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Revisiting the Nexus of Wages, Prices and Private Consumption in the EMU Period through Graphical Multivariate Panel Data Models

Revisitando el nexo entre salarios, precios y consumo privado en el periodo UEM a partir de modelos gráficos multivariantes para datos de panel

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Abstract

This paper aims to analyse the dynamic relationships between prices, wages and private consumption for a sample of the 12 initial Economic and Monetary Union (EMU) members for the period 1999-2019. To do so, we adopt a novel approach based on panel-VAR model that allows us to perform a multivariate Granger causality analysis between the variables mentioned within a complex information system which also includes labour market and economic cycle variables. In a second stage, we complete this analysis with the application of the iterative PC algorithm that makes it possible to interpret the results of the model in the lines of graphic theory and causal graphs methods. The results obtained reveal a causal relationship from prices to wages, supporting the wage indexation hypothesis for the whole sample. On the contrary, we do not find evidence of wages causing any increase of prices, which enables us to rule out the wage-inflation hypothesis. Additionally, the approach adopted enables country-specific analyses, which are essential for understanding the specificities of each economy. In this regard, we find that Ireland is the only country where private consumption appears to exert pressure on prices.

Meanwhile, Mediterranean economies like Spain and Greece seem to follow a debt-led model where private consumption drives wage levels.

Keywords: Prices, Wages, Private Consumption, Granger causality, Causal maps.

Resumen

Este trabajo tiene como objetivo analizar las relaciones dinámicas entre precios, salarios y consumo privado para una muestra de los 12 miembros iniciales de la Unión Económica y Monetaria (UEM) durante el período 1999-2019. Para ello, adoptamos un enfoque novedoso basado en modelos panel-VAR que nos permiten llevar a cabo un análisis de causalidad multivariante de Granger entre las variables mencionadas dentro de un sistema de información complejo que incluye también variables del mercado laboral y del ciclo económico. En una segunda etapa, completamos este análisis con la aplicación del algoritmo PC iterativo que nos permite interpretar los resultados del modelo en términos de teoría gráfica y métodos de gráficos causales. Los resultados obtenidos muestran una relación causal de los precios a los salarios, apoyando la hipótesis de indexación salarial para el total de la muestra. Por el contrario, no encontramos evidencia de que los salarios causen un aumento de los precios, lo que nos permite descartar de forma generalizada la hipótesis de inflación salarial. Adicionalmente, el enfoque que adoptamos permite llevar a cabo análisis individuales de países, los cuales son esenciales para comprender las particularidades de cada economía. En este sentido, obtenemos que Irlanda es el único país donde el consumo privado parece ejercer presión sobre los precios. Mientras tanto, las economías mediterráneas como España y Grecia parecen seguir un modelo impulsado por la deuda donde el consumo privado impulsa los niveles salariales.

Palabras clave: Precios, salarios, consumo privado, causalidad de Granger, mapas causales.

JEL Classification/ Clasificación JEL: E31, J31, E21, C33.

1. Introduction

One of the topics that has generated the most interest since the integration of the Economic and Monetary Union (EMU) has been the effects that sharing a common currency and a single monetary policy could have on the main macroeconomic variables in the member states. Particular attention has been given to the potential impact this may have on price convergence, as the ECB's primary objective is the maintenance of a 2% inflation rate. However, after the Covid-19 crisis and particularly since the beginning of Russia-Ukraine conflict, countries worldwide have been experiencing strong pressures on their prices. In the Euro Area, inflation rose from 2.6% in 2021 to 8.4% in 2022 and 5.4% in 2023. However, the EU countries exhibited a significant degree of variability. While inflation in the Netherlands reached a value of 11.6% in 2022, in France it remained close to 5.9%.

The surge in prices has once again called into question the adequacy of the European institutional framework. In this regard, attention has primarily focused on the effects that acceleration of inflation has had, particularly on wages and consumption, which are key indicators of household wellbeing. Similarly to prices movements, wage response has differed in the EMU members, depending on the degree of wage stickiness. For instance, wages evolution during 2021-2022 reacted and helped mitigate some of the negative effects of inflation in Spain and France whereas wages in Italy and Germany were unable to catch up with prices increases (Palloti et al., 2023)

Previously, such a complex topic has been explored intensively in the literature from various perspectives. However, the nature of the interconnection between prices, wages and private consumption still remains unclear as the nature of the relationship between them is complex and the different links can be mediated by direct effects as well as indirect effects. In this regard, the multivariate approach proposed here allows the inclusion of other relevant economic variables that may be playing a not negligible role in shaping the dynamics driving the relationship between our main nexus.

This has led to the revival of old discussions that seemed to have been overcome. Of particular importance has been the debates about the relationship between inflation and wages, which echoed the episode of 1980s wage-inflation spiral. From a theoretical point of view, there are several mechanisms by which wages and prices can be related. As wages constitute an important component of production costs, an increase in nominal wages, motivated by

workers' pressures to maintain and even gain purchasing power may lead to an increase in nominal prices. So, for economies with a fast degree of price-wage adjustment, wage responses to an increase in prices will be reflected again on prices, which will lead to an inflationary spiral (Blanchard, 1986).

In line with these postulates, this mechanism can also operate with opposite sign, which is the case internal devaluation policies. Essentially, those postulates emphasize the role of wages as an internal cost of firms and suggest the application of wage devaluation policies as a way to reduce domestic prices and to gain external competitiveness, so in that way economies could transit to *export-led* models. Studies analysing these claims were particularly popular in Europe during the 2008 crisis and confronted two different economic models: those of Mediterranean economies, with uncoordinated wage bargaining and poor economic performance, and other coordinated economies, highlighting Germany as prototypical example of success in the application of internal devaluation policies (Dadush et al., 2010; Lapavitsas et al., 2012; Darvas, 2012; De Grawe, 2012; Storm and Naastepad, 2015).

Nevertheless, wage devaluation strategies may come at the cost of weakening the purchasing power of domestic demand which, in turn, can offset the potential gains of improving trade imbalances, particularly through a reduction of domestic private consumption due to the loss of nominal income. In economies where private consumption constitutes one of main drivers of economic growth, *consumption led* economies, internal devaluation policies may even trigger an aggregate weakening of the economic performance through a spiral of purchasing power loss.

Likewise, private consumption can be directly linked to pressures on prices and not just indirectly via wages. Unexpected periods of inflation are translated into a loss of real income which may lead to a decline of private consumption -*uncertainty hypothesis*-. Nevertheless, if inflation is anticipated and expected to be persistent on time, the effect on private consumption could be positive, as households may anticipate their purchases to protect themselves from further loss of purchasing power -*expectations hypothesis*-. Finally, this trend may be mediated in the opposite direction, as excessive consumption could exert significant pressure on prices through excess demand.

