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External Competition Flattens the Phillips Curve

La competencia exterior aplana la Curva de Phillips

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Abstract

In this paper we elaborate an open economy Phillips curve (OEPC) with micro-founded analysis, in which external competition significantly impacts the domestic inflation rate. This influence is transmitted through two channels: a) the gap between the current and potential growth of imports, and b) real exchange-rate misalignment. We estimate this OEPC by applying two econometric techniques, panel regressions and PVAR accompanied by impulse/response analysis. A sample of 15 advanced economies is used with data for the period 1994-2017. The results from both methodologies endorse the validity of this theoretical relationship and suggest that international competition reduces the pricing power of domestic firms, thereby curbing inflationary pressures. We also find that the slope of the OEPC has significantly declined in the years after the Great Recession.

Keywords: Open economy Phillips curve, RER misalignment, Cross-sectional dependence, PVAR, impulse/response analysis.

Resumen

En este trabajo elaboramos una curva de Phillips para economías abiertas (CPEA) con fundamentación microeconómica, en la que la competencia exterior impacta significativamente sobre la inflación interna. Esta influencia se transmite a través de dos canales: a) el desfase entre las tasas de crecimiento actual y potencial de las importaciones, y b) el desalineamiento del tipo de cambio real. Estimamos esta CPEA aplicando dos tipos de técnicas econométricas:

regresiones de panel y PVAR acompañado de un análisis de respuestas al impulso. Utilizamos una muestra de 15 economías avanzadas con datos del periodo 1994-2017. Los resultados de las dos metodologías apoyan la validez de la relación teórica y sugieren que la competencia internacional reduce el poder de mercado de las empresas domésticas, frenando así las presiones inflacionistas. Encontramos también que la pendiente de la CPEA ha disminuido sustancialmente en los años posteriores a la Gran Recesión.

Palabras Clave: curva de Phillips en economía abierta, desequilibrio del tipo de cambio real, dependencia en sección cruzada, VAR de panel, análisis impulso/respuesta.

JEL Classification / Clasificación JEL: F41, F44, F62.

1. Introduction

In this paper, we examine the contribution of globalization to lowering domestic inflation, and to making this variable less sensitive to changes in economic slack throughout the last decades. Technically speaking, we analyze how international developments may have shifted the Phillips curve downwards and affected its slope.

Several recent contributions stress the relevance of global linkages in weakening the domestic Phillips curve relationship. Rogoff (1985, 2003) and Romer (1993) argue that openness incentivizes central banks to stabilize inflation at low levels, by causing excessive variations on the real exchange rates. Bean (2006, p.308), in a commentary on Rogoff (2006), points out that globalization could limit firms' ability to increase prices, thus changing the slope of the Phillips curve. Carney (2015, p.443) suggests that increased trade and deeper global value chains may have reduced the sensitivity of consumer price index (CPI) inflation to local labor market conditions. Additionally, Seydl and Spittler (2016), using US sectorial data between 1986 and 2014, point out that the growing importance of globalization and of the service sector could be contributing to the flattening of the Phillips curve. Szafranek (2017) examines the Phillips curve of a small, open economy -the Polish economy- between 2002 and 2015, concluding that this curve has flattened partly due to underutilization of labor and that the influence of global factors on this curve has increased. Ferroni and Mojon (2017, p.87) and IMF (2019) emphasize that greater international competition shrinks workers' capacity to negotiate wage increases and accentuates mark-ups' counter cyclicality. Finally, Bobeica and Jarocinski (2019) stress the spillovers from US to euro-area inflation, particularly during the Great Recession.

