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**THE RELATIONSHIP BETWEEN INFLATION RATES
IN ADVANCED ECONOMIES**

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ABSTRACT

This article analyses the link between the changes in and the drivers of inflation in a broad range of advanced economies, with special emphasis on those of the euro area. Inflation rates are seen to be highly synchronised across countries, especially in the euro area economies, reflecting their close economic and financial links and the common monetary policy. Also, the comovement of inflation is found to be a phenomenon that tends to be more visible in the medium and long-term. At the same time, the synchronisation of core inflation, which is based on products with more stable prices, is seen to be limited. The interdependence of headline inflation, by contrast, is significantly higher and has increased considerably in recent years. The drivers of inflation, according to New Keynesian Phillips curve models, such as inflation expectations, the cyclical position and external prices, also help to explain the relationship between inflation rates in advanced economies and especially in those of the euro area.

Keywords: Inflation, Phillips curve, comovement, trend inflation.

JEL classification: E31, E32, C50.

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Introduction¹

In recent decades there has been increase – associated with growing economic and financial integration – in the interconnectedness or interdependence of the world's economies. This process of globalisation is affecting the behaviour of real macroeconomic variables (an aspect on which there is an extensive literature),² but also that of nominal variables, such as inflation (a phenomenon that has to date been relatively less analysed). The purpose of this article is twofold. First, a number of stylised facts relating to the comovement of inflation rates across a broad sample of advanced economies are identified. Second, the extent to which the behaviour of certain macroeconomic variables can explain the comovement of inflation is analysed.

The relationship between price movements in different economies can be analysed in the light of national inflation rates. A standard way of understanding inflation is to use what is known in the literature as the New Keynesian Phillips curve model. According to this analytical framework, inflation in one economy depends positively on activity, inflation expectations and external prices. For their part, these determinants do not behave independently across countries, but rather tend to display a high degree of comovement.

First, the business cycles of advanced economies display a high degree of synchronisation. When one economy is in an expansion (recession) others are usually expanding (contracting) simultaneously. This national expansion (recession) puts upward (downward) pressure on prices, so that the synchronisation of business cycles causes the inflation rates of different countries to resemble one another.

Second, the synchronisation of inflation across countries may also be a result of the similar behaviour of agents' inflation expectations. These, in turn, may be driven by the similarities of the various monetary policy strategies pursued by the respective central banks.

1 This article summarises the main results of the recent empirical study of Álvarez *et al.* (2019).

2 See, among others, Kose *et al.* (2008) and Haan *et al.* (2008).

Third, commodity prices are largely determined on global markets and are a source of shocks that have a simultaneous impact on the consumer prices of the various economies. This fact is particularly relevant in the case of oil prices, given their rapid pass-through to the consumer prices of fuels and energy.

Finally, the adoption of common technologies may lead to parallel productivity developments, which also generate inflation synchronisation across countries (Henriksen *et al.* (2013)).

At the same time, the relative importance of the drivers of inflation and their degree of comovement across countries may change over time. In particular, the greater degree of openness of economies and the consequent increase in competition, as a result of globalisation, means that they are more sensitive to external shocks, which may lead to similar inflation developments in different economies. In this respect, the growing importance of global value chains increases the degree of interconnectedness of inflation (see Auer *et al.* (2017)).

That said, the economic literature dedicated to analysing the synchronisation of inflation dynamics is, to date, rather limited. Some studies simply analyse the correlation coefficients between the inflation of pairs of advanced economies, generally finding that these are positive, i.e. that inflation rates tend to move in the same direction across countries (see Wang and Wen (2007) and Henriksen *et al.* (2013)). An alternative approach estimates models in which the inflation fluctuations in each country are explained by factors common to different countries and, also, idiosyncratic factors (see Cicarelli and Mojon (2010) and Forster and Tillmann (2014)).