All in all, the main objective of this paper is to revisit from a *data driven approach* the nexus between prices, wages and private consumption for twelve euro area member states in the Economic and Monetary Union (EMU) period (1999-2019) in order to achieve a more comprehensive understanding of dynamic of the preceding period, somehow a key feature for efficiently addressing potential challenges stemming from current shocks, as proved during the inflationary period that followed the COVID-19. To be more precise, we do not rely on a specific branch of literature and try to test the validity of the hypotheses proposed therein but rather adopt a broader perspective that allows us to simultaneously test the interaction of different streams of literature. In this way, for the period and sample analyzed, we can test the test the validity from various branches of literature.

To do so, we propose to follow the approach developed in Gil-Bermejo et al (2022) to analyze Granger causality within the framework of Vector Autoregressive (VAR) models. This approach offers the advantage to easily allow the increase of the number of relevant variables included in the analysis, which enables us to compare the validity of the results when moving from a reduced model to a higher-dimensional system representing a complex dependency network. In addition, we apply graph theoretic methods along with a causal discovery algorithm -*PC algorithm*- which help us to select the optimal causal ordering between variables. So, we also include in the analysis other labor market indicators - labor productivity and employment rate - and economic growth. In this way, the methodology adopted here enables a deeper understanding of the different transmission channels between the variables of interest in the medium and long term.

The rest of the paper is organized as follows: in section 2 we will briefly describe the main related literature. Section 3 is devoted to describe our empirical strategy, so we present our dataset, the recent developments of our main variables of interest our econometric approach. In section 4 we will discuss our main results. Finally, section 5 concludes.

2. Related literature

In this section we elaborate in more detail on the connections between the hypotheses presented in the introduction and those previous studies constituting the theoretical framework for our work. To do so, we focus on potential relationships between the variables prices, wages and private consumption by pairs, as it is quite common in economic theory to find several models that exhibit chains of causality operating in different directions. Table 1 offers a synthesis of the section.

As such, the relationship between wages and consumption has played an important role in post-Keynesian literature, commonly known as demand regimes and/or growth models. Within these branches of literature, the question of wages has been studied mainly in terms of the structural characteristics of economies, opposing growth-enhancing transmission[1] channels like wages-led vs. profit-led economies in the case of the former and export-led vs debt-led, in the latter (Caldentey and Vernengo (2017), Gonzálvez, Cárdenas and Villanueva (2024)). In this regard, in *wage-led economies,* it is argued that in the long run the growth of economies is driven by an increase in the wage share, as this implies an increase in the level of consumption[2]. (Kalecki, (1971), Steindl (1952), Rowthorn (1981), Dutt (1984), Taylor (1985), Blecker (1989; 2011), Bhaduri and Marglin (1990) and Stockhammer and Onaran, (2013)). On the

1 See Cardenas and Arribas (2021) for a more detailed analysis about the growth models in Europe
2 In wages-led demand regime, not only consumption has an impact on growth, but also investment due to the accelerator effect and production due to the multiplier effect (Cárdenas et al., 2024). Analysing this in detail goes beyond the purpose of our study.

contrary, some authors (see Dupor et al., 2019, among others) argue that in the presence of nominal wages rigidity, increases in demand, and consequently in private consumption, may lead to a subsequent impact on wages.

Regarding the wage-prices relationship, in the presence of strong general collective bargaining agreement, the phenomenon of wage indexation argues that, in order to maintain the purchasing power of workers, increases in the general price level should be simultaneously followed by increases in the nominal wage level. However, this could also operate on the opposite sense and lead to a feedback mechanism that end up in a *wage-inflationary* process (Dureval (1999); Shannon and Wallace (1985)). This process is explained by unit labour costs theory, which points out that a general increase in labour compensation will most likely be followed by a general increase in prices, as wages constitute one of the main determinants of prices (Friedman (1968); Phelps (1970), Shannon and Wallace (1985), Dureval (1999), Schmidt (2000), Mehra (1991), Kagitci et al. (2011)). Nevertheless, the *unit labour costs theory* also sustains the postulates of the internal devaluation policies, which aims for economies to gain export competitive advantage by reducing their domestic prices, achieved through wage reductions (Villanueva et al. (2020), Baccaro and Tober (2022), Herrero and Rial (2023), Bayoumi et al. (2011), Chen et al. (2012), Álvarez, Uxó and Febrero (2019)).

Table 1. Literature review's synthesis

Relationship	Direction	Paper
W ↔ C	W → C (specifically)	Regan (2017), Caldentey and Vernengo (2017), Villanueva et al. (2020)
	W → C (component of Aggregate demand)	Kalecki (1971), Steindl (1952), Rowthorn (1981), Dutt (1984), Taylor (1985), Blecker (1989; 2011), Bhaduri and Marglin (1990), Gonzálvez, Cárdenas and Villanueva (2024), Onaran and Galanis (2013), Onaran and Obst (2016), Stockhammer et al. (2019) and Hein and Vogel (2008).
	C → W (nominal wages rigidity)	Dupor et al. (2019)
P ↔ W	P → W	Friedman (1968); Phelps (1970), Shannon and Wallace (1985), Dureval (1999), Schmidt (2000), Mehra (1991), Kagitci et al (2011)
	W → P	Holzman (1960); Schmidt (2000); Jonsson and Palmqvist (2004); Baccaro y Tober (2022), Herrero y Rial (2023), Bayoumi et al. (2011), Chen et al. (2012), Álvarez, Uxó and Febrero (2019)
P ↔ C	P → C	Wright (1967), Heien (1972), Juster and Wachtel (1972b), Juster and Taylor (1975), Houthakker and Taylor (1966), Weber (1970, 1975), Gylfason, (1981); Paradiso et al. (2012); Duca-Radu et al. (2021); McCloud (2024). Christev eand Melitz (2013)
	C → P	Eickmeier and Hofmann (2022), de Soyres et al. (2022), Stiglitz y Regmi (2023), Nersisyan and Wray (2022).

Source: Own elaboration.

