Additionally, considering the ability of workers to engage in lobbying activities and the presence of asymmetric information among other interest groups regarding the actual lobbying power of workers, the model provides a plausible explanation for the failure of the Macri stabilization program and

the subsequent reversal in the political equilibrium that favored, once again, a businessperson-worker coalition in 2019.
The paper is structured as follows: Section 2 presents a literature review; Section 3 introduces the model and expounds on how the political exchange hypothesis operates; Section 4 delves into the analysis of the lobby function in the model; Finally, Section 5 summarizes the conclusions.

3.2 Literature review

This paper is related to several strands of literature. On the one hand and from a generalist perspective, this paper builds on the vast literature that has tried to explain the drivers behind post-convertibility Argentina inflation. The price dynamics after the 2001-2002 crisis have been largely analyzed and, as Heymann (2010) affirms, the response of the economy to the sharp devaluation triggered by the crisis did not take the form of a price level adjustment at gradual declining rates, but rather the form of low initial inflation rates which subsequently turned into an inflation plateau around the two-digit range. The upward trend in inflation became more acute in the 2010s.
Numerous theories tried to address the phenomenon. Buera and Nicolini (2019), for instance, point out the existence of fiscal dominance, and argue that the surge in inflation took place after the year 2007, when budget surpluses progressively turned into deficit and, since the country had not any access to foreign borrowing –until 2016-, it resorted to seigniorage. On their part, Redrado et al. (2006), Sturzenegger and Talvi (2008), Basturre et al. (2008) and Heymann (2010), support the idea that inflation was the result of a monetary policy strategy, which was not focused on the control of inflation. Instead, these latter affirm that after the collapse of the currency board exchange rate regime, monetary policy was diagrammed in order to use the exchange rate both as a policy objective and as an instrument of policy. Rapetti and Gerchunoff (2016) provide a good explanation from a structuralist point of view, by which inflation dynamics are driven by misalignments in the real exchange rate and regular currency depreciations triggered by current account deficits. On the other hand, the structuralist approach gives particular importance to the effects of the redistributive conflict between workers, businesspeople and the commodity sector and, hence, it shows a clear connection with the so-called cost-push hypothesis. Among other arguments, some have focused on the existence of lack of commitment due to adverse shocks that affected commodity prices after 2011.
Our primary interest stems from the fact that inflation in Argentina was not a political agenda until the election of Macrì, indicating a delay in implementing inflation containment policies. In this regard, inflation is the subject of study from the perspective of political economy literature.
In this line, one of the main contributions is the war of attrition hypothesis of Alesina and Drazen (1991). According to this hypothesis, countries may procrastinate inflation stabilization even when price dynamics reach sub-optimal levels. The delay would be explained by the political stalemate that arises when interest groups, even when aware of the need for stabilization, are not willing to bear its costs. Since asymmetric information regarding the ability of groups to bear inflation is assumed, stabilization takes place when the weaker group surrenders and is forced to

pay for the costs. Fernandez and Rodrik (1991) affirm that the delay could obey the fact that it may be difficult to identify beforehand the gainers and losers of the reforms. Drazen and Grilli (1993), on its part, but also Labán and Sturzenegger (1994), stress that worsening economic conditions constitute a major driver of stabilizations, since in this context the interests of different groups tend to align because the costs of stabilizing become smaller than those of keeping the conflict.

Our work pays special attention to heterogeneous effects of inflation. Seghezza and Morelli (2014) argue that most literature focused on the analysis of delayed stabilizations supports the idea that inflation is the unintentional result of the conflict between interest groups. However, they claim that, since the effects of inflation are heterogeneous among different groups, this approach does not appear to be that appealing. For instance, procrastination may obey not to the deadlock that arises from a war of attrition between interest groups, but to the political exchange that takes place between interest groups and political parties, some of them benefitting from procrastination and enough political power to actually postpone the stabilization.

Rentiers jump into the scene once understood that inflation has a clear effect on financial wealth. The political exchange hypothesis draws its foundations from the work of Beetsma and Van der Ploeg (1996) that underlines that in economies with a high degree of financial polarization and fixed-interest rates financial portfolios, inflation constitutes a tax burden to those who hold financial wealth. This phenomenon is also addressed by Doepke and Schneider (2006a,b). Pittaluga and Seghezza (2012a) resort to the political exchange hypothesis and address the stabilization processes of most European countries in the 1920s, putting particular emphasis on the role of financial rentiers. Seghezza and Morelli (2014) test the model also to account for inflation stabilizations in developed countries during the 1980s and conclude that stabilizations are usually carried out by coalitions of rentiers and businesspeople, with marginal roles played by workers and left- wing parties. The fact that inflation may hit financial wealth –rentiers- opens the possibility to challenge the idea that inflation hits low-income people the most. For instance, some pioneer studies, such as Wolff (1979), had already shown that the great inflation had reduced income inequality in the United States.

Is our interest analyze the political equilibriums that allow the inflation rate to emerge in post-convertibility Argentina and try to provide a reasonable explanation for the delay in attempting a stabilization; third, by providing some insights on the heterogeneous effects of inflation and the difficulties stabilization may carry with.

3.3 Failed stabilization and political exchange in post convertibility Argentina

After suffering a macroeconomic crisis in 2001-2002, Argentina started a period of economic growth that lasted until 2011 and was only interrupted due to the side effects of the Great Recession in 2008-2009. Along with economic growth, inflation came into the picture again, after a decade of low inflation under the currency board exchange rate regime that characterized the country in the 1990s. During the period 2003-2015, the Kirchner administration remained in office without interruptions, but lost the presidential elections in 2015, giving place to the Macri administration. Meanwhile, inflation had tended to increase. The Macri administration took office supported by a coalition of more conservative constituencies and setting as a primary goal that of reducing inflation. However, this government lost power in 2019, after a defeat in the presidential elections, without having reduced inflation and giving place to the Fernandez administration, supported by the same groups that had backed the Kirchner administration before.

A priori, using the lenses of the model presented in Section 3 and the empirical analysis carried out in this section, the Kirchner and the Macri administrations may be identified with a businessperson-worker coalition and a businessperson-rentier coalition, respectively. Indeed, as Degiusti and Scherlis (2020) note, lower and lower-middle Argentinian classes have systematically supported Peronism (Kirchnerism) while the middle and upper-middle classes have supported non-Peronist alternatives. Moreover, since the beginning, the Kirchner administration would have constituted the expression of organized urban labor and domestic firms against the "elites", such as international creditors, the commodity sector and some multinational companies. According to Richardson (2009), Kirchner was the promoter of an innovative "export-oriented populism", where exports were both taxed and promoted, generating fiscal revenues to support populist programs at the same time that real wages increased and the balance of payment crisis were avoided.

As observed by Vommaro (2019), political polarization has intensified in Argentina since 2008 and, more strongly, since 2011. The first date marks the conflict between agricultural producers and the recently initiated government of Cristina Fernández de Kirchner over the official proposal to increase export taxes on grain exports. As a direct consequence of the conflict and the side effects of the 2008-2009 crisis, the government was defeated in the legislative elections of 2009. It pulled itself together from the defeat by accentuating the most radicalized constituencies, with an anti-establishment discourse and winning the presidential elections of 2011. The erosion of its popularity led to the electoral defeat in 2013 and the emergence of the center-right coalition Cambiemos in 2015, led by the political party PRO (Propuesta Republicana).

3.3.1 How a businessperson-rentier coalition came to office: the analysis through the political exchange hypothesis

A first glance at post-convertibility Argentina allows to distinguish two periods in what regards the situation of the three interest groups. In Figure 1, it may be observed that between 2004 and 2015 real wages increased, experiencing minor reductions only in some particular years, such as 2008, 2012 and 2014. Instead, the real interest rate on central bank's notes was negative during the whole period, turning positive only during the period 2017-2020. Inflation, on its part, tended to increase all along the period, although with important irregularities. These facts, clearly, show that under the Kirchner administration workers were benefitted, but macroeconomic policy aims at hurting rentiers' financial wealth.

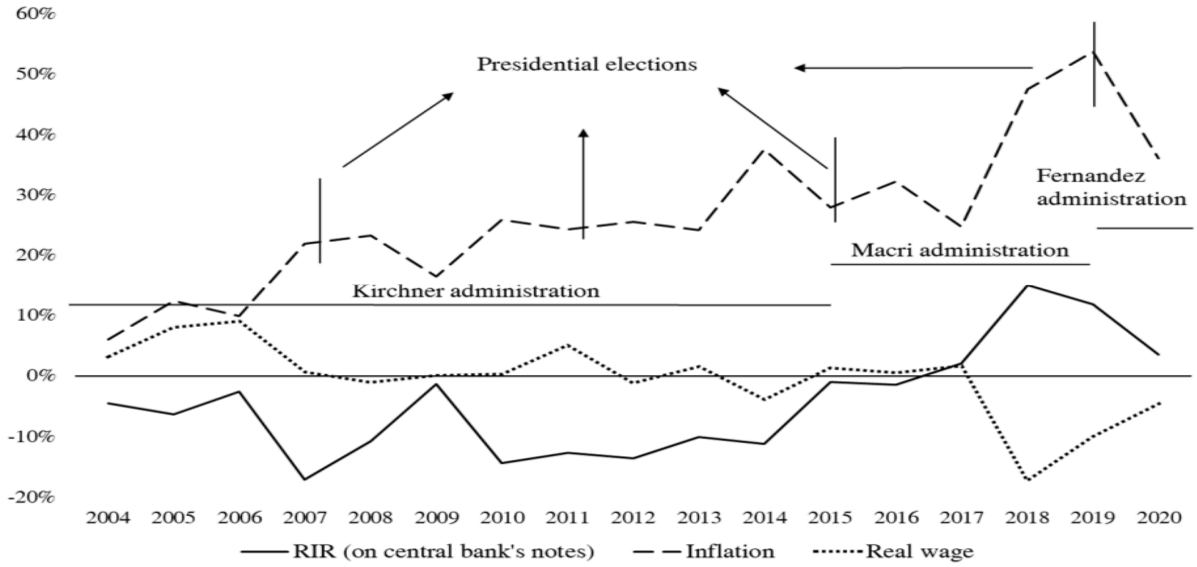

Figure 1:Inflation, real interest rate and real wage [12]