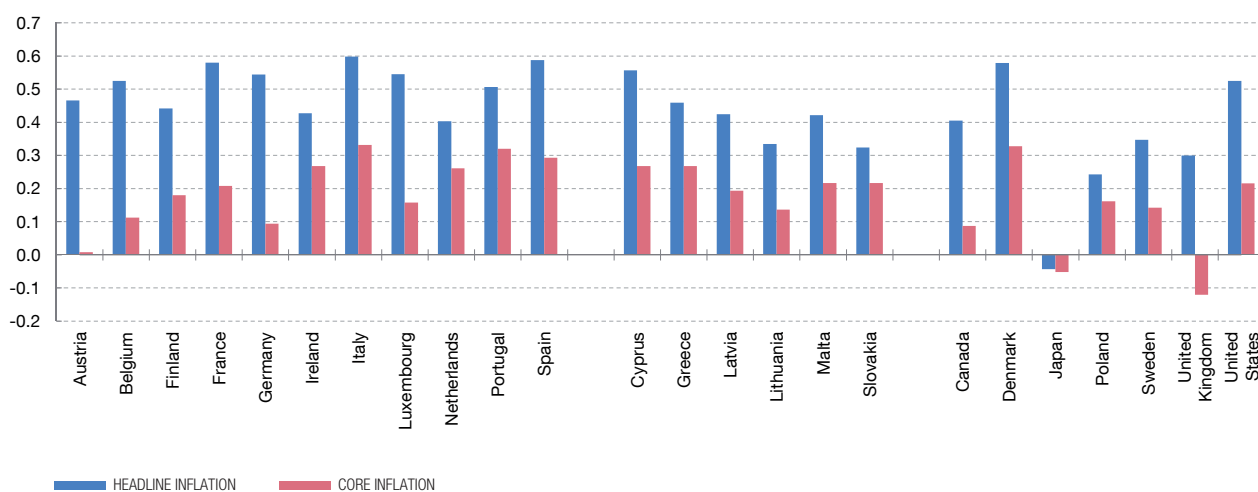
The main contribution of this article is to show the extent to which the interdependence of inflation across countries is linked to the behaviour of a number of variables such as inflation expectations, business cycles and external prices. Second, given that the different components of the consumption basket display different sensitivities to different types of shocks, such as external shocks, the extent to which this heterogeneity of the different components of the price indices affects the degree of interdependence is analysed. As one would expect, comovements in inflation are found to be strong in response to common shocks, such as energy and food price shocks. However, the degree of comovement is appreciably weaker in the case of core inflation (which excludes energy and food prices). Third, the extent to which the degree of inflation interdependence depends on the temporary or permanent nature of inflation fluctuations is studied, the interconnectedness of inflation rates being found to be essentially a medium and long-term phenomenon.

The next section describes a number of stylised facts regarding the interdependence of inflation among advanced economies, and how they have changed over time. Subsequently, the main drivers of cross-country price dynamics are analysed.

Chart 1

INFLATION INTERDEPENDENCE. COUNTRIES

Headline inflation is more interrelated across countries than core inflation. The interdependence tends to be greatest for the founding countries of the euro area than for the euro area countries as a whole. Inflation in the other advanced economies usually displays less synchronisation, as each country tends to have fewer trade links with the other countries and they each have their own monetary policy.



SOURCE: Authors' calculations, on the basis of Eurostat, Bureau of Labor Statistics, Statistics Canada and Statistics Bureau of Japan.



Stylised facts

The data used for this study correspond to the economies of the European Union,³ Canada, Japan and the United States for the period from January 1996 to April 2018. A simple way of analysing the comovement of inflation is to consider for each country the average of the correlation coefficients of that country with each of the other countries. Chart 1 shows that the average correlation tends to be greater for the countries belonging to the euro area than for the advanced economies as a whole, in keeping with the high degree of economic and financial integration between these countries and the fact that they have a common monetary policy. Also, the correlation is especially high for the founding countries of the euro area relative to the rest of the sample countries. In terms of core inflation (defined as headline inflation excluding energy and food) the average correlations between countries are substantially lower than for headline inflation.

A more rigorous way of analysing the degree of synchronisation between inflation rates is to use the modified Moran index of Stock and Watson (2008). This index summarises in a single number the degree to which a set of variables are interrelated and allows the changes over time to be seen.⁴ The value of this index ranges from -1