Finally, focusing on the private consumption-prices nexus, it also may operate through different channels: On the one hand, it alters the composition of the consumption-savings basket for individuals. Thus, in the face of the loss

of value of money due to rising prices, it may lead to an advance in consumption at the expense of savings in order to protect individuals from subsequent and greater losses *(expectations hypothesis)*. However, the rise in prices also erodes the purchasing power of consumers, so it would also be plausible to expect a negative effect over consumption in lower income households *-uncertainty channel- (*Wright (1967), Heien (1972), Juster and Wachtel (1972b), Juster and Taylor (1975), Houthakker and Taylor (1966), Weber (1970, 1975), Gylfason, (1981); Paradiso et al. (2012); Duca-Radu et al. (2021); McCloud (2024). Christev eand Melitz (2013)). On the other hand, excessive increases of consumption of certain good or services will exert to pressure on prices, which is known as *excess demand (*Eickmeier and Hofmann (2022), de Soyres et al. (2022), Stiglitz y Regmi (2023), Nersisyan and Wray (2022)).

3. Empirical strategy

3.1. Data

In this study, we provide an analysis of the main dynamics between wages, prices and consumption and labour market indicators for twelve euro Area member states over the periods 1999Q1-2019Q4 which makes a total of 84 observations for each country. We purposely exclude COVID19 and later data from our sample as such a strong exogenous shock could be affecting our econometric analysis. In addition, we strongly consider that getting a deeper understanding of the different transmission channels affecting the dynamic between the variables of interest the EMU period will be essential for efficiently addressing potential challenges stemming from current shocks.

Our database is composed of the following variables: (i) Nominal Wages (*WAGE*) as a proxy for household income; (ii) Private Consumption (*CONSU*); (iii) Harmonized Index of Consumer Prices (*HICP)* as a proxy of inflation; (iv) Gross Domestic Product *(GDP)* as a proxy for economic activity (v) *LPROD*, Labour productivity and (vi) TEMP, total employment (number of employees) to include labour market indicators. The selected European economies are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and Greece. The complete dataset in obtained from Eurostat.

3.2. Descriptive analysis

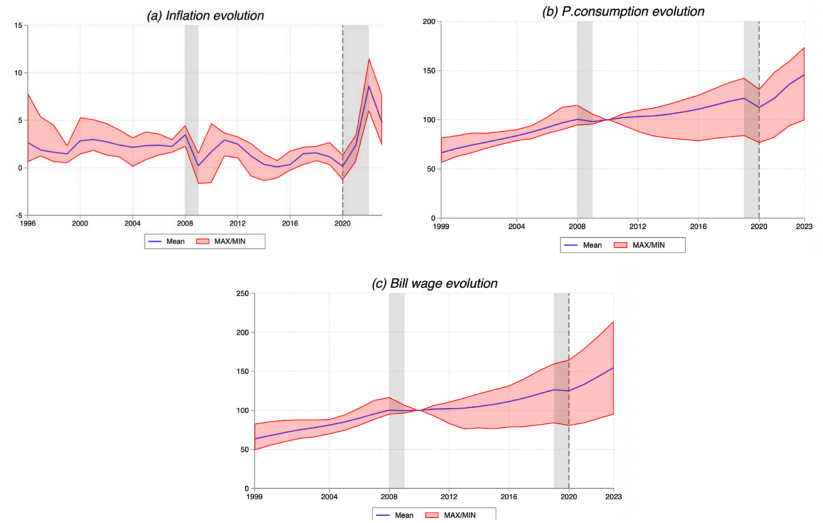
Before presenting our econometric approach, we set the stage by discussing the evolution of our main variables of interest (prices, consumption and wages) over the past decades. Figure 1 represent a foretaste of evolution of the mean value and the range between the maximum and the minimum values of the HICP for the 12 countries included in our analysis. Panel (a) highlights key insights about the evolution of general price level. In general terms, inflation in the last decades has fluctuated but remained very close to the target set by the ECB. However, notable exceptions in specific periods have been observed.

Of particular importance have been the price explosion in the aftermath of the Covid-19 crisis, after which inflation reached record levels. Similarly, the periods of deflation that followed 2008, after the outbreak of the Great Recession and 2012, following the Debt Sovereign Crisis. In addition, a non-negligible degree of dispersion in general price levels between member states is registered. At the beginning of the period, the range between minimum and maximum value was of almost 7 points. Likewise, after 2008 minimum values were negative, reaching -1.7%, while maximum values where close to 4.7%. However, this gap seems to narrow in period of worse economic performance (2008-2009; 2020-2022).

So, it can be hypothesized that during periods marked by exogenous shocks, national inflation rates do not only seem to react by showing greater responsiveness but also by exhibiting a reduction in the spread of values across countries. This pattern not only occurs under common deflationary pressures, but under the influence of inflationary forces as well, suggesting that it cannot be merely imputed to changes in scale.

Panel (b) and (c) focus on the dynamics of total private consumption and wage bill. A bird's-eye view reveals that, although both variables show a more stable behaviour than inflation, with slight growth throughout the period, a much greater dispersion between maximum and minimum values is found, especially from the recovery period following the Great Recession onwards,

Figure 1. Price, private consumption and nominal wage bill

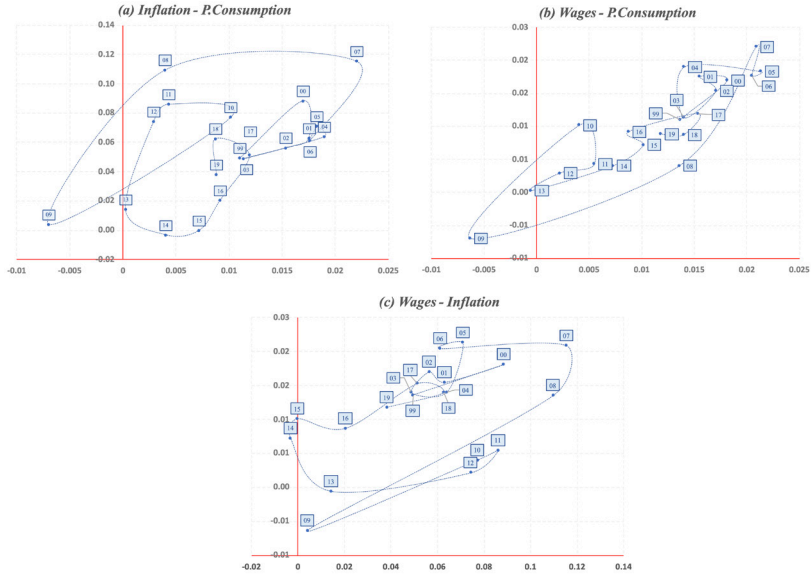


Notes: Countries of the sample: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and Greece. Mean represent the unweight average value.
Source: Own elaboration.

contrary to what happens in the case of inflation. This greater level of dispersion seems to be determined, above all, by the evolution of the minimum values, which do not seem to have recovered the levels prior to the 2008 crisis.