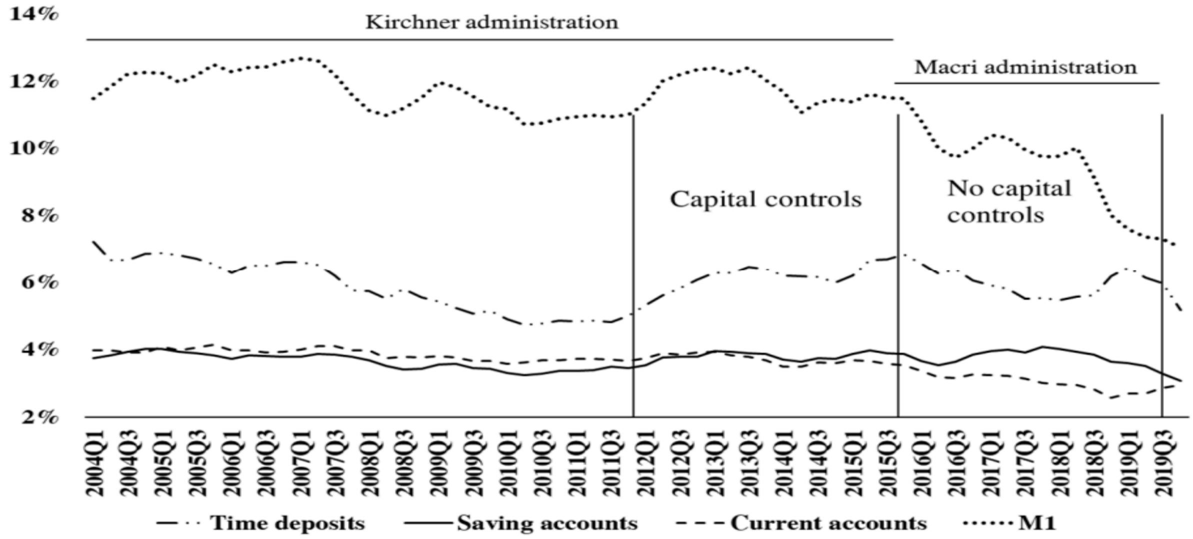

Figure 2:Deposits in domestic currency and M1 (% of GDP) [13]

[12] The sources for figure 1 are the following: for inflation, Cavallo and Bertolotto (2016) for the period 2004-2016 and from the official statistics of the INDEC (https://www.indec.gob.ar/); RIR is calculated, until 2015, using the average interest rate of all LEBACS issued each year for the shortest maturities (less than 53 days) and reported by the Central Bank of Argentina (http://www.bcra.gov.ar/). After 2015, the monetary policy rate is used; real wage is calculated using the wage index from the INDEC and correcting this index for inflation.

[13] Data for deposits in domestic currency and M1 is retrieved from the dataset provided by the Central Bank of Argentina (http://www.bcra.gov.ar/), then the average for each period was calculated and converted into percentage of the GDP by dividing for the current GDP series retrieved from the INDEC.

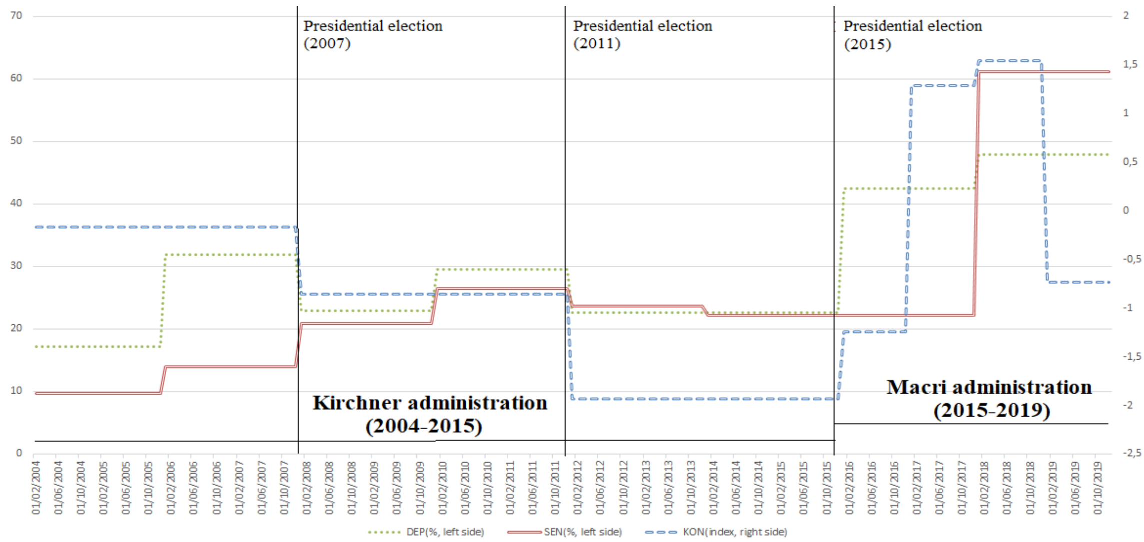

Figure 3: financial openness index (KON)[14] and center-right parties ratio at Chamber(DEP) and Senate(SEN)

In Figure 2, it becomes clear that rentiers fled during the whole period from deposits in domestic currency, trying to protect their financial wealth. This process was particularly important between 2004 and 2011, when M1 too dropped. Capital flight progressively increased during this period, becoming a dominant strategy among rentiers. The possibility to move capital abroad was abruptly stopped after the presidential elections of 2011, when capital controls were imposed. After 2011, as detailed by Rua and Zeolla (2018), the number of measures introduced to constrain capital flows strongly increased. This implied forcing rentiers to keep their investment portfolios in domestic currency. In Figure 2, indeed, it is also possible to observe that between 2011 and 2015 time deposits in domestic currency increased, and so did M1.

The dynamic of capital flight may be appreciated in Figure 3 and 4, where it is possible to check that after capital controls were introduced it dropped to almost zero. This evidence suggests that the Kirchner administration was, to a certain extent, successful in forcing rentiers to stay in domestic currency in a context of negative real interest rates. Moreover, as Gómez- Gonzalez (2019) shows, inflation-linked debt issuance decreased in Argentina –as a fraction of total public debt- between 2004 and 2016, probably due to the lack of confidence in the public statistics. The manipulation of the official CPI index took place around 2007 and would have negatively affected the demand for inflation-linked bonds, cutting for rentiers the possibility to safeguard their financial wealth through these instruments.

[14] The KON variable is taken by the Chinn-Ito index (Chinn and Ito, 2006), while the data for SEN and DEP are taken by Figure 8 and Table 1 of this chapter.

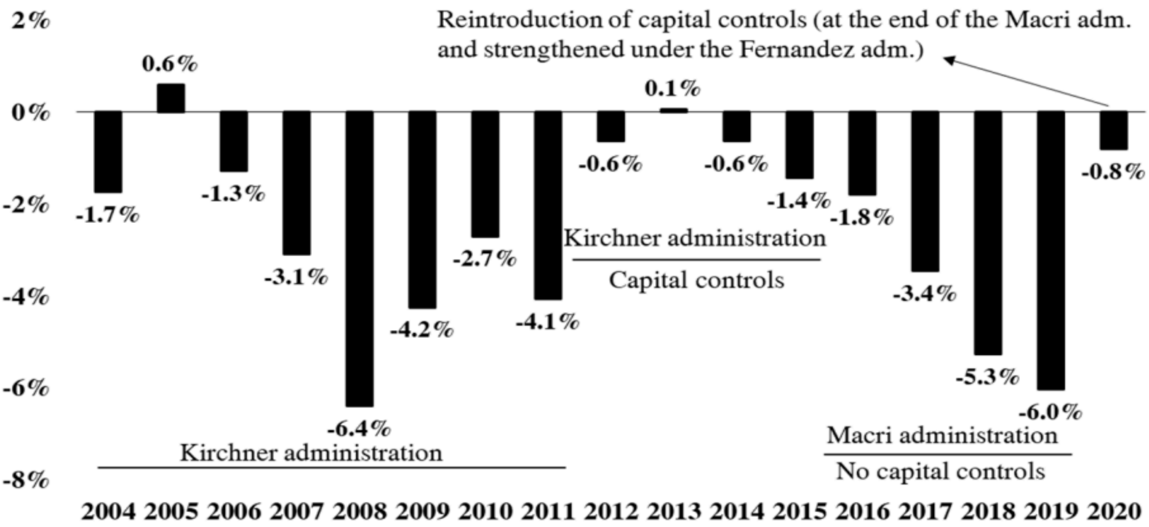

Figure 4: capital flight (% of GDP)[15]

Overall, it is possible to affirm that rentiers were not able to fully protect from inflation during the period 2011-2015 and, hence, γ_R would have remained somehow low. Thus, it seems implausible to explain the change in the coalition by resorting only to the behavior of γ_R.