The traditional channel through which external opening impacts on the Phillips curve is the price of imported intermediate goods. See, for instance, McCallum and Nelson (1999), Paloviita (2009), Blanchard, Cerutti and Summers (2015) or Blanchard (2016). However, as Carney (2015, p.443) points out, the net effect on the slope of the Phillips curve of opening an economy to imported goods is, in principle, ambiguous. On the one hand, there is a downward pressure on inflation as consumers and firms can substitute domestic goods and inputs with cheaper foreign equivalents, an argument also put forward by Andrews, Gal and Witheridge (2018) and IMF (2019, pp.19-21), therefore restraining price increases as a result of changes in domestic macroeconomic conditions. But, on the other hand, more frequent price changes brought about by stronger competition could increase the pass-through of both price variations of imported inputs and of nominal exchange rate fluctuations to domestic inflation (Cavallo, 2018). This ambiguity underlines the relevance of examining the effect of external variables on the Phillips curve.

Another traditional path through which external opening impacts on the Phillips curve is the real exchange rate, included, for instance, in Galí and Monacelli (2005) or Forbes (2019). The impact of the real exchange rate on domestic macroeconomic conditions has been examined by numerous authors. Frenkel and Ros (2006) highlight the impact of this rate on unemployment, in particular affecting the labor intensity of the economic process, that is, changing the capacity to create employment of an economy due to variations in international relative wages. They also underline the relevance of considering the existence of tradable and non-tradable goods in the analysis, as we do in this paper, since it can affect how external opening influences macroeconomic outcomes.

Several authors have recently analyzed the influence of participation in global value chains (GVC) on macroeconomic variables. For instance, Gereffi and Luo (2015) point out that participation in GVC threatens the survival of less efficient firms. Indeed, even though trade liberalization in general has a positive impact on growth (Inwin, 2019) and productivity (Topalova and Khandelwal, 2011), authors such as Dix-Carneiro (2014) and Dix-Carneiro and Kovak (2017) have pointed out that it may take several transition years for welfare gains to be registered. In this regard, Acemoglu, Autor, Dorn, Hanson and Price (2016) and Autor, Dorn and Hanson (2016) expose the relevance of import competition, showing how China's emergence as a trade giant reduced US employment, a result that highlights the major influence of competition from foreign firms on macroeconomic outcomes. Regarding specific research on the Phillips curve, Auer, Borio and Filardo (2017), in their study of GVCs, find that proxies of global economic slack improve the explanatory power of traditional Phillips curve approaches. Forbes (2019), using a sample of 43 economies in the period from 1990 to 2017 and Moretti, Onorante and Saber (2019), analyzing the Eurozone between 1999 and 2018, also highlight the relevance of the global output gap, jointly with world oil prices, import price deflators, and real effective exchange rates, in explaining domestic inflation. Gilchrist and Zakrajsek (2019) in a study of the U.S. between 1962 and 2017 find that exposure of the U.S. economy to international trade is flattening its Phillips curve. Finally, Eser, Karadi, Lane, Moretti and Osbat (2020) examine inflation in the Eurozone through the Phillips curve models used in the European Central Bank and point out that mark-up fluctuations play an important role in accounting for the variation in inflation, and call for further work to analyze this issue in order to factor it into central banks' analysis. We follow this suggestion and analyze how foreign competition affects the Phillips curve through its impact on mark-ups.

Building on the Eser et al. (2020) suggestion and on the previous literature on the issue, we develop a new approach to analyze foreign influence on domestic macroeconomic outcomes. In our framework, one key aspect is that mark-ups depend on the amount of competitive pressure from foreign firms. In particular, we present two routes by which foreign competition impacts mark-ups in domestic markets: first, the gap between the current and potential growth of imports and, second, the real exchange-rate misalignment. The rationale for the first channel is that higher market share of foreign goods in domestic markets can curb market power of local firms and, as a result, reduce mark-ups. Indeed, as a country's exposure to imports grows (i.e., as the degree of imports openness increases), the greater foreign competitive pressure will induce domestic producers to keep prices low to avoid market-share losses. The influence of the second channel derives from relative prices: foreign competitive pressure will be higher when foreign products are relatively cheap, reducing mark-ups. To our knowledge, the application of this dual mechanism to capture the impact of globalization on the Phillips curve is an innovation of our paper.