Regarding the relationship between variables, Figure 2 represents the degree of average pairwise association over the period (by comparing their annual growth rates). In general, all three variables show a positive degree of association, in virtually any combination, which it is indicative of a strong correlation between the phenomena. However, it is easily observed that there are some specific periods in which the relationships behave differently, breaking the consistency of the association between the variables. This is the case of the association between inflation and private consumption -panel (a)- and wages and private consumption -panel (b)- for the year 2009 where the sign of the association get inverted. Moreover, inflation and wages and wages and private consumption seem to show a higher correlation whereas the relationship between inflation and wages -panel (c)- seems of a different nature. Although still positive, the Great Recession and Sovereign Debt crisis years -2008 to 2014- appear to separate from the main cluster of values, which may be indicating that factors other than these both variables are playing a role in shaping the relationship between the variables.

Figure 2. Association between variables



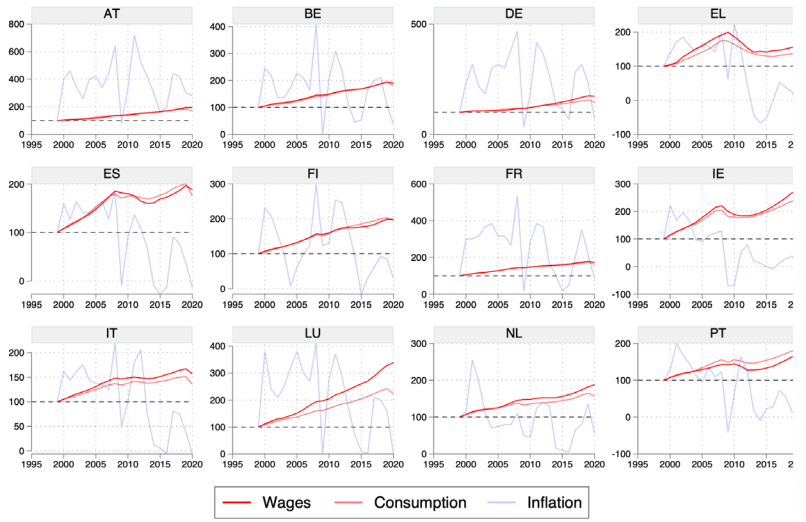
Notes: Countries of the sample: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and Greece. Observations represent the unweighted yearly average value.
Source: Own elaboration.

Finally, Figure 3 helps to visualize the country-specific inflation-wages-private consumption evolution within our sample, which allows to complete the information about common patterns identified in Figures 1 and 2. From this figure, some interesting facts emerge. Private consumption and wages tend to show a parallel evolution in every country in the sample. However, there some exception where both variables are more distant from each other. This is the case of Greece and Luxembourg and to a lesser extent, France, Portugal and Ireland, where a gap is found, especially since 2008 economic crisis.

Also, from 2008 onwards, it can be observed a decrease in both wage and consumption levels in Spain, Greece, Italy, Portugal and Ireland, as a result of the wage devaluation policies implemented in those countries (Afonso, (2019), Cruces et al. (2015), Campos-Lima et al (2021)). In fact, since then, in most of these countries, the wage growth curve has become practically flat, showing today levels very close to those at the beginning of the crisis.

On the other hand, if we focus on the whole period under analysis, we can notice that the country with a higher level of wage growth is Luxembourg, where in 2020 wage levels were almost 4 time those of 1999. In contrast, and in coherence with what has been highlighted by many empirical studies, Germany is the country where wages have grown the least over the past 25 years, exhibiting also weak growth in private consumption. This is particularly interesting since the German economy has also shown the greater spread in inflation rates and the highest figures in price indicators, reaching values close to 5% at different times during the period. All those facts together have may

Figure 3. Country-specific evolution



Source: Own elaboration.

well have depressive effects on domestic demand by weakening both nominal and real income of German households (Storm and Naastepad, 2015; Herrero and Rial, 2023).

In general terms, performance of prices has been more volatile and very country-specific. In Spain, Greece, Italy, Portugal but also France, prices present the highest value at the beginning of the period, in 1999, and with exceptions related to specific episodes, they have not exceeded that level throughout the period.

3.3. Methodological issues

To analyse the dynamic causal relationships between prices, wages and consumption we use the econometric approach proposed in Gil-Bermejo et al (2022) to address Granger causality[3] with VAR models in a panel data environment. This approach basically consists of the obtention of aggregated measures for the entire sample based on information of each individual cross-sectional unit. This econometric approach is then combined with the application of the PC algorithm[4] and the results are represented in the lines of the causal graph-theoretic method (Lauritzen and Richardson (2002), Demiralp and Hoover (2003), Eichler (2007)).

Our first benchmark specification is the next multivariate vector autoregressive panel model (P-VAR) limited to the main variables of the study:

$$Y_{it} = \mu i + \Phi_{i(\tau i)} Y_{i,t-\tau} + \varepsilon_{it} \quad i = 1, \dots, N;\ t = 1, \dots, T \tag{1}$$

Where Y_{it} is the vector of (p) endogenous variables of a country i in a year t. The index i shows each cross-sectional unit, and t denotes the periods. $\Phi_{i,1},\dots,\Phi_{i,\tau i}$ are (p x p) matrices of parameters. τ_{it} is (p x 1) of error terms, which are independently and identically distributed (iid). Finally, τi is the order of the autoregressive process.

One of the main advantages of this approach is that it allows for easily increasing the number of endogenous variables included in the model at a low computational cost, making it particularly suitable for testing the validity of reduced models in complex information systems. Thus, in this context, we will compare the validity of the results by contrasting two different models: a reduced model, which includes only the three main variables of our analysis. This is *wages, prices,* and *private consumption,* respectively. We will also analyse an extended model, which includes *labour productivity, employment*

3 This approach relies on the work of Dolado and Lütkepohl (1996) to address potential structural breaks and cointegration processes.

4 This algorithm was developed by Spirtes et al (2000) and is considered a useful tool for assessing the robustness of the results obtained in econometric analyses. The underlying idea is to examine the survival of the significance of a relationship between variables as the remaining available information is sequentially included in the control set.

rate and *economic growth* as additional endogenous variables that may play a significant role in shaping the dynamics between wages, prices, and consumption.

Thus, to address Granger non-causality, the null hypothesis for the *i-th* individual is defined as the standard causality Wald test:

$$H_0 : \Phi_i = 0 \text{ for all } i. \tag{2}$$

The resulting information from contrasting the null hypothesis is then aggregated on a synthetic composite measure by performing Fisher's (1923) transformation of the *p-values*. From this synthetic indicator (λ) we are able to determine is a relationship between variables is significant for the entire sample.

$$\lambda = -2 \sum \ln p_i \tag{3}$$

This test has a chi-square distribution with 2*N* degrees of freedom.