What would be possible to say, then, about the behavior of γ_B? Pittaluga and Seghezza (2012b) affirm that disinflation started in Italy after the country joined the European Monetary System (EMS), because businesspeople were no longer able to resort to nominal depreciations in order to protect from inflation. Thus, from that moment on, it became more profitable for them to form the governing coalition with rentiers and not with workers. Something similar might have happened in post-convertibility Argentina.

After 2007, it may be noted in Figure 5, the real exchange rate tended to appreciate. The appreciation was similar in both periods, 2007-2011 and 2011-2015, with a reduction in the multilateral real exchange rate index of around 30%. However, in 2011 the Kirchner administration won the presidential elections again. Even when this may be seen as a puzzle, it is, possibly, far away from being one.

[15] Data for capital flight is retrieved from the dataset provided by the Central Bank of Argentina and converted into percentage of the GDP by dividing for the current GDP series retrieved from the INDEC.

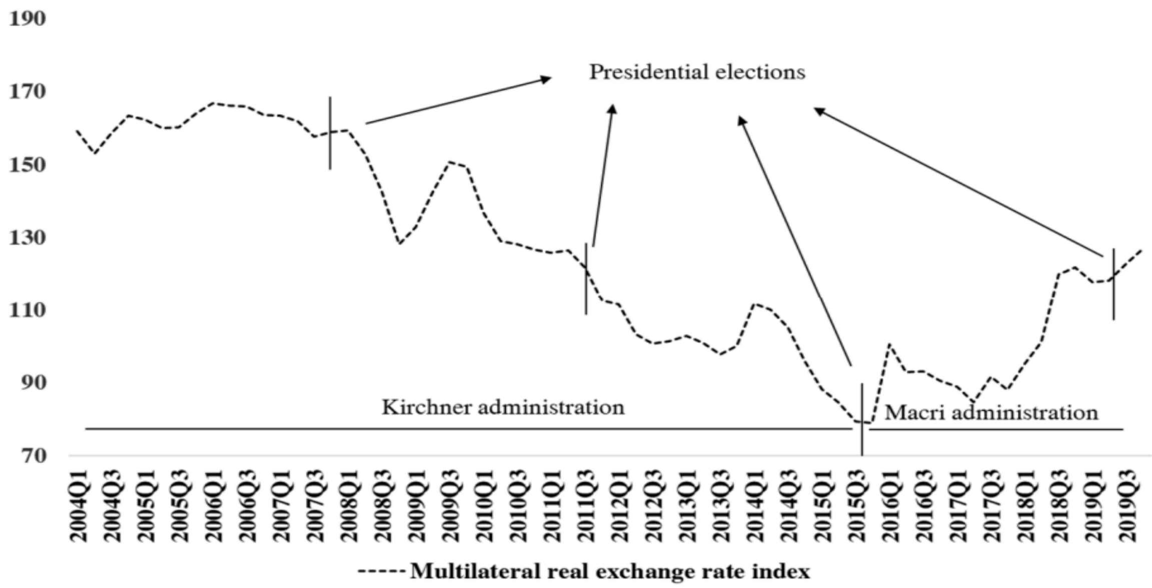

Figure 5: multilateral real exchange rate index(2005=100)[16]

After the 2001-2002 crisis, the real exchange rate depreciated and the index reached a maximum of 187 points with respect to the 68 points of December 2001. After that, it slightly appreciated and then remained more or less stable until 2007. This real exchange rate was clearly undervalued, allowing businesspeople to experience high profit margins. The appreciation experienced between 2007 and 2011, although significant, was not enough to drive the real exchange rate below its long-term equilibrium (based on the country's economic fundamentals). The picture after 2011 is somehow different. Coppola et al. (2016), for instance, estimate an overvaluation of the exchange rate of around 39% by the end of 2015 with respect to its long-term equilibrium value.

The relative success of capital controls may have pushed the government to use the exchange rate as a tool to control inflation, reducing the level of protection and the competitiveness of businesspeople. The switch in the coalition that took place in 2015 was probably due to two facts: first, the appreciation of the currency led γ_B down, pushing businesspeople to choose rentiers and throw workers out of the governing coalition; second, the relative power of workers inside the businessperson-worker coalition had been, evidently, high enough to allow for the steady increase in real wages, but not as high for businesspeople to expect a high power of lobby from them once thrown out of the coalition.

[16] Data for multilateral real exchange rate is retrieved from the dataset provided by the Central Bank of Argentina.

3.3.2 The failure of the stabilization program

The Macri administration took office in December 2015, with a policy agenda that favored the constituencies of the new coalition. Sturzenegger (2019) has analyzed the evolution of fiscal accounts during the Macri administration and points out that the new government eliminated export taxes and reduced other taxes such as those to the automotive industry and those to small and medium size firms. In addition, the new coalition aimed at benefiting rentiers from the very beginning, removing capital controls and, after the initial sharp depreciation of the currency and inflation acceleration experienced in 2016, setting positive real interest rates. In Figure 3, indeed, it may be observed that capital flight increased between 2016 and 2019. At the same time, as shown in Figure 6, deposits in foreign currency sharply increased while those in domestic currency dropped.

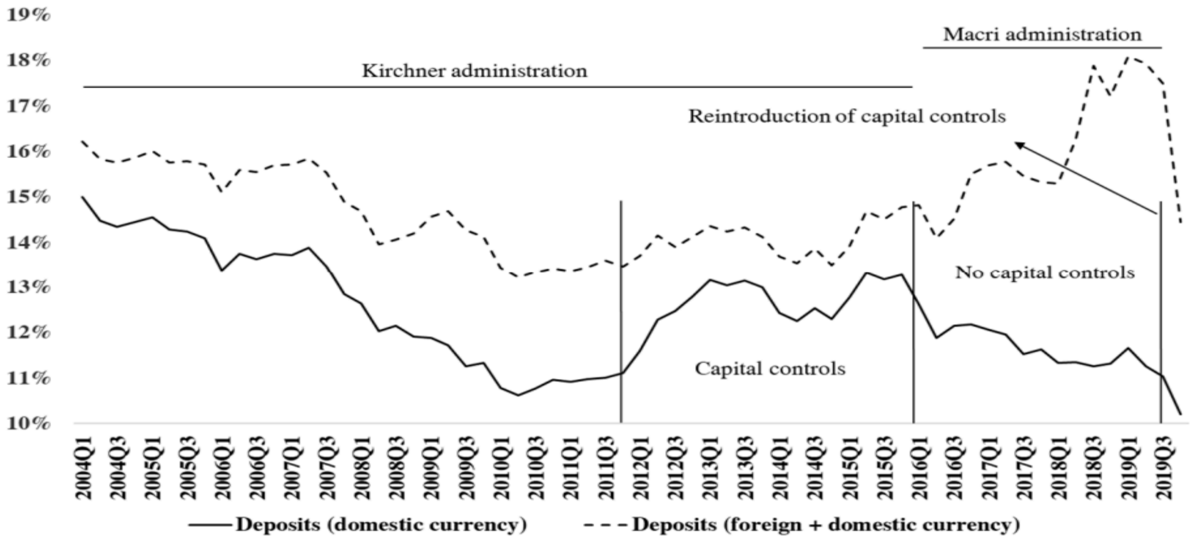

Figure 6: Deposits in domestic and foreign currency (% of GDP)[17]

Although the businessperson-rentier coalition put into practice a series of policies tending to protect rentiers and businesspeople, it also implemented policies tending to favor workers. Indeed, during 2016, the government increased the minimum income required to pay the income tax and indexed this amount. According to Sturzenegger (2019), this had a fiscal cost of 0.6% of the GDP. According to the IMF Article IV Report released in November 2016, the fiscal cost would have been 0.9% and 0.6% of the GDP in 2016 and 2017, respectively. In addition, a VAT tax cut was introduced for low-income households and the reduction in energy subsidies was combined with a *tarifa social*, aimed at protecting vulnerable households as well. This latter measure was implemented after the strong opposition that the increase in energy prices faced from the public. Overall, tax reductions triggered an increase in the federal budget deficit, as shown in Figure 7. Fiscal conditions allow us to see that the worsened of the deficit was more after election of the 2015

[17] Data for deposits in foreign currency is retrieved from the dataset provided by the Central Bank of Argentina, then the average for each period was calculated and converted into percentage of the GDP by dividing for the current GDP series retrieved from the INDEC