So, in this paper, we derive an open economy Phillips curve (OEPC) in which both these external factors play an important role. We test the OEPC by using a sample of 15 advanced countries with annual data for the period 1994-2017. That way, we echo Lane's (2019, p.25) suggestion that the use of panel and cross-country variation and/or external instruments are promising routes to identify the Phillips curve slope. The initial year of our time sample is based on the findings of IMF (2013), which examines advanced economies between 1975 and 2012, Blanchard *et al.* (2015) and Blanchard (2016), using in both cases a sample of 20 economies between 1961 and 2013, showing that the Phillips curve in advanced countries has remained stable since the early 1990s.

Our research also innovates in both the theoretical approach and the applied methodology. As regards theory, we perform a micro-funded analysis to derive a Phillips curve for an open economy, in which inflation depends on expected inflation, the output gap, the imports gap (the difference between the current growth of imports and the long-run imports growth) and real exchange-rate misalignment[1]. In the applied section of the paper, we perform two types of tests. We first estimate the main equation for our sample of 15 advanced countries. We execute panel regressions instead of regressions based on individual countries, or on cross-country means, as usually done in the literature. Then we estimate a panel VAR (PVAR) and perform impulse-response analysis to check and derive the dynamic impact of changes in the explanatory variables.

Our empirical analysis shows that all the explanatory variables are statistically significant and have the sign predicted by the theoretical model.

[1] As many other authors, for instance Galī and Monachelli (2005), we use the output gap instead of the cyclical unemployment as an indicator of economic slack. Thus, our approach is based on the aggregate supply curve, which is the other side of the coin of the traditional Phillips curve.

We so confirm that the Phillips curve is alive, and that competitive pressures coming from abroad, captured by the two relevant variables, reduce domestic firms' pricing power. Our estimate of the Phillips curve slope is small, in line with Blanchard *et al.* (2015), Blanchard (2016), Forbes (2019) and Moretti *et al.* (2019). Thus, for the average country of the sample, a 1 percentage point increase in the output gap raises the domestic rate of inflation by 0.03 percentage points. We also find that the slope of the Phillips curve has notably declined since 2010.

The rest of the paper is structured as follows. The micro-founded analysis and derivation of the Phillips curve for an open economy is presented in Section 2. In Section 3 we estimate the main equation using two different econometric techniques, panel regressions and PVAR estimations accompanied by impulse-response analysis. Finally, Section 4 summarizes the main conclusions and derives some policy considerations.

2. Micro-foundations of the open economy Phillips curve

Following a standard approach (for example, in Ireland, 2004, or Galī and Monachelli, 2005), we assume a small, open economy with two representative agents: (i) households, who try to maximize their utility from consumption and leisure; and (ii) firms, which seek to maximize profits. Both agents are rational and face uncertainty about future prices, in line with Paloviita (2009).

We also assume the existence of imperfect competition in the domestic goods market, a usual assumption found, among others, in Galī and Monacelli (2005), Rumler (2007) or Paloviita (2009), and that there are not any other restrictions or market failures besides those mentioned. As a result, the representative domestic firm will enjoy some market power in the domestic market. It is proposed in this paper that foreign competition limits this market power.

2.1. Households and labor supply

The representative household makes consumption-leisure decisions based, firstly, on their preferences, represented by a well-behaved utility function in which leisure is a normal good; secondly, on the real wage; and, finally, on the cost of consumer goods, which will also be normal. We propose an intertemporal utility function in terms of working time, L, after replacing leisure (H) with D - L, D being the time divided between work and leisure. We assume a family dynasty with intergenerational solidarity, so that the time horizon approaches infinity. Each period will be represented by t. There are no credit constraints or other market failures, except uncertainty about future prices.