Subsequently, we follow David (1949) who proposed an estimation of a comprehensive measure to obtain the dominant correlation among cross-sectional individuals, which provides insights into the direction and strength of the connection[5].

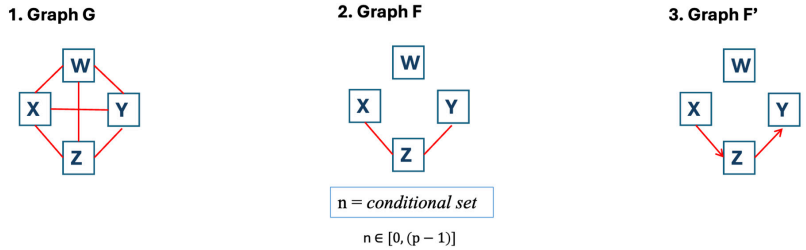
Finally, all the results obtained are interpreted on the lines of causal graphic-theoretic methods. In this context, we propose using the PC algorithm in its stable version to carry out the causality analysis (Colombo and Maathuis, 2014)[6]. This is an iterative algorithm based on qualitative information about whether a particular local conditional independence constraint holds, as all available information is sequentially included. The steps in the algorithm are the following (Demiralp and Hoover, 2003):

1. Start with a graph *G* in which each variable is connected by an edge to every other variable (*a complete undirected* graph).
2. Set $n = 0$. Test for *n*th-order conditional causality between every pair of variables conditioning on every subset of variables of size *n*. (For $n = 0$, the conditioning set is the null set, so that conditional relation is equivalent to unconditional relation.) If a pair of variables is conditionally unrelated, we eliminate the edge between them.
3. Set $n = n + 1$ and successively repeat step 2 until all possible conditionings set have been exhausted. Call the resulting graph F.
4. Consider each pair of variables (*X* and *Y*) in F that are unconnected by a direct edge but are connected through an undirected path through a third variable (*Z*). Orient *X—Z—Y* as $X \rightarrow Z \leftarrow Y$, if and only if *X* and *Y* are dependent

5 For a more detailed description of the procedure, see Gil-Bermejo et al (2022).

6 The main difference between the original version and the stable version is that the stable version of the algorithm maintains unchanged the adjacent sets of nodes at each particular level. Thus, the output is independent of the order of the variables.

Figure 4. Illustrative example of the PC algorithm steps



Source: Own elaboration based on Demiralp and Hoover (2003) and Colombo and Maathuis (2014).

when conditioned on every subset of variables, excluding *X* and *Y,* that includes *Z*. Call the resulting graph F'.

5. Repeat until no more edges in F' can be oriented: if $X \rightarrow Z$ and $Z - Y$ and *X* and *Y* are not directly connected, then orient $Z - Y$ as $Z \rightarrow Y$.

To keep things simple (see Figure 4), at the final stage of the process, whenever a robust causal relationship is found to exist between a pair of variables, there is said to be an 'oriented edge' between them. This edge indicates not only the existence of the relationship but also the sense of the link (which variable leads) and the intensity of the relationship (measured in our case as the dominant crossed correlation function).

4. Results

This section is devoted to the main results of our analysis by using the empirical procedure mentioned above.

First, we analyse the expected association between variables by means of a correlation matrix for each of the countries included in our sample for the period 1999-2019, which will help us assess some insights found in previous sections. In this regard, Table 2 provides a detailed overview of the correlation coefficients amongst the main variables for every country included in our sample as well as the dominant cross-correlation function (CCF) which is representative of the aggregate for the entire panel. This method enables us to exploit the cross-sectional unit's information, to understand the country-specific profiles, as well as to extract a common pattern among them.

We propose a degree scale to obtain a better interpretation of these correlations in absolute terms. The initial interval covers values between 0 and 0.2, indicating a weak correlation. The subsequent interval denotes a moderate correlation, extending from 0.2 to 0.5. A strong correlation falls within the range of 0.5 to 0.8, whereas values exceeding 0.8 indicate a very strong correlation. It's worth noting that even when the correlation between variables is low, a causal relationship may still exist.

In accordance with the previously established criteria, Table 2 indicates that there is a very strong -positive- correlation can be found between all pairs of variables, which means that all the variables tend to co-move in the same direction. Particularly strong seems the association between wages and consumption, which smaller value is 0.98. Focusing now in the country-variations, every country presents a correlation coefficient between the three pairs of variables close to 1 except for Portugal, which seems to behave somewhat differently with respect to the prices. The correlation coefficient between wages and prices is 0.67 and the one between consumption and prices is 0.65, which lowers the association degree from very strong to strong. However, it is important to bear in mind that *association* between variables does not means *causality,* even in the cases where the coefficient obtained represent a very strong relationship.

Once we have checked the sign of the possible relations among our set of variables, we conduct the iterative process of the Granger causality analysis along with the application of the PC algorithm, through which all possible causality links between the selected variables are examined and inspected. In this sense, as we mentioned earlier, we start with a model of the reduced set of variables, exclusively limited to the three main variables -prices, wages and private consumption-. However, it seems clear that our control variables contribute to gaining a comprehensive understanding of the set of dependencies. For this reason, it is necessary to consider a second model, where we focus on other variables closely related with the labour market and the economic cycle. Thus, in our extended model are included as endogenous variables the following: prices, wages, and private consumption as well as labour productivity, employment rate and economic growth.

Our approach begins -level 1- with bivariate tests between every combination of pairs of endogenous variables included in each model. By iteratively computing the tests and then storing the results, an analysis of all the possible bidirectional connections between variables is conducted. In this stage, those linkages where the causal relationships were not significant are excluded from further levels of analysis. For those, instead, in which a causal relationship is indeed found, the test is then repeated but controlling, independently, for the remaining endogenous variables included in each model. In this new level -level 2-, non-significant links between pairs of variables get newly excluded from the analysis and only survivant relationships will be studied in the next one. The final result is obtained throughout a computationally demanding iterative process based on the inclusion, for any additional level of analysis, of an additional variable to the control system[7]. The process is set off when the maximum level is reached. This level will coincide with the *(p -1)* endogenous system variables of each model.

7 The size of the control set will always be the current level of the application of the algorithm minus one. So, in level 1, the size of the control set will be zero; in level 2, will be 1, etc.