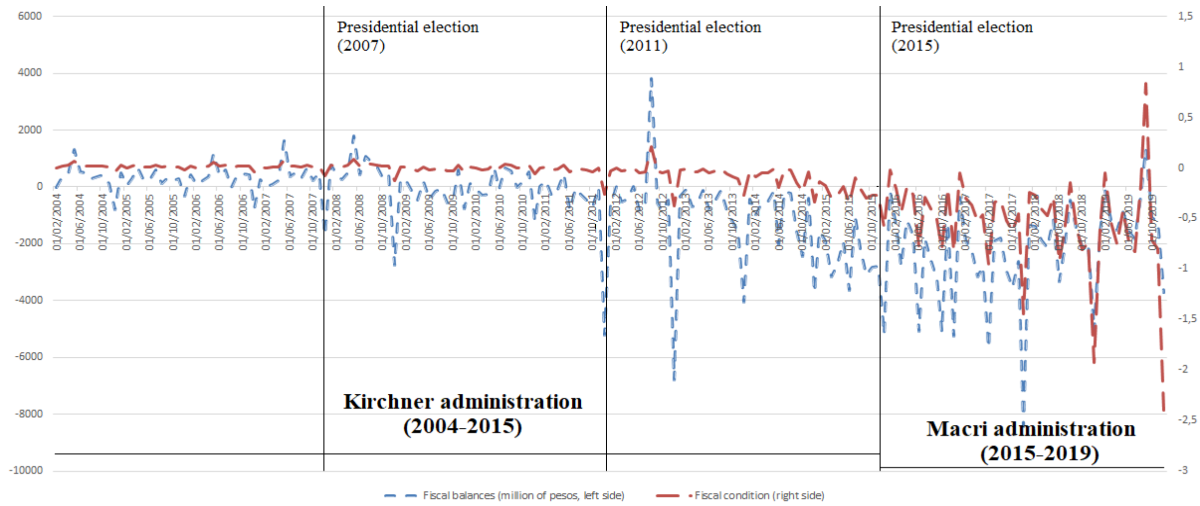

Figure 7: fiscal balances and fiscal conditions[18]

The fiscal cost due to the tax exemptions granted to workers may be seen as a loss to the new coalition due to the power of lobby of this group of interest. Interestingly, a good proxy variable of this power could be inferred from the fact that during the first two years of the Macri administration, the real wage of workers did not fall and, in fact, it actually increased in 2017 before the mid-term elections, as previously shown in Figure 1. In any case, the power of the workers lobbying cannot be properly inferred without shedding light on the political equilibriums that took place in post-convertibility Argentina.

An analysis of the political equilibriums between 2003 and 2019 let us understand that, while in general the Kirchner administration governed with parliamentary majorities (or as the first minority, at least), the Macri administration faced a tight situation in both chambers and sometimes conflict situations inside its own governing coalition, showing recurrent frictions between center and center-right constituencies. Indeed, at least until 2017, the Macri administration had to deal with narrow numbers in the Chamber of Deputies and a clear minority in the Senate. In Table 1, an analysis of the Argentine Parliament constituencies is carried out, while in Table 2 and Table 3, the evolution of the political party constitution of both chambers is presented for the whole period under analysis.

[18] Data for fiscal balances are taken by CEIC. For the fiscal conditions, we have proposed a measure based on Pittaluga and Seghezza(2012) defined as "the ratio of the fiscal balance to the level of government expenditure". Fiscal balances were obtained in pesos through CEIC data, while public spending in dollars was obtained from INDEC. Balances were converted into dollars using the peso-dollar exchange rate from FRED and then the actual ratio between the two variables was calculated.

Political Party	Constituency (a)	Constituency (b)	Constituency (c)
PJ-FPV	Center/Center-Left	B-W	Kirchner Adm. (KA)
PRO	Center/Center-Right	B-R	Macri Adm. (MA)
UCR	Center	B-W/B-R	Macri Adm. (MA)
ARI-CC	Center/Center-Right	B-R	Macri Adm. (MA)
Others (Center/Center-Right)	Center/Center-Right	B-R	None
Others (Center/Center-Left)	Center/Center-Left	B-W	None
Others (Various)	Left/Center/Right	B-W/B-R	None, KA or MA

Table 1: Political party constituencies[19]

Political Party	2004	2006	2008	2010	2012	2014	2016	2018
PJ-FPV	50%	46%	50%	34%	45%	46%	31%	25%
PRO	0%	4%	4%	4%	4%	7%	16%	21%
UCR	17%	14%	9%	17%	15%	14%	15%	16%
ARI-CC	4%	5%	11%	7%	2%	1%	2%	4%
Others (Center/Center-Right)	13%	22%	9%	18%	16%	14%	25%	23%
Others (Center/Center-Left)	8%	3%	14%	16%	14%	14%	9%	7%
Others (Various)	8%	5%	3%	4%	4%	3%	2%	4%

Table 2. Political party constitution of the Chamber of Deputies

[19] Tables 1, 2 and 3, and Figure 8 were elaborated by the authors. Note that:
a) FPV refers to "Frente de la Victoria", PJ to "Partido Justicialista", UCR to "Unión Civica Radical", ARI to "Afirmación para una República Igualitaria", CC to "Coalición Cívica" and PRO to "Propuesta Republicana".
c) Constituency (b) is assigned in order to build a clear match between the actual constituency of the political parties in terms of Constituency (a) and the categories used in the model presented in Section 3.
b) Constituency (c) refers to the position taken by the political party when the corresponding administration (KA or MA) was in office.
d) The so-called "PJ-Federal", under its different denominations, is included in the category "Center/Center-Right".
e) The category "Others (various)" includes political parties of left, center and right constituencies or those that, due to an inconstant or ambiguous behavior, are difficult to assign to a particular category.
f) The UCR is assumed to be a center political party since it has not be in power by itself during the period under analysis and it meets the requirement of having played a prominent role both in order to allow for a B-W coalition to remain in power or to allow for an B-R to take office in 2015. Indeed, though with complex internal debates, part of the UCR backed the FPV-PJ coalition in the elections of 2007, while, also, the whole party was part of the center/center-right coalition that reached power in 2015.
g) Elaborated by the authors. Data for parliamentary composition is retrieved from the dataset provided by the Chamber of Deputies of Argentina (https://www.diputados.gov.ar).

Political Party	2004	2006	2008	2010	2012	2014	2016	2018
PJ-FPV	58%	58%	58%	43%	43%	44%	51%	11%
PRO	0%	0%	0%	0%	0%	4%	8%	13%
UCR	20%	18%	11%	19%	19%	15%	11%	17%
ARI-CC	0%	0%	6%	1%	1%	0%	0%	0%
Others (Center/Center-Right)	10%	14%	15%	25%	22%	18%	14%	42%
Others (Center/Center-Left)	4%	3%	7%	7%	13%	14%	11%	11%
Others (Various)	8%	7%	3%	4%	1%	4%	4%	7%

Table 3. Political party constitution of the Senate

The parliamentary minority of the governing coalition and the existence of a center/center-left majority in the Argentinian Parliament provides another plausible proxy variable to understand why the power of lobby of workers could have forced the businessperson-rentier coalition to postpone the fiscal consolidation. There might be a chance that, in a presidential system, before reaching the government, the businessperson-rentier coalition have underestimated the actual implications of dealing with such minorities or that it might have overestimated its own power to make the center/center-left constituencies collapse before the midterm elections. Indeed, it was only after the midterm election success in 2017 that the coalition got the proper numbers in the Argentinian Parliament to put into practice the stabilization program, as shown in Figure 9. The defeat in the elections led to a break in the compact block of the PJ-FPV and increased the center/center-right constituencies in both the Chamber of Deputies and the Senate.

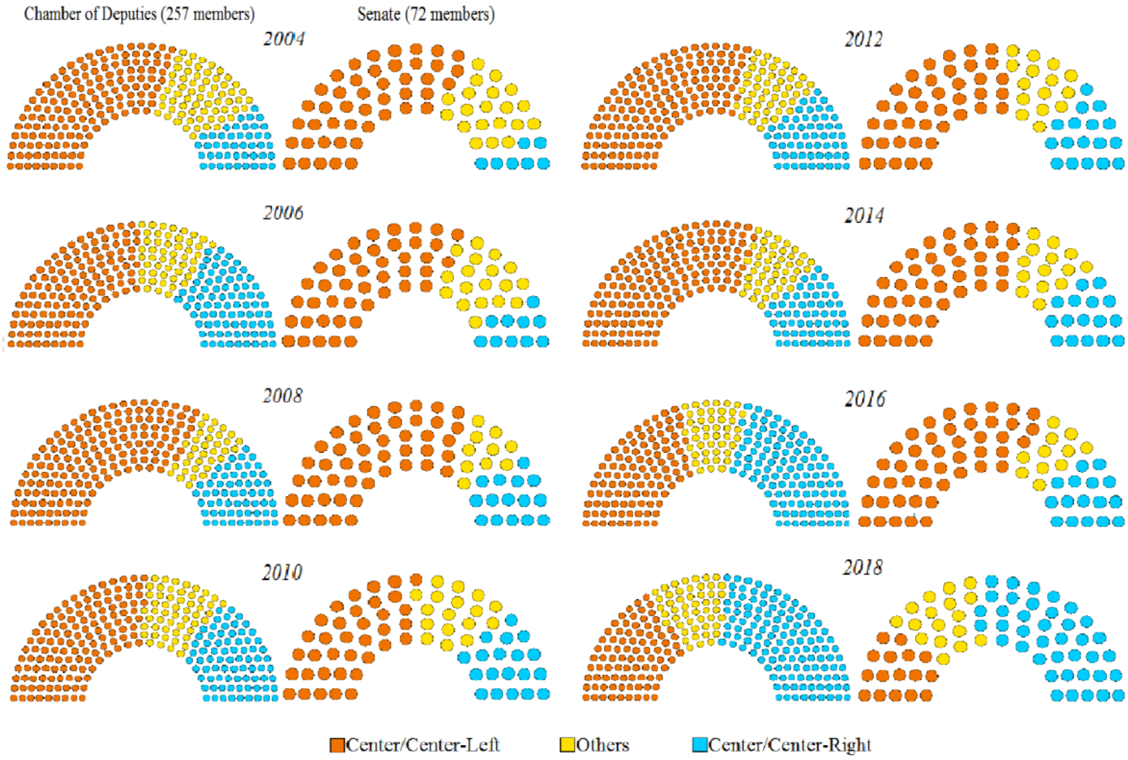

Figure 8. Constituency (c) of the Argentine Parliament

Despite the political power reached in the midterm elections, the plan to reduce the federal budget deficit encountered several problems. In particular, the speed of the fiscal consolidation was low in 2018, in which a pension system and tax reforms were implemented, but while the former tended to reduce expenditures, the latter (including a reduction in the corporate tax) implied a reduction in future tax collections. Partly due to the lack of fiscal consolidation, as affirmed by Sturzenegger (2019), partly due to the increase in the current account deficit, as affirmed by Weisbrot and Merling (2018), Argentina suffered in 2018 a *sudden stop*, which pushed the country to resort to an IMF Stand-By Arrangement (SBA). The agreement aimed at restoring market confidence while favoring the conditions to accelerate the pace of the fiscal adjustment.