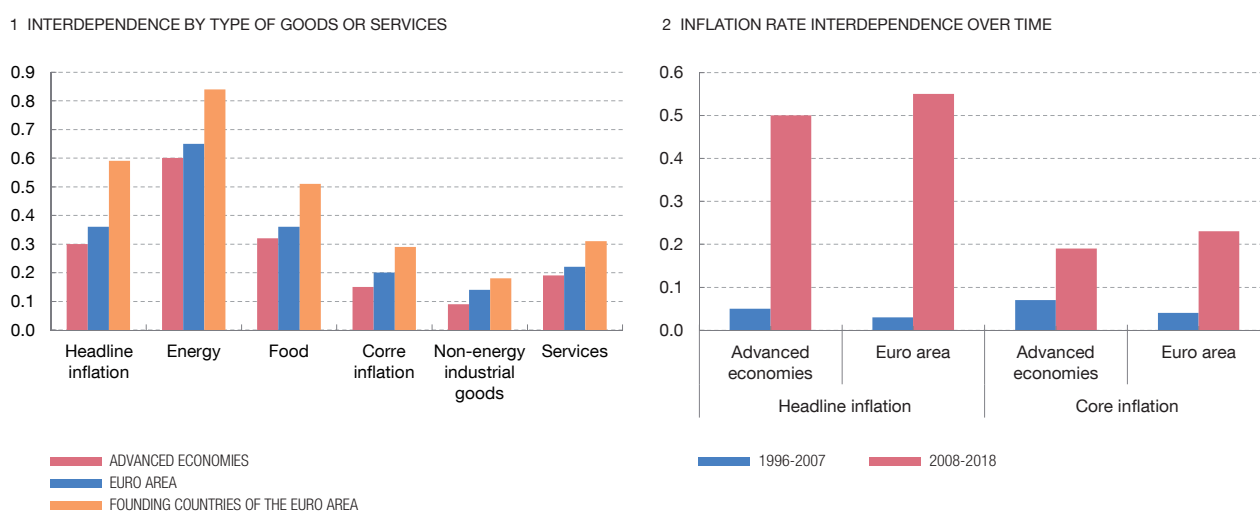
³ The absence of sufficiently long time series is the reason why countries such as Bulgaria, Croatia, Slovenia, Estonia, Hungary, the Czech Republic and Rumania are not considered.

⁴ An advantage of this index is that its distribution is known. For this reason statistical inference has been used and confidence intervals calculated. The results are presented in Álvarez *et al.* (2019).

Chart 2

INFLATION INTERDEPENDENCE (a)

Energy and, to a lesser extent, food prices tend to be affected by common shocks, so that their synchronisation is especially high. The interdependence of inflation across countries appears to have increased in the period following the crisis.



SOURCES: Authors' calculations, on the basis of Eurostat, Bureau of Labor Statistics, Statistics Canada and Statistics Bureau of Japan.

a The interdependence measure used is the modified Moran index of Stock and Watson (2008). The higher (lower) the value, the greater (lesser) the degree of interdependence.



to 1, and the higher (lower) its absolute value the greater (lower) the degree of comovement. A positive value indicates that the upward and downward inflation fluctuations in different countries are aligned. Chart 2.1 presents this measure of interdependence, which confirms the results obtained from the correlation analysis.

As one would expect, a high degree of heterogeneity is found in the degree of comovement of price change measures for the different types of goods and services. The synchronisation of headline inflation is substantially greater than that of measures of core inflation, in line with Carney (2017). The synchronisation is particularly low for non-energy industrial goods. This result can be explained by various factors. On one hand, the analysis refers to consumer prices, and not to export prices, and the non-tradable component of consumer prices – linked to labour costs and rentals, for example – is substantial. On the other hand, there are differences between countries as regards the timing of sales periods, which have a particularly strong effect on the price fluctuations of goods such as clothing, footwear and household appliances, so that price changes do not occur simultaneously across countries. Finally, we find that food prices are also quite synchronised, probably owing to the globalisation of food product markets and the increasing importance of multinational companies.

To analyse the changes over time in the degree of synchronisation of inflation, two different subsamples have been considered: the first subsample covers the period

prior to the world financial crisis, between 1996 and 2007, while the second covers the subsequent period (2008 to 2018). Chart 2.2 shows that the interdependence of inflation has increased very considerably since the global financial crisis. The factor explaining this is the increase in the degree of openness of the various economies with the resulting greater impact of common shocks on the various countries. This increase in the relative importance of global shocks explains the greater alignment of inflation fluctuations in advanced economies.