Table 2. Cross-Correlation among prices, wages and consumption

Country	Wages - Prices	Consumption - Wages	Prices - Consumption
Austria	1.00	0.99	0.99
Belgium	0.99	1.00	1.00
Finland	0.96	0.98	0.98
France	0.95	0.99	0.96
Germany	0.96	1.00	0.96
Ireland	0.98	1.00	0.98
Italy	0.96	0.99	0.99
Luxembourg	0.97	1.00	0.96
Netherlands	0.95	0.99	0.97
Portugal	0.67	0.98	0.61
Spain	0.90	0.98	0.95
Greece	0.97	1.00	0.98
CTE	0.98	1.00	0.98
OTH	0.94	0.99	0.96
ALL	0.97	1.00	0.98

Source: Own elaboration.

Next, we will present an illustrative hypothetical example directly based on our analysis. At level 1, we will have two different set of variables. The reduced model only will include prices, wages and private consumption whereas the extended one will include also the first set plus labour productivity, total employment and economic growth. In both sets, relationships will be analysed by pairs. For instance, on the *indexation hypothesis* (PRICES $\Rightarrow$ WAGES), we start conducting usual unconditional Wald test. If this relationship is proven to be significant, we would advance to the next level in which we would repeat the test but adding one-by-one the rest of the endogenous variables of the system. In the case of the reduced model, only private consumption, the remaining endogenous variable, would be included in the control set in level 2 (PRICES $_{consu}$ $\Rightarrow$ WAGES). However, in the extended model, we will also have to include in the control set the other three endogenous variables, so we will end up by conducting the following tests (PRICES $_{consu}$ $\Rightarrow$ WAGES; PRICES $_{lprod}$ $\Rightarrow$ WAGES ; PRICES $_{temp}$ $\Rightarrow$ WAGES ; PRICES $_{GDP}$ $\Rightarrow$ WAGES). Thus, the reduced model will only be able to reach level 2 while the extended model will continue up to level 5.

All in all, in Figure 5 we have represented in the causal maps resulting for both models along the lines of graph theoretic methods for the whole panel of euro area countries, with the first and last levels of each model (level 2 and 5, respectively). It can be easily observed that in the reduced model the three variables seem to be connected by direct links. In this regard, prices play a key role, leading the dynamics among them and having a positive effect on both wages and consumption. In addition, the bidirectional causality between wages and consumption found on level 1 get depurated by the application of the PC algorithm, ending with consumption *positively causing* the former, strengthening the global influence of prices on wages. These results seem to

be in line with the *indexation hypothesis,* on the one hand, as wages react to movement in prices. However, we cannot state that this could lead to a *wage-inflation* spiral as suggested by Blanchard (1986) since prices do not react back to wages. Similarly, our results do not seem to point in the direction of the *internal devaluation hypothesis*, as the relationship between both variables goes in the opposite direction of the transmission mechanisms suggested by their postulates.

On the other hand, we can also observe that private consumption is preceded by prices, so in a sense, household may be reacting to the *expectations channel* and be very sensitive to the evolution prices as they try to protect themselves of future increases on prices. Finally, private consumption also seems to precede wages, which may serve us a hint of the existence of nominal wages rigidity (see Dupor et al., 2019, among others).

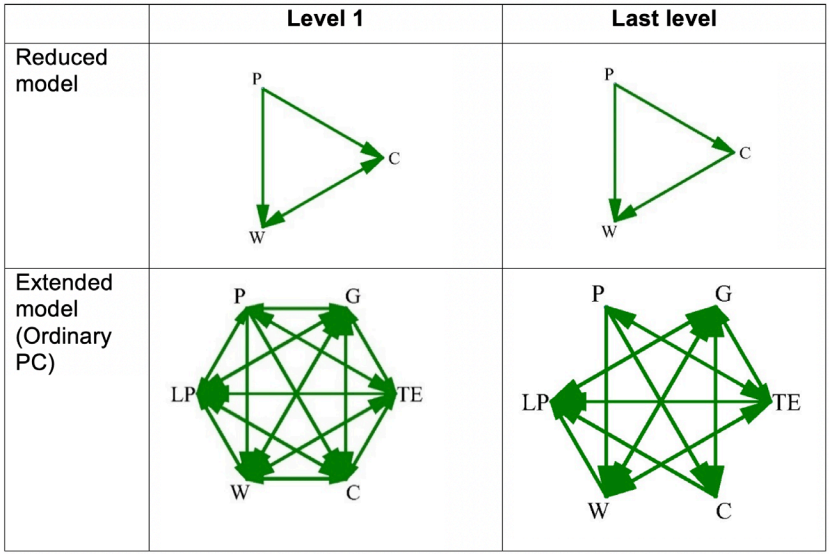
Nevertheless, some of these results lose validity once we transition to a more complex system. In a first stage, we can observe that all the variables appear to be interconnected, without any of them seeming to lead the dynamics. However, looking closely, we notice that prices received fewer arrows than other variables, which can serve as a clue of its potential role in shaping the common dynamics, as also was anticipated in the reduced model. In fact, when we move to the last level (level 5) we observe that most of the interconnexion have been depurated. Indeed, prices conserve its role in explaining the most relevant linkages. Regarding our main variables, we still found the causal nexus between prices and wages and between prices and consumption that were found on the reduced model, so both *indexation hypothesis* and *expectations hypothesis* seem to hold still within the complex system.

However, the direct causal link found from private consumption to wages disappears in the extended model. In fact, it becomes an indirect link that is channeled through other variables. Thus, we find a causal link from consumption to economic growth, and from economic growth to wages, which seems to confirm the signals of the *consumption led* orientation found on the reduced system.

Another interesting issue observed in the extended model relates to the dynamics between labor market indicators. While in the reduced version wages seemed not to play any leading role, by extending the number of relevant variables it is found that they contribute to the dynamics of the whole system causing positively to both employment rate and labor productivity (through both direct and indirect channels).

As mentioned, one advantage of this empirical strategy is that we are able to analyse not only the whole panel but also any of these countries individually. Figure 6 represents the p-values at the final level for individual countries in both models, focusing on the relationships within our primary nexus of variables. This is W⇔P, W⇔C, C⇔P, which makes 6 different tests, one in each direction. In this sense, we can examine which specific countries participate in the common findings found in the aggregate and which ones behave according to a more specific pattern.

Figure 5. Path obtained for the complete sample



Source: Own elaboration using Causality Map Toolbox.
Notes: (1) Results obtained from Granger's causality test at 10% of significance level, for the periodo 1999-2019. Solid line indicates that the crossed-correlation between each pair of nodes is positive (2) : (i) Nominal Wages (*W*; (ii) Private Consumption (C); (iii) Harmonized Index of Price Consumer (*P)*; (iv) Gross Domestic Product *(G);* (v) *LP*, Labour productivity and (vi) TE, employment rate.