The program signed with the IMF was, in part, behind the breakdown in the governing coalition. As it may be observed in Figure 2, the period 2018-2019 was characterized by highly positive interest rates (which benefited rentiers) and a sharp decrease in real wages, due to the sudden stop and its derivations in terms of an abrupt depreciation of the currency and a hike in inflation.In the midst of a severe macroeconomic crisis, attempting to shift the entire fiscal adjustment burden onto workers became an impossible task. Consequently, the government implemented a series of taxes to heighten fiscal pressure on businesspeople. This included the reinstatement of export taxes, the postponement of tax reforms, an increase in the wealth tax, and further reductions in energy subsidies.

Another factor contributing to the coalition's instability was the IMF's intervention in the labor market. The IMF proposed several measures, emphasizing fiscal tightening (through reductions in public wages, employment, and pensions) and a more accommodative monetary policy (facilitated by lower fiscal requirements in a crowding-out argument), while prohibiting deficit financing (Bortz et al, 2021). Additionally, it recommended supply-side reforms, including labor market flexibilization and deregulation, coupled with lower taxes and tariffs. Many of these recommendations were incorporated into the program associated with the Stand-By Arrangement. Moreover

In conclusion, the speed required by the fiscal consolidation was not consistent with the austerity measures the government needed to load on workers. This implied that part of the coalition, businesspeople in this case, was forced to pay for part of the fiscal adjustment. However, now the exchange rate had again moved over its long-term equilibrium and the temptation to switch the coalition partner became appealing for businesspeople again, since this way they would be able to transfer their share of the fiscal burden to the rentiers, repaying the residual debt with high inflation. The fact that in the middle of the 2018 financial crisis rentiers kept on being favored was, for sure, a signal that only part of the coalition had incentives to break it. Moreover, this shows that the coalition was not able to share the costs of stabilization and the lobby of workers in equal parts, as expected in the model of Section 4. Coordination mechanisms between both interest groups failed.

An electoral shift also took place. Murillo and Zarazaga (2020) has emphasized the role of swing voters in the rise and fall of Macri's government. In 2015, this crucial segment of the electorate had punished the Peronists, particularly the dominant faction of Kirchner, for high inflation, sluggish growth, and Argentina's economic isolation.

In 2015, an intra-Peronist split resulted in two rival Peronist tickets on the presidential ballot, creating an opportunity for Macri. However, after four years out of office, Peronist leaders refocused on the prospect of regaining power. This led to the formation of a loosely aligned pan-Peronist coalition known as the *Frente de Todos* (Front for All, FDT). Frente de Todos proved to be an effective electoral platform for Alberto Fernández. Despite Macri's efforts, the combination of a weakened economy and a unified Peronist ticket proved insurmountable, ultimately resulting in voters granting the presidency to Alberto Fernández. So Macri, similarly to the Peronists four years earlier, was criticized for the state of the economy.

The new change in the governing coalition took place in December 2019, driving the stabilization attempt to an end. Although not enough time has passed yet and data cannot be analyzed straightforwardly due to the COVID-19 outbreak and its economic consequences, it is possible to affirm that the new businessperson-worker coalition in power tried to load on rentiers the highest possible fiscal burden. The fact that, in 2019, rentiers rapidly fled from domestic currency and deposits once known the results of the presidential elections had already given a signal of the constituencies of the just elected Fernandez administration. Among other measures, the new government imposed strong capital controls, charged a tax on foreign currency purchases and sharply reduced real interest rates. Additionally, real wages reduced their rate of fall during 2020, even under the economic consequences of the COVID-19 pandemic.

3.4 The model

Following the representation of Pittaluga and Seghezza (2012), let us assume that the political system is a democracy conformed by three interest groups, *businesspeople* (B), *workers* (W), and *rentiers* (R), with populations given by n^B, n^W, and n^R, respectively and which actions are based on a two-periods system. First, no group holds a majority in order to govern on its own. For simplicity, we assume that each group accounts for one-third of the total population. In each period, elections are held and a coalition of two out of the three interest groups is elected and that $y^B > y^R > \bar{y} > y^W$, with $\bar{y}$ denoting the economy's average income and y^B, y^W and y^R that represent a non-storable income in each period for businesspeople, workers and rentiers respectively. This model draws its construct from the political conflict model of Acemoglu and Robinson (2006). Let us think that interest groups aim at winning political power in order to pursue their own interests. To do so, the government in office may use three types of taxes: an indirect tax (I), a proportional tax (τ), and an inflationary tax (τ_I). Tax collections are used to repay a debt equal to D, which must be fully repaid by the end of the second period. Given that each group has different taxation preferences, the underlying problem is to decide which taxes to use to repay the debt, a decision that, of course, depends on the taxation preferences of the coalition in office. The net income (*NI*) after taxes of each group in periods t = 1 and t = 2 is given by:

$$NI_1^B = (1-\tau_1)\,y^B - \tau_{I,1}y^B - f(\tau_{I,1}) - I_1 \tag{1}$$

$$NI_2^B = (1-\tau_2)\,y^B - \tau_{I,2}\left(\frac{1}{\gamma_B}\right)y^B - f(\tau_{I,2}) - I_2 - \frac{1}{2n^B}n^W L^e I_2 \tag{2}$$

$$NI_1^W = (1-\tau_1)\,y^W - f(\tau_{I,1}) - I_1 \tag{3}$$

$$NI_2^W = (1-\tau_2)\,y^W - f(\tau_{I,2}) - I_2 + LI_2 \tag{4}$$

$$NI_1^R = (1-\tau_1)\,y^R - \tau_{I,1}y^R - f(\tau_{I,1}) - I_1 \tag{5}$$

$$NI_2^R = (1-\tau_2)\,y^R - \tau_{I,2}\left(\frac{1}{\gamma_R}\right)y^R - f(\tau_{I,2}) - I_2 - \frac{1}{2n^R}n^W L^e I_2 \tag{6}$$

$$0 \le \tau_t, \tau_{I,t}, L, L^e \le 1\,;\ \gamma_B, \gamma_R > 0$$

where γ_B and γ_R capture the possibility that businesspeople and rentiers protect part of their income from inflation in t = 2, f suggests that inflation imposes a cost on society as a whole, affecting all groups. Here, L^e and L represent the expected and actual fraction of indirect taxes that workers recover due to their lobbying power. In the absence of workers in the governing coalition, businesspeople and rentiers divide this payment in t = 2. Consequently, businesspeople would oppose proportional taxes, while workers would resist indirect taxes. Additionally, the net income of rentiers and businesspeople differs from that of workers due to their exposure to the inflationary tax, τ_I. However, γ_B and γ_R enable these groups to shield a portion of their income in the second period. This mechanism is derived from the frameworks of Seghezza and Morelli (2014), Perotti (1996), and Labán and Sturzenegger (1994). Higher γ_B and γ_R values allow businesspeople and rentiers to safeguard a greater proportion of income and pay fewer taxes. For workers, it is assumed that wages are indexed, providing protection against inflation. While this assumption may seem restrictive, it accurately reflects the situation of formal labor market workers in Argentina. In the case of informal labor market workers, alternative transfer mechanisms (e.g., welfare state policies) would aim to counteract inflation effects, especially when a businessperson-worker coalition is in power.

Regarding the general effects of inflation, the idea behind *f* is that inflation represents a cost (C) for the economy as a whole following C(0)=0, C'(f)>0 and C''(f)<0. It is implicitly assumed that inflation is a regressive tax (note that it is not set as proportional to taxes).

An important difference respect to the classical political exchange hypothesis model is that workers are able to carry out lobbying activities in $t = 2$ and, as a result, they get a transfer equal to LI_2, which means that they partially recover their payment in concept of indirect taxes. Let us assume that $0 < L^e, L \leq 1$ only if workers are not part of the governing coalition in $t = 2$, otherwise $L^e = L = 0$. The variable L^e is an expected variable, and represents the power of lobby businesspeople and rentiers expect from workers in the case they decide to push them out of the governing coalition. This assumption, which introduces asymmetric information in the model. For the moment, we consider that $L^e = L = 0$.