We also assume that households smooth their consumption and leisure patterns with neutral time preferences, which implies that their time discount rate, δ, equals the real interest rate r (that is, $\delta = r$). In addition, from the discount rate we define the discount factor β as: $\beta = \frac{1}{(1+\delta)}$. We denote the variables of interest as follows: C_t, is consumption in period *t,* which includes both domestic and imported products ($C_t = C_t^d + M_t$, where C_t^d is consumption of domestic goods in period *t* and M_t stands for consumer goods imports in period *t*); W_t is the nominal wage in period *t*; and P_t^c is the price index of the basket of goods consumed by the representative household in period *t*. As a result, we pose the following optimization problem:

$$\max U = \sum_{t=0}^{\infty} \left\{ \beta^t f\left(C_t, L_t\right) \right\}$$
$$s.a \sum_{t=0}^{\infty} \left\{ \frac{C_t}{(1+r)^t} \right\} = \sum_{t=0}^{\infty} \left\{ \frac{\left[W_t / P_t^c \right] L_t}{(1+r)^t} \right\} \tag{1}$$

This problem indicates that the household wants to maximize its utility over time, but they face budget constraints. Therefore, they must decide how much leisure they want to sacrifice in favor of work to obtain an income with which to consume. Solving this problem, we obtain the intra-temporal equilibrium condition from the first order condition (F.O.C.):

$$-\frac{\partial U / \partial L_t}{\partial U / \partial C_t} = \frac{W_t}{P_t^c} \tag{2}$$

This indicates that the supply of labor is such that the utility per monetary unit provided by the last leisure unit (or, alternately, the marginal disutility per monetary unit of the last working hour offered) is equal to the marginal utility of consumption per monetary unit paid. From this condition, we deduce that a real wage $\frac{W_t}{P_t}$ rise will increase labor supply and consumption, and vice versa.

We can also obtain the intertemporal equilibrium condition from the F.O.C. We must recall that, as aforementioned, $\delta = r$ and therefore $\beta(1 + r) = 1$. Since there is uncertainty about future prices, households have to forecast in period *t* the price level in $t + 1$ and, therefore, they also forecast the real wage in that period $t + 1$. Based on the expected real wage, they will also estimate the labor they will supply in $t + 1$:

$$\frac{\partial U / \partial L_t}{E\left[\partial U / \partial L_{t+1} \right]} = \frac{\left[W_t / P_t^c \right]}{E\left[W_{t+1} / P_{t+1}^c \right]} \tag{3}$$

As previously noted, households prefer to smooth their consumption and leisure patterns and, therefore, their labor supply. Thus, the amount of work they supply in a period is part of their optimal long-term path. All in all, in equilibrium, and in the absence of unexpected shocks, the optimal amount of work in period *t* and what they expect to work in *t + 1* will be the same, as will the real wage they receive in *t* and the one they expect to receive in *t + 1*:

$$\partial U / \partial L_t = E\left[\partial U / \partial L_{t+1}\right] \tag{4}$$

$$\left[W_t / P_t^c\right] = E\left[W_{t+1} / P_{t+1}^c\right] \tag{5}$$

Considering that agents agree on nominal wages at the beginning of each period, and thus that at the start of *t + 1* uncertainty only affects future prices, equation (5) can be rewritten as:

$$\left(W_{t+1} / W_t\right) = \left(E\left[P_{t+1}^c\right] / P_t^c\right) \tag{6}$$

This implies that agents want their nominal wages to vary at the same rate as they expect prices to change in order to keep their real wages and their work supply stable. Therefore, in equilibrium, the variation of nominal wages between periods is equal to the expected inflation. This idea is expressed more directly in the following equation (7). In this equation, $\hat{W}_t$ is the change rate of the nominal wage for the period *t* with respect to the previous period and $E\{\pi_t^c\}$ is the expected inflation rate for the period *t*:

$$\hat{W}_{t+1} = E\{\pi_{t+1}^c\} \text{ and, in general, in equilibrium } \hat{W}_t = E\{\pi_t^c\} \tag{7}$$