It can be observed that for the case the causal path from prices to wages in the reduced model, although it survives until the last level for many countries (Austria, Greece, France, Ireland, Luxembourg, Netherland and Portugal), it results non-significant only for three of them. However, when analysing the extended model the degree of survival to the PC algorithm disappears, with no individual country reaching the last level. Interestingly, the opposite link, from wages to prices, does not survive in practically any country (only Belgium, Finland and France in the reduced model). These results call into question the hypothesis of internal devaluation for most of the countries in the sample. Particularly, it is worthy to highlight the case of Germany, for which no causal relationship between prices and wages is found, despite being considered as the prototypical example of successful internal devaluation policies (Dadush et al., 2010; Lapavitsas et al., 2012; Darvas, 2012; De Grawe, 2012; Storm and Naastepad, 2015).

In terms of the effect of prices on private consumption, it does not survive in Germany, Greece and Ireland when we restrict to the reduced model, and it turns out to be not significant in Austria, France, Luxembourg, Netherlands and Portugal. However, when we consider the complex system, it seems now a weaker relationship, as only two countries (Belgium and Spain) survive up

to the 5th level. Nevertheless, in both countries the relationship is significant. Furthermore, the contrary seems to be observed for the link in the opposite direction. It does not survive for practically any country even in the reduced model and the only case where we can find a significant relationship is in Ireland (in the reduced version of the model). So in this regard, for the countries and period analysed there is no evidence of signs of excess demand.

Finally, if we focus on the causal links between wages and consumption, we find that, although the degree of survival to the process of depuration in the last levels is higher in both models (compared to previous links), this relationship tends to be much less significant in the extended model. In fact, Spain is the only exception for which we do find a significant link from consumption to wages when we consider the extended version of the model, although for the reduced version we find that the relationship is significant in every country except for France and Italy (where the link dies along the process) and Portugal. This points to the importance of relying on more complex frameworks that allows to test the robustness of evidence found on more simple models. Conversely, we find fewer cases of survival for the link from private consumption to wages, both in the reduced and extended models, but once we do, they tend to be significant. This is the case for France, Italy, Netherland, Luxembourg and Portugal in the reduced model. In fact, the only relationship that survives but results not significant is Germany. However, in the extended model, it only survives for the case of Portugal. So very few economies tend to show signal of consumption leading to an increase in wage levels.

All in all, we can summarize all this information to test for the degree of compliance both individually and jointly with the major hypotheses explored in the literature (see Table 3).

Table 3. Cross-country specific results in the lines of the related literature

Relation	Hypothesis	Reduced model	Extended model	Total sample countries
W→P	*Unit labour costs hypothesis*	BE, FI, FR, PT		NONE
P→W	*Indexation wages hypothesis*	EL, FR, LU, NL,		BOTH
P→C	*Uncertainty channel or expectations hypothesis*	BE, ES, FI, IT	BE, ES	BOTH
W→C	*Debt led model hypothesis*	AT, BE, DE, EL, ES, FI, IE, LU, NL	ES	PARTIALLY (REDUCED)
C→W	*Short-term sticky nominal wages hypothesis*	FR, IT, LU, NL, PT	PT	PARTIALLY (REDUCED)
C→P	*Excess demand*	IE, PT		NONE

Source: Own elaboration.
Notes: (1) None denotes that the hypothesis does not hold in any model; Both denotes that the hypothesis holds in the reduced and the extended model; Partially denotes that the hypothesis holds in either the reduced or the extended model.

Figure 6. P-values for a selection of bivariate relationships

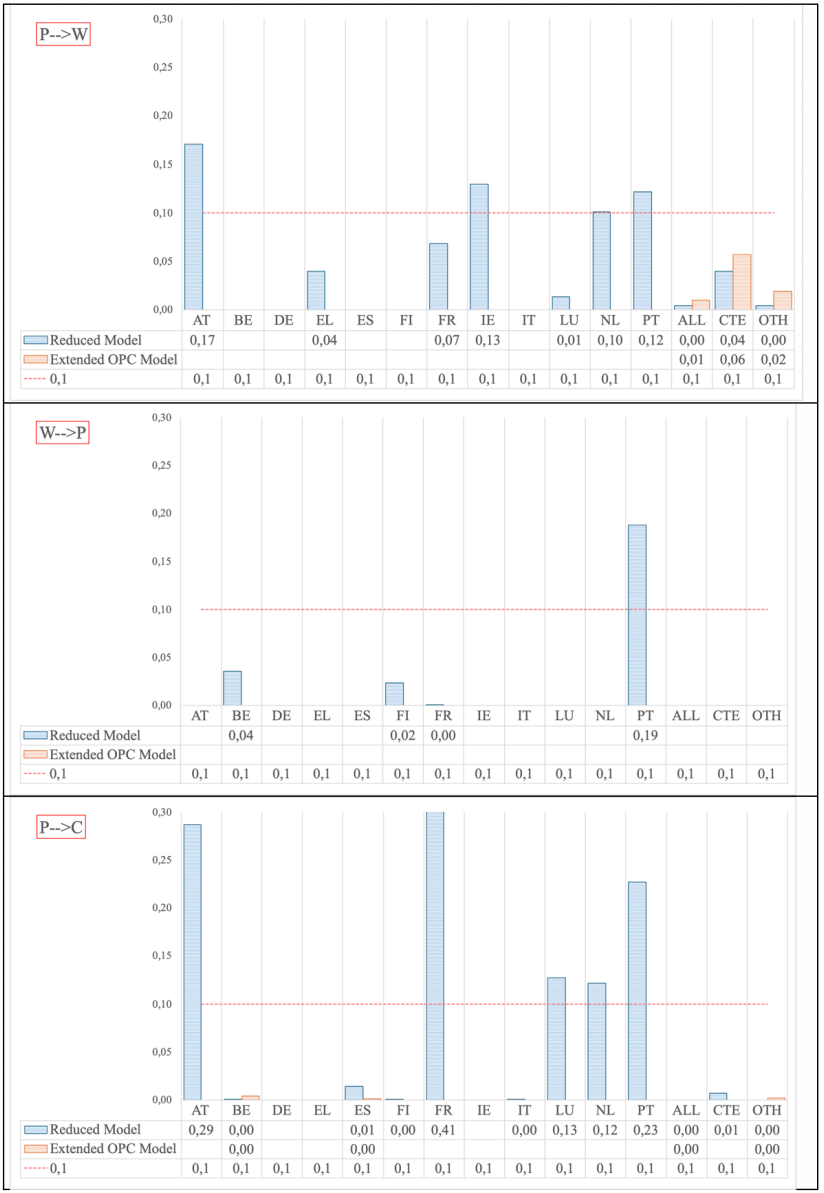
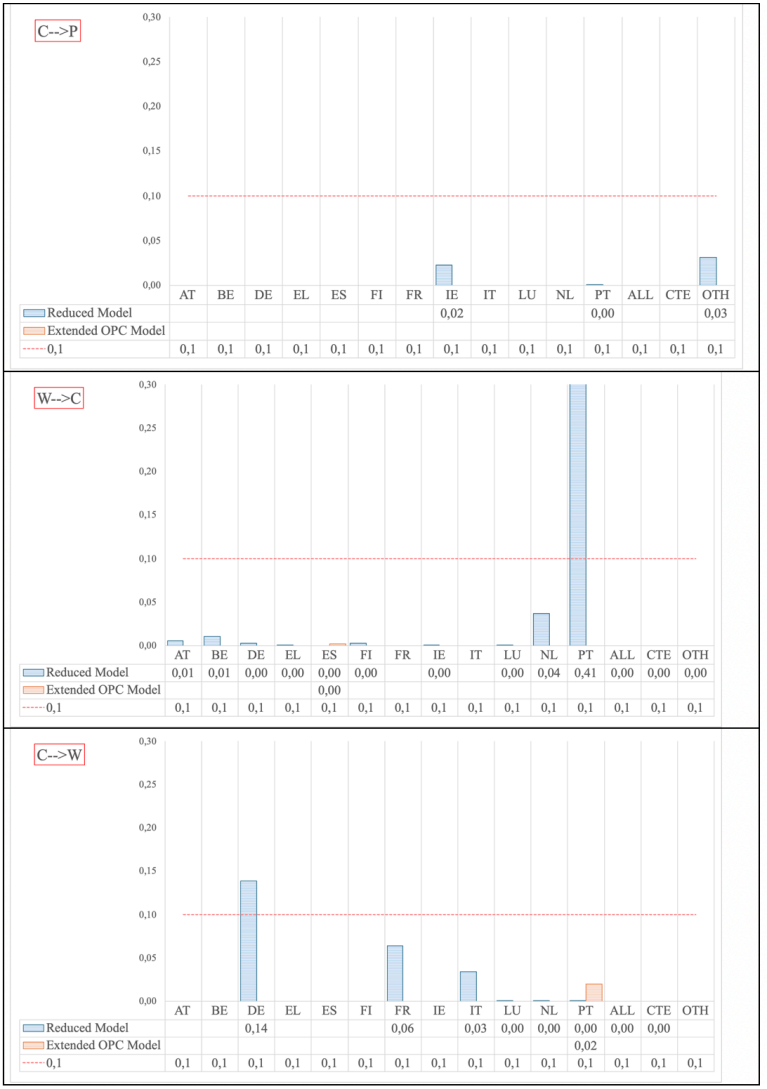