The government faces a budget constraint in every period given by

$$BC_1: R_1 \geq \tau_1 \sum n^i y^i + \tau_{I,1} n^R y^R + \tau_{I,1} n^B y^B + NI_1 \tag{7}$$

$$BC_2: R_2 \geq \tau_2 \sum n^i y^i + \tau_{I,2} n^R y^R \left(\frac{1}{\gamma_R}\right) + \tau_{I,2} n^B y^B \left(\frac{1}{\gamma_B}\right) + NI_2 - n^W L^e I_2 \tag{8}$$

$$D = R_1 + R_2 \tag{9}$$

Eq. (7) and Eq. (8) state that government's collections must be at least equal to the amount of debt that the government chooses to repay in every period, R_1 and R_2. The debt is equal to D and, as stated in Eq. (9), what the government does not pay in $t = 1$ must be completely repaid in $t = 2$. Moreover, it is assumed that only a fraction $R_{1,max} < D$ is feasible to pay in $t = 1$. In $t = 2$, it may be observed, the budget constraint is different, since rentiers and businesspeople may protect part of their income from inflation while workers may carry out lobbying activities to get a transfer from the government.

3.4.1 The case of gradual stabilization

Respect to the case of *immediate stabilization* (i.e if rentiers were the majority of the population or if it is induced from abroad through a foreign loan to repay the debt), our analysis will be focused on the case of *gradual stabilization*, which appears to be suitable to understand inflation dynamics in post-convertibility Argentina.

In the case of gradual stabilization, it is assumed that interest groups are not numerous enough to govern on their own. Thus, coalitions must be formed. For simplicity, let us assume that $N = 3$ and that $n^B = n^R = n^W = 1$. The model is solved using backward induction, since agents are assumed to be rational and forward-looking. Hence, in the first place the coalitions that may be formed in $t = 2$ are analyzed. Let us assume that in $t = 2$ a businessperson-rentier coalition is called to office. This coalition maximizes

$$max\ \frac{1}{2}[NI_2^B + NI_2^R] \tag{10}$$

s.t

$$R_2 \geq \tau_2 \sum n^i y^i + \tau_{I,2} n^R y^R \left(\frac{1}{\gamma_R}\right) + \tau_{I,2} n^B y^B \left(\frac{1}{\gamma_B}\right) + 3I_2 - L^e I_2 \tag{11}$$

where Eq. (10) denotes the average income of the coalition and Eq. (11) the budget constraint. From the first order conditions (FOCs) of the maximization problem and the Kuhn-Tucker conditions (K-T) it is possible to infer that the businessperson-rentier coalition would be inclined to set $\tau_{I,2} = 0$, $\tau_2 = 0$, and pay R_2 using I_2.

What would happen if the businessperson-rentier coalition was not called to office and, instead, a businessperson-worker coalition is in power? This coalition would maximize

$$max\ \frac{1}{2}[NI_2^B + NI_2^W] \tag{12}$$

s.t

$$R_2 \geq \tau_2 \sum n^i y^i + \tau_{I,2} n^R y^R \left(\frac{1}{\gamma_R}\right) + \tau_{I,2} n^B y^B \left(\frac{1}{\gamma_B}\right) + 3I_2 \tag{13}$$

where it is possible to observe that there are not any lobby expenditures to pay in the budget constraint ($L^e = 0$) and any income derived from lobbying inside NI^W ($L = 0$). This coalition, as it is derived from the FOCs and the K-T conditions would set $I_2 = 0$, $\tau_{I,2} > 0$, and would chose to repay any remaining debt that cannot be paid with inflation using proportional taxes such that

$$f'(\tau_{I,2}) = -\frac{y^B}{2\,\gamma_B} + \frac{y^B + y^W}{2\sum n^i y^i}\left[\frac{y^B}{\gamma_B} + \frac{y^R}{\gamma_R}\right] \tag{14}$$

Following an analogous procedure, it would be possible to note that the logical choice for a rentier-worker coalition would be to set $\tau_{I,2} = 0$, $I_2 = 0$ and repay the debt using τ_2.

The coalition that comes to power in the second period depends on the payoffs each group of interest receives under each coalition, and these, in turn, would be:

$$NI_{2,B-W}^{i} = y^{i}\left[1 - \frac{R_2 - \tau_{I,2}{}^{*}\left(\frac{y^R}{\gamma_R}\right) + \tau_{I,2}{}^{*}\left(\frac{y^B}{\gamma_B}\right)}{\sum n^i y^i}\right] - f(\tau_{I,2}{}^{*}),$$

$$i = B, W \qquad (15)$$

$$NI_{2,B-R}^{i} = y^{i} - \frac{R_2}{3} - \frac{1}{2}L^{e}I_2, \quad i = B, R \qquad (16)$$

$$NI_{2,R-W}^{i} = y^{i}\left[1 - \frac{R_2}{\sum n^i y^i}\right], \quad i = R, W \qquad (17)$$

It is derived straightforward from Eqs. (15)-(17), that in $t = 2$ a businessperson-rentier coalition comes to office if businesspeople stick to rentiers and vice versa. The former happens when:

$$\frac{R_2}{3} + \frac{1}{2}L^{e}I_2 < y^{B}\,\frac{R_2 - \tau_{I,2}{}^{*}\left(\frac{y^R}{\gamma_R}\right) + \tau_{I,2}{}^{*}\left(\frac{y^B}{\gamma_B}\right)}{\sum n^i y^i} + f(\tau_{I,2}{}^{*}) \qquad (18)$$

while the latter does it if

$$\frac{R_2}{3} + \frac{1}{2}L^{e}I_2 < \frac{y^R R_2}{\sum n^i y^i} \qquad (19)$$

The analysis of the payoffs for each group of interest allows understanding the underlying reasons that may trigger the access of rentiers to the governing coalition and, thus, a stabilization. In particular, it may be noted throughout Eqs. (18)-(19) that rentiers may come to power, ceteris paribus, if the costs of inflation are higher ($f(\tau_{I,2}{}^{*})$), if the ability to protect from inflation for rentiers (businesspeople) increases (decreases) and if the expected power of lobby of workers (L^e) decreases.

Let us focus now on $t = 1$ and let us assume that, in this period, the coalitions maximize their income assuming that Eqs. (18)-(19) hold, so a businessperson-rentier coalition will be called to office in $t = 2$. Let us assume, then, that a businessperson-worker coalition takes office in $t= 1$. This coalition chooses to set $I_1 = 0$ and pays the maximum amount of debt possible, $R_{1,max}$, using τ_1 and $\tau_{I,1}$ such that

$$f'(\tau_{I,1}) = -\frac{y^B}{2} + \frac{[y^R + y^B]\,[y^B + y^W]}{2\sum n^i y^i} \qquad (20)$$

In an analogous way, it could be proven that a worker-rentier coalition sets inflation and indirect taxation to zero and pays $R_{1,max}$ using τ_1, while a businessperson-rentier coalition would pay using I_1. However, these cases have not any interest in the present analysis, since that would mean that stabilization would take place in t = 1.

By taking a look at the payoffs for each group considering now both periods it is possible to note that businesspeople make the coalition with workers if:

$$\frac{R_1}{3} > y^B \left[\frac{R_{1,max} + \tau_{I,2}{}^{*} y^B - \tau_{I,2}{}^{*} y^R}{\sum n^i y^i}\right] + f(\tau_{I,2}{}^{*}) \qquad (21)$$

On its part, rentiers choose to make the coalition with businesspeople if

$$\frac{y^R}{\sum n^i y^i} > 0 \qquad (22)$$

Since rentiers will always choose to form a coalition with businesspeople, it is possible to infer that, if Eq. (21) holds, then a businessperson-worker coalition seeks to pay $R_{1,max}$ using the inflationary tax in t = 1, while a businessperson-rentier coalition is called to office in $t = 2$ and stabilizes the economy.

3.4.2 The role of workers' lobbying

The model developed in Section 3 assumes that if Eqs. (18)-(19) hold, then a businessperson- rentier coalition comes to power in $t = 2$. In this sense, at least two questions need to be answered in what follows: first, which drivers, among all the possible ones found in Eqs. (18)- (19), were behind the switch from a businessperson-worker into a businessperson-rentier coalition in Argentina in December 2015? Second, what could have caused the stabilization plan put forward by the new governing coalition to fail soon after its start?

The model allows workers to carry out lobbying activities when they are not part of the coalition in power. The introduction of lobby and asymmetric information allows counting on a straightforward mechanism to explain why a businessperson-rentier coalition may implement a stabilization program but fail halfway. *A priori*, one may be tempted to assume that, simply, $L^e < L$ and, so, a simple mismatch between expected and actual lobby would make the stabilization plan fail. In this case, however, it would be necessary to explain why businesspeople would decide to break the coalition with workers based on wrong premises. Otherwise, the argument would just rely on the existence of irrationality.

Let us consider that in our economy the actual power of lobbying of workers that carry out *good lobby*. Let us assume that the number of unions[20] in this economy is given by μ, of which a fraction η carries out good lobbying activities while a fraction $(1 - \eta)$ carries out *bad lobby*. Additionally, let us normalize $n^W = 1$ and assume that all workers belong to an union, so that the average size of unions in this economy is given by $\bar{n}^W = n^W/\mu$. However, not all the unions have the same size and not all of them make good lobby. Hence, it is possible to define n^W as the average number of workers belonging to a good

[20] We assume that workers can apply lobbying on the ruling coalition through the action of trade unions. However, we can also assume that workers can do good or bad lobbying without necessarily going through the unions by positing that a fraction of them may be ideally represented as a *swing voter* who could support the policies of the businesspeople-rentiers coalition government while being part of the workers. For simplicity we identify unions as the main lobbying medium in this model.

union and $\bar{n}^{W} = n^{W}/\,(\eta\mu)$ as the average size of the unions that carry out good lobbying activities.