The above analysis has not considered possible differences in the interconnectedness of inflation across countries, according to the more or less temporary nature of the shocks that have an impact on inflation. Specifically, we break down inflation into short, medium and long-term movements.⁵ Thus, temporary shocks specific to one country, such as those that may arise from changes to indirect taxation or regulated prices, tend to reduce comovement in price developments. Conversely, the interdependence of inflation rates can be expected to be greater at cyclical frequencies, since the Phillips curve mechanism (the relationship between activity and inflation), which causes activity pressures to be passed through to prices, can be expected to be more powerful over the cycle than short-term or long-term movements. Finally, changes in trend inflation across countries resemble each other insofar as different central banks have similar inflation targets, companies adopt similar technologies and consumers have similar preferences.

When headline inflation is broken down in this way, its short-term movements are found to be barely related across countries, reflecting the importance at the highest frequencies of temporary shocks specific to each economy (see Chart 3.1). In contrast, medium-term inflation movements (corresponding to cyclical frequencies) display a particularly high degree of association, since the interdependence of activity in the various countries contributes to generating aligned inflation rate movements. The longer-term inflation movements also show a high degree of association, so that the interdependence of inflation can be characterised as a medium and long-term phenomenon. When the degree of association of inflation in different geographical areas for different periods is compared, it is seen to be higher for euro area countries and especially for the founding countries of the euro area, than for advanced economies as a whole. The higher correlation between euro area countries, especially the founding countries, may be explained by the existence of the common monetary policy, the stronger trade and financial relations and a high degree of economic convergence.

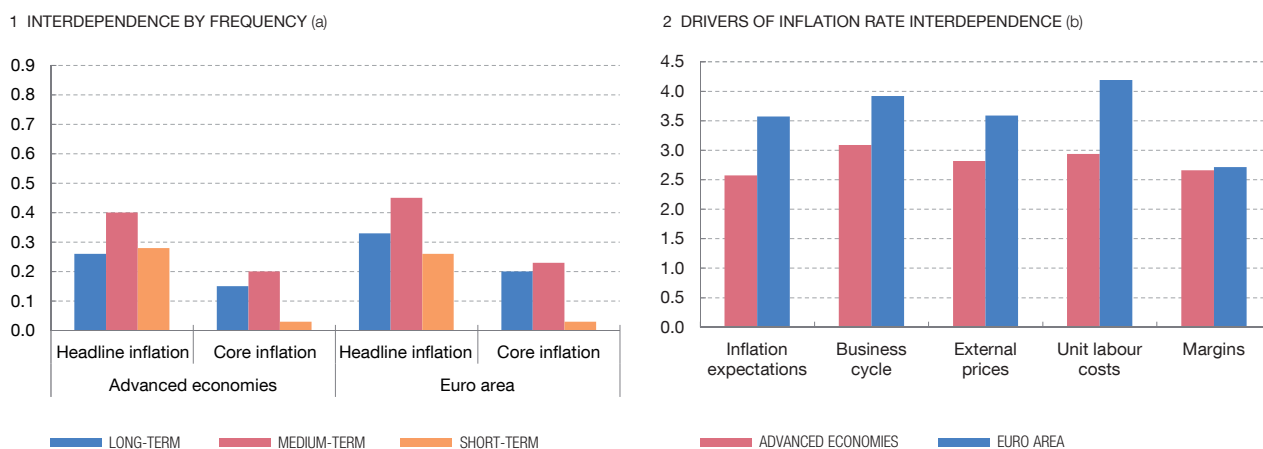
As regards core inflation, the degree of interconnectedness is lower than for headline inflation for all the frequencies considered. Its short-term fluctuations are again seen

⁵ The inflation rate was broken down into trend, cycle and short-term fluctuations using what is known in the literature as a band pass filter, specifically the one proposed by Christiano and Fitzgerald (2003). Short term refers to fluctuations of less than two years, the cycle to fluctuations of between two and five years, and the trend to fluctuations of over five years.

Chart 3

INFLATION INTERDEPENDENCE: FREQUENCIES AND DRIVERS

The interdependence of inflation is a medium and long-term phenomenon. Short-term shocks tend to be idiosyncratic. The interdependence would be attributable to comovements of inflation expectations, the business cycle, external prices and unit labour costs.



SOURCE: Authors' calculations, on the basis of Eurostat, Bureau of Labor Statistics, Statistics Canada and Statistics Bureau of Japan.