Figure 6 (cont). P-values for a selection of bivariate relationships



Source: Own elaboration using Causality Map Toolbox.
Notes: (1) Blank cell indicate that the relationhip do not survive to last level, so the test is not cumputed. (2) Results obtained from Granger's causality test at 10% of significance level, for the periodo 1999-2019. Solid line indicates that the crossed-correlation between each pair of nodes is positive (3) : (i) Nominal Wages (*W*; (ii) Private Consumption (C); (iii) Harmonized Index of Price Consumer (*P*; (iv) Gross Domestic Product *(G)* (v) *LP*, Labour productivity and (vi) TE, employment rate for including labour market indicators.

5. Concluding remarks

Recently, we have observed an increase in interest in the phenomenon of price tensions, driven by the widespread price hikes experienced in the aftermath of the COVID pandemic. The initial signs of price tension were observed in 2021 and explained by supply chain bottlenecks affecting the supply of goods and services. Additionally, Russia's war against Ukraine has only heightened these price tensions, particularly energy prices. Most of those studies focus on countries of the Euro Area, as they were primarily affected by the inflation shock. Among others, Bobasu et al (2023) analysed the effect of prices across households. Basso et al (2023) analysed the relationship between inflation, fiscal policy and distributional output.

In this paper we propose to focus on the preceding period, revisiting the causal nexus that shape the dynamic between prices, wages and private consumption that enables us to achieve a deeper understanding of the structural changes that were entrenched prior to the price shock. Although this issue has been studied in the related literature, due to computational limitations, a great share of these applications has been limited to the analysis of potential causality between pairs of variables. However, expanding the conceptual framework to complex information systems appears to be a necessary task for the accurate identification of existing patterns of causality. Hence, we apply a novel approach based on Gil-Bermejo et al. (2022) that allows us to analyse the causal links across a broader spectrum of indicators and identify an ultimate "causality path".

In this line, our results provide novel empirical evidence which help, on the one hand, to confirm certain hypotheses present in the literature. For example, focusing on our main nexus, we obtain a significant causal relationship emerging from prices to wages, supporting the *wage indexation hypothesis* for the whole panel. At the same time, it allows us to rule out hypotheses that hold in reduced models but lose significance when the model is expanded. Interestingly, we find no evidence that this relationship works in the opposite direction, which allows us to rule out both *inflationary spiral and internal devaluation theories*, since wages do not seem to have an effect on prices.

In our analysis prices seem to be playing a leading role in the dynamic of the whole set of variables for the Economic and Monetary Union (EMU) which highlights the importance of monetary policy as an effective instrument for steering economic activity in the context of a monetary union. In addition, we also found a significant and bidirectional link between prices and the employment rate, which can be an opportunity to create synergies insofar as employment policies can create a virtuous circle in the dynamics.

In addition, our approach also allows to perform several country-specific analyses, which becomes essential in order to be aware of the specificalities of each economy, something which can be fundamental in making efficient economic policy decisions in a coordinated manner, as for example monetary policy in the EMU countries. For instance, we can highlight the case of Spain,

which is the only country where we can observe that movements in wage level cause changes in the private consumption in the same direction. However, prices are followed by an increase in private consumption for the case of Belgium, and Spain. This point out to Spain as an economy where private consumption dynamics are more sensitive to other variables than the rest of economies of the EMU. From the points of view of the different hypothesis mentioned, we can highlight that, in the complex framework we find no evidence in any country of the of compliance with the postulates of internal devaluation hypothesis or of excess demand.

Finally, as an extension of the present analysis, future research should consider the potential importance of fiscal policy in influencing these dynamics at the country level, especially given the ECB's centralised role in monetary policy coordination.

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