Using a simple mechanism *à la* Akerlof, let us consider the case in which businesspeople know that there exists a fraction η of unions that carries out good lobby, but cannot identify exactly which ones. In consequence, businesspeople are able to see $\bar{n}$_n^{W} but not $\bar{n}$u,n^{W} . This is a plausible assumption, for instance, when unions are numerous and fragmented and/or if coordination problems exist inside the group of businesspeople. The Argentinian case, for sure, fits these features properly. In addition, this could be interpreted as a prior that businesspeople have regarding the actual power of unions, assuming that all workers will follow the political leads traced by the leaders of the union to which they belong. However, there may exist a possibility that not all the workers follow them and even if unions made bad lobbying, workers would be able to lobby as well, and do it better. It is possible, now, to define the functions for lobby such that

$$L^{e} = (\sqrt{\bar{n}_{\mu}^{W}}) \tag{23}$$

$$L = (\sqrt{\bar{n}_{\mu,\eta}^{W}}) \tag{24}$$

Eq. (23) establishes that the expected income businesspeople and rentiers expect to concede in $t = 2$ positively depends the average size of unions. Instead, according to Eq. (24), the actual amount L depends on the average size of unions making good lobby. Moreover, the square root in the function implies that the bigger the average size of unions implies a larger expected and actual transfer, but the increment in both functions in decreasing, probably due to increasing collective action costs, such as in Fredriksson et al. (2005).

Given Eqs. (23)-(24), there may exist a chance that businesspeople rationally decide to switch the coalition in favor of rentiers but, if $L^{e} < L$, the stabilization may fail. This would happen, for instance, if

$$\frac{R_2}{3} + \frac{1}{2}L^{e}I_2 < \; y^{B}\,\frac{R_2 - \tau_{I,2}{}^{*}\left(\frac{y^{R}}{\gamma_R}\right) + \tau_{I,2}{}^{*}\left(\frac{y^{B}}{\gamma_B}\right)}{\sum n^{i}y^{i}} + \; f\left(\tau_{I,2}{}^{*}\right) \tag{25}$$

and

$$\frac{R_2}{3} + \frac{1}{2}LI_2 > \; y^{B}\,\frac{R_2 - \tau_{I,2}{}^{*}\left(\frac{y}{\gamma_R}\right) + \tau_{I,2}{}^{*}\left(\frac{y}{\gamma_B}\right)}{\sum n^{i}y^{i}} + \; f\left(\tau_{I,2}{}^{*}\right) \tag{26}$$

In Fig. 1, it is possible to appreciate that whenever $L^{e} < L$ the probability of failure is non-negative. However, the outcome of the stabilization program depends also on the value of the rest of the parameters.

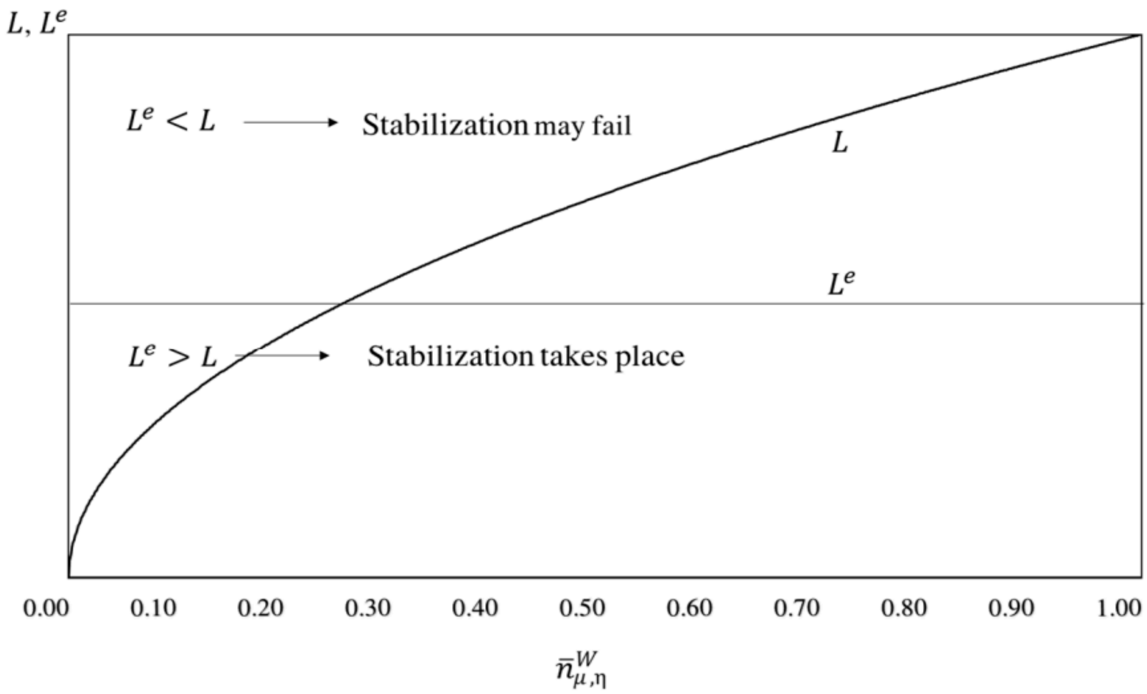

Figure 9. Power of lobby of workers and probability of failure of stabilization

From this perspective, bad lobbying by workers' representatives (i.e., unions) can be considered a structural characteristic of the Argentine economy. As emphasized by Santos and Duhalde (2021), unionism in Argentina, while experiencing a consolidation phase during the progressive government's tenure, has always been problematic regardless of the ruling coalition. Capitalists, however, had their reasons to expect positive lobbying, as stabilization would have allowed real wages to be less impacted by inflation. Anticipating a fiscal policy that would provide more benefits to workers, it was conceivable that the costs of belonging to the coalition with rentiers would facilitate the completion of stabilization, falling into the case of $L^e > L$. As shown in Figure 2, general real wages increased in the period 2015-2017 (despite the inflation increase due to the significant devaluation post-December 2015), and, as we will see, the conditions for identifying a policy aimed at increasing workers' income to limit bad lobbying were present.

A further interpretation is the limitation of the bargaining power of labor unions. Indeed, back in 2017 there were attempts by the Macri government to liberalize the labor market as part of its liberal agenda (Montes Cato and Ventrici, 2017). However they found strong opposition from progressive parties and the unions themselves, but the IMF's requests of reform in 2018 allowed for an "*absence of bad lobbying*" (which conceptually is like having an ideal L≤Le). In light of what was discussed in Section 3, the "inflation targeting" regime was more "wage targeting" regimes continuing with the proposition of Bortz et al(2021). Since the capacity to control inflation is noticeably greater when there is weaker resistance to wage adjustments, the limitation of the bargaining power of the unions allows the political exchange to continue (despite the fact that fiscal consolidation then did not yield the desired results).

3.6 Conclusions

This paper builds on the political exchange hypothesis put forward by Beetsma and Van der Ploeg (1996) and assesses inflation dynamics in post-convertibility Argentina in connection with the political equilibriums that characterized the country since the beginning of the 2000s. To this end, it presents a model in the line of Pittaluga and Seghezza (2012) in which three groups of interest –businesspeople, rentiers and workers- express their demand for inflation and political parties compete to reach the government by representing these demands. Since no group is numerous enough to govern by itself, coalitions are formed and, once a coalition comes to office, it sets inflation in order to meet the demand of its constituencies. Just as in Seghezza and Pittaluga (2012), the approach assumes that inflation may be used as any other tax to collect resources from the population and then redistribute them among government supporters.

Through the lenses of the model, Argentina experienced, after the macroeconomic crisis of 2001-2002, two political equilibriums, consistent each of them with different rates of inflation. Between 2003 and 2015, a businessperson-worker coalition (Kirchner's administration) was in power, which favored workers and businesspeople but left rentiers aside and tried to make them pay an increasing inflationary tax. However, the decreasing level of protection from inflation experienced by businesspeople due to an overvaluation of the real exchange rate and the low power of lobby expected from workers pushed businesspeople to switch the coalition in 2015, letting workers aside and bringing rentiers in. This businessperson-rentier coalition (Macri's administration) implemented a stabilization program that aimed to reduce inflation -failing to do so- and favor its constituencies. The coalition, indeed, favored rentiers with high real interest rates and free capital mobility and businesspeople with tax cuts. The fact that, ex post, the actual power of the lobby of workers turned out to be higher than expected implied that businesspeople had to bear part of the costs of stabilization. This may explain the failure in stabilization and the reversal in the political equilibrium, which brought a businessperson-worker coalition back to power in 2019.

Connecting the political equilibriums with inflation dynamics in the light of the political exchange hypothesis constitutes a novel approach to explain the causes of inflation, the delay and the failure in stabilization in post-convertibility Argentina. The inclusion of rentiers contributed largely to the originality of the approach, since it allowed extending the model to analyze the evolution of financial wealth in times of inflation. Clearly, even when inflation hurts low-income households the most, it could have a wider effect over rentiers eroding their portfolios in domestic currency.

In terms of policy implications, the model provides some leads to understand how to prevent episodes of inflation and how to put into practice a successful stabilization program. On the one hand, the model allows inferring that if financial wealth is polarized and rentiers are a minority, there is a great incentive for policymakers to use the inflationary tax as a way to redistribute wealth. This situation could be discouraged if rentiers counted on a developed financial system, which provided them instruments to protect from inflation. On the other hand, it is possible to presume that if a stabilization program is implemented in the future, it should be highly coordinated so that the benefits and potential costs of the stabilization are equally shared between the groups of interest inside the governing coalition. Hence, the probability to suffer a coalition break would be minimized. From this minimization it should be derived the possible speed of a disinflation program.