- a The interdependence measure used is the modified Moran index of Stock and Watson (2008). The higher (lower) the value, the greater (lesser) the degree of interdependence.
- b The measure of similarity used is the standardised inverse of the Frobenius norm. The higher (lower) the value, the greater (lesser) the similarity of inflation to each of its drivers.



to be largely unrelated, indicating that the interdependence of core inflation is also a medium and long-term phenomenon. The difference between the degree of association observed for headline inflation and for core inflation is essentially due to the consumer prices of energy which, being associated with oil prices on international markets, behave very similarly across countries.

The drivers of inflation rate interdependence

In order to shed light on the macroeconomic variables that explain the degree of interdependence of inflation rates across countries, a number of variables suggested by theoretical price setting models are considered. First, New Keynesian Phillips curve models, which relate actual inflation to inflation expectations, the economy's cyclical position and external prices, are considered. Second, markup price settings models are used, which explain inflation dynamics in terms of the unit labour cost growth rate (which can, in turn, be broken down into average compensation and productivity), profit margins and external prices.⁶

⁶ To represent these variables, a measure of inflation expectations based on consumer surveys is used, business cycles are measured using GDP growth, external prices are calculated using the import deflator, unit labour costs are obtained from the national accounts, while margins are calculated as the difference between the growth rates of the GDP deflator and unit labour costs.

The extent to which the interconnection between the possible determinant variables of inflation explains the degree of interdependence of inflation rates across countries is evaluated. For this purpose, the degree of similarity between two correlation matrices – the inflation matrix and the matrix of each of its possible determinants – is calculated, using a matrix norm to assess the distance between the correlation matrices.⁷

To facilitate interpretation of the results, this measure has been standardised.⁸ A higher (lower) value of this measure means that the interdependence of the explanatory variable is closer to (further from) that of inflation.

Chart 3.2 presents the results of the measure used to determine whether the interdependence of these variables is similar to that of headline inflation. Specifically, the results obtained identify five relevant variables, which include the three usual variables in New Keynesian open economy models (i.e. inflation expectations, the cyclical position and external prices), along with the variables used in markup models: unit labour costs and profit margins. Also, these variables are found to explain the interconnectedness between inflation in the euro area countries more precisely than in the advanced economies as a whole, which is consistent with the greater trade and financial integration of these economies.

Conclusions

This article documents how inflation tends to be highly synchronised across the advanced economies. This has implications in terms of the interrelatedness of the economic policies pursued by different countries. This is particularly true for euro area countries, which have significant trade ties and share a common monetary policy. Also, there is significant heterogeneity in the degree to which inflation rates are interconnected, according to product type: it is particularly high for energy prices which depend to a large extent on world oil markets, but rather modest in the case of core inflation. This fact is not unrelated to the fact that central banks do not have inflation targets based on any measure of core inflation. At the same time, the degree of comovement of inflation across countries is greater when the short-term fluctuations, which tend to be rather idiosyncratic in each country, are eliminated, so that the interdependence of inflation is essentially a medium to long-term

7 Specifically, we use the Frobenius norm to calculate the similarity of two correlation matrices. The way to interpret this measure is as follows: the lower (higher) the value of this norm, the closer (more distant) are the two matrices. In the extreme case in which the two matrices are identical, the Frobenius distance between them is equal to zero. Given that the statistical distribution of the Frobenius norm between two correlation matrices is not known, we use Monte Carlo techniques to estimate it. Specifically, to assess the importance of each determinant an exercise was designed in which we calculate the empirical distribution with 10,000 replicas of two random correlation matrices with a dimension equal to the number of countries in the sample.

8 The measure used is calculated as the standardised inverse of the Frobenius norm, so that it does not depend on the number of countries analysed.

phenomenon. Also, the synchronisation of inflation has increased in recent years, against a background of growing globalisation. However, the recent upsurge in protectionism would suggest that the degree to which inflation rates are connected across countries will not necessarily continue to increase in future.

As regards the sources of inflation interdependence, we find that the comovements in the drivers of open-economy Phillips curve models (inflation expectations, the cyclical position and external prices) and the markup price settings models (unit labour costs and margins) help to explain it.

An interesting line of research not addressed by this article is the role of trade intensity in explaining the interconnectedness of inflation rates; countries with closer trade ties should have more strongly related inflation rates. Another aspect that should be studied in future is the implications for economic policies of a high degree of inflation interdependence, such as that displayed by the founding countries of the euro area.

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