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Appendix: mathematical detail of Section 3.4

Optimization problems for each coalition:

Businessperson-rentier ($t = 2$):

$$max\ \frac{1}{2}\left[NI_2^{\ B} + NI_2^{\ R}\right] \tag{A1}$$

s-t

$$R_2 \geq \tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + 3I_2 - L^e I_2 \tag{A2}$$

FOCs

$$\frac{\partial}{\partial \tau_2} = \frac{y^B + y^R}{2} + \lambda \sum n^I y^i \leq 0 \tag{A3}$$

$$\frac{\partial}{\partial \tau_{I,2}} = \frac{y^R}{2\gamma_R} - \frac{y_B}{2\gamma_B} - f'(\tau_{I,2}) + \lambda\left(\frac{y^R}{\gamma_R} + \frac{y^B}{\gamma_B}\right) \leq 0 \tag{A4}$$

$$\frac{\partial}{\partial I_2} = -\left[1 + \frac{1}{2}L^e\right] + \lambda[3 - L^e] \leq 0 \tag{A5}$$

$$\frac{\partial}{\partial \lambda} = \tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + 3I_2 - L^e I_2 - R_2 \geq 0 \tag{A6}$$

Kuhn-Tucker (K-T) conditions

$$\tau_2 \geq 0;\ \tau_2\left(-\frac{y^B + y^R}{2} + \lambda \sum n^i y^i\right) = 0 \tag{A7}$$

$$\tau_{I,2} \geq 0;\ \tau_{I,2}\left[-\frac{y^R}{2\gamma_R} - \frac{y^B}{2\gamma_B} - f'(\tau_{I,2}) + \lambda\left(\frac{y^R}{\gamma_R} + \frac{y^B}{\gamma_B}\right)\right] = 0 \tag{A8}$$

$$I_2 \geq 0;\ I_2\left[-\left(1 + \frac{1}{2}L^e\right) + \lambda(3 - L^e)\right] = 0 \tag{A9}$$

$$\lambda \geq 0; \lambda\left\{\tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + I_2(3 - L^e) - R_2\right\} = 0 \tag{A10}$$

Businessperson-worker (t= 2):

$$max\ \frac{1}{2}\left[NI_2^{\ B} + NI_2^{\ w}\right] \tag{A11}$$

s.t

$$R_2 \geq \tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + 3I_2 \tag{A12}$$

FOCs

$$\frac{\partial}{\partial \tau_2} = \frac{y^B + y^w}{2} + \lambda \sum n^I y^i \leq 0 \tag{A13}$$

$$\frac{\partial}{\partial \tau_{I,2}} = -\frac{y_B}{2\gamma_B} - f'(\tau_{I,2}) + \lambda\left(\frac{y^R}{\gamma_R} + \frac{y^B}{\gamma_B}\right) \leq 0 \tag{A14}$$

$$\frac{\partial}{\partial I_2} = -1 + \frac{1}{2}\left(L - \frac{1}{2}L^e\right) + \lambda[3 - L^e] \leq 0 \tag{A15}$$

$$\frac{\partial}{\partial \lambda} = \tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + 3I_2 - R_2 \geq 0 \tag{A16}$$

Kuhn-Tucker (K-T) conditions

$$\tau_2 \geq 0;\ \tau_2\left(-\frac{y^B + y^w}{2} + \lambda \sum n^i y^i\right) = 0 \tag{A17}$$

$$\tau_{I,2} \geq 0;\ \tau_{I,2}\left[-\frac{y^B}{2\gamma_B} - f'(\tau_{I,2}) + \lambda\left(\frac{y^R}{\gamma_R} + \frac{y^B}{\gamma_B}\right)\right] = 0 \tag{A18}$$

$$I_2 \geq 0;\ I_2\left[-\left(1 + \frac{1}{2}L^e\right) + \lambda(3 - L^e)\right] = 0 \tag{A19}$$

$$\lambda \geq 0; \lambda\left\{\tau_2 \sum n^i y^i + \tau_{I,2}\left[n^R y^R\left(\frac{1}{\gamma_R}\right) + n^B y^B\left(\frac{1}{\gamma_B}\right)\right] + 3I_2 - R_2\right\} = 0 \tag{A20}$$

Businessperson-worker (t= 1):

$$max\ \frac{1}{2}\left(NI_1^B + NI_1^w\right) + \frac{1}{2}\left(y^B + y^w\right) - \left(\frac{R_2}{3} + \frac{1}{2}L^e I_2\right) \tag{A21}$$

s.t

$$R_1 \geq \tau_1 \sum n^i y^i + \tau_{1,1}\left(y^R + y^B\right) + 3I_2 \tag{A22}$$

$$R_{1.\,max} - R_1 \geq 0 \tag{A23}$$

FOCs

$$\frac{\partial}{\partial \tau_1} = \frac{y^B + y^w}{2} + \lambda_0 \sum n^I y^i \leq 0 \tag{A24}$$

$$\frac{\partial}{\partial \tau_{I,1}} =- \frac{y_B}{2} - f'(\tau_{I,1}) + \lambda_0 \left(y^B + y^W\right) \leq 0 \tag{A25}$$

$$\frac{\partial}{\partial I_1} =- 1 + 3\lambda_0 \leq 0 \tag{A26}$$

$$\frac{\partial}{\partial R_1} =- \frac{1}{3} - \lambda_0 + \lambda_1 \leq 0 \tag{A27}$$

$$\frac{\partial}{\partial \lambda_0} = - R_1 + \tau_1 \sum n^i y^i + \tau_{I,2}(y^B + y^R) + 3I_1 - L^e I_2 - R_2 \geq 0 \tag{A28}$$

$$\frac{\partial}{\partial \lambda_1} =- R_{1,max} + R_1 \geq 0 \tag{A29}$$

Kuhn-Tucker (K-T) conditions

$$\tau_1 \geq 0;\ \tau_1 \left(- \frac{y^B + y^w}{2} + \lambda_0 \sum n^i y^i\right) = 0 \tag{A30}$$

$$\tau_{I,1} \geq 0;\ \tau_{I,1} \left[- \frac{y^B}{2} - f'(\tau_{I,1}) + \lambda_0 \left(y^R + y^B\right)\right] = 0 \tag{A31}$$

$$I_1 \geq 0;\ I_1(- 1 + 3\lambda_0) = 0 \tag{A32}$$

$$R_1 \geq 0;\ R_1 \left[- \frac{1}{3} - \lambda_0 + \lambda_1\right] = 0 \tag{A33}$$

$$\lambda_0 \geq 0; \lambda_0 \left[- R_1 + \tau_1 \sum n^i y^i + \tau_{I,2}(y^B + y^R) + 3I_1\right] = 0 \tag{A34}$$

$$\lambda_1 \geq 0; \lambda_1(- R_{1,max} + R_1) = 0 \tag{A35}$$

Note that the objective function here has three terms. The first term constitutes the average net income of the groups in t = 1, the second term is the average income in t = 2 and, finally, the third term detracts from this latter the indirect income groups will face in that period. The existence of two constraints accounts for the fact that, in $t = 1$, a maximum amount of debt $R_{1,max}$ is assumed to be paid so that the residual debt R_2 is positive. Payoffs for each group in (t= 1) assuming a businessperson-rentier coalition in (t= 2):

$$NI^B_{1,B-w} + NI^B_{2,B-R} = y^R \left[1 - \frac{R_1 + \tau^*_{I,2}(y^B + y^R)}{\sum n^i y^i}\right] - f(\tau^*_{I,2}) + y^B - \frac{R_1}{3} - \frac{1}{2} L^e I_2 \tag{A36}$$

$$NI^B_{1,B-R} + NI^B_{2,B-R} = 2y^B - \frac{R_1 + R_2}{3} - \frac{1}{2} L^e I_2 \tag{A37}$$

$$NI^R_{1,B-R} + NI^R_{2,B-R} = 2y^R - \frac{R_1 + R_2}{3} - \frac{1}{2} L^e I_2 \tag{A38}$$

$$NI^R_{1,R-w} + NI^R_{2,B-R} = y^R \left(2 - \frac{R_1}{\sum n^i y^i}\right) - \frac{R_1 + R_2}{3} - \frac{1}{2} L^e I_2 \tag{A39}$$

$$NI^{w}_{1,R-w} + NI^{w}_{2,B-R} = y^{w}\left(2 - \frac{R_1}{\sum n^i y^i}\right) - \frac{R_1 + R_2}{3} - \frac{1}{2} L^{e} I_2 \tag{A40}$$

$$NI^{w}_{1,B-w} + NI^{w}_{2,B-R} = y^{w}\left[2 - \frac{R_1 - \tau_{I,2}^{*}(y^B + y^R)}{\sum n^i y^i}\right] - f(\tau_{I,2}) - \frac{R_2}{3} - \frac{1}{2} L^{e} I_2 \tag{A41}$$

where $R_1 = R_{1,max}$ and $R_2 = D - R_{1,max}$

Note that the income of businesspeople is condensed in Eqs. (A.36)-(A.37) (for both cases, in which they make a coalition with workers and rentiers in t = 1, respectively); the income of rentiers is condensed in Eqs. (A.38)-(A.39) (for both coalitions with businesspeople and workers in t = 1, respectively); and the income of workers is presented in (A.40)-(A.41) (for both coalitions with rentiers and businesspeople in tt= 1, respectively).

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