2.2. Firms and labor demand

Following the extensive literature on the Phillips curve that establishes labor and wages as key elements in real marginal costs and inflation dynamics (for example, Chen, Imbs, and Scott, 2004, Galī, 2011, or Blanchard, 2016), we assume that there is only one input, labor *L* and, therefore, we do not explicitly consider capital nor intermediate goods. Thus, the representative firm has a single-factor production function, with labor (*L*), and diminishing returns to scale:

$$Y_t = AL_t^{\sigma} \tag{8}$$

In the above equation, Y_t is the production in period t, L_t the amount of work in period t, A represents technology, σ is a parameter that reflects labor productivity, where $0 < \sigma < 1$ since there are diminishing returns. The firm is a profit maximizer in a market with imperfect competition, which implies that it is not a price-taker, and that it incorporates the demand function in its optimization problem, which is the following:

$$\max B^o = \sum_{t=0}^{\infty}\left\{P_t\left[Y_t(L_t)\right]Y_t(L_t) - W_t L_t\right\} \quad (9)$$

In the equation above, B^o is the profit; $P_t\left[Y_t(L_t)\right]$ is the inverse demand function in period t where P_t is the index of domestic prices; $Y_t\ (L_t)$ is the production that depends on labor L_t; and, finally, W_t is the nominal wage in period t. From its F.O.C.[2], we obtain the following equilibrium condition:

$$P_t\, MP_{Lt}\left(\frac{1+\varepsilon_t}{\varepsilon_t}\right) = W_t \quad (10)$$

MP_{Lt} stands for the marginal productivity of labor in period t; and ε_t is the price-elasticity of demand for goods in period t. Taking the MP_{Lt} obtained from the production function (8) ($MP_{Lt} = \sigma\, A\, L_t^{\sigma-1}$), and substituting into the previous equation (10), the resulting equilibrium condition is:

$$P_t\,\sigma\, A L_t^{\sigma-1}\left(\frac{1+\varepsilon_t}{\varepsilon_t}\right) = W_t \quad (11)$$

The mark-up is represented by v_t, which emerges as a consequence of imperfect competition, and we define it as follows:

$$v_t = \left(\frac{1+\varepsilon_t}{\varepsilon_t}\right) \quad (12)$$

[2] F.O.C. from $\frac{dB^o}{dL_t} = 0$ → $\frac{\partial P_t}{\partial Y_t}\frac{\partial Y_t}{\partial L_t}Y_t + P_t\frac{\partial Y_t}{\partial L_t} - W_t = 0$;

(i) replacing $\frac{\partial Y_t}{\partial L_t}$ by marginal productivity of labor MP_{Lt}

and solving for W_t: $\frac{\partial P_t}{\partial Y_t}MP_{Lt}Y_t + P_t\, MP_{Lt} = W_t$;

(ii) taking MP_{Lt} as common factor: $MP_{Lt}\left[\frac{\partial P_t}{\partial Y_t}Y_t + P_t\right] = W_t$;

(iii) multiplying $\frac{\partial P_t}{\partial Y_t}Y_t$ by $\frac{P_t}{P_t}$: $MP_{Lt}\left[\frac{\partial P_t}{\partial Y_t}\frac{Y_t}{P_t}P_t + P_t\right] = W_t$;

(iv) replacing $\frac{\partial P_t}{\partial Y_t}\frac{Y_t}{P_t}$ by $\frac{1}{\varepsilon}$ and taking P_t as common factor: $P_t MP_{Lt}\left[\frac{1}{\varepsilon}+1\right] = W_t$;

(v) from $\left[\frac{1}{\varepsilon}+1\right]$ we can multiply to obtain $\left(\frac{1+\varepsilon_t}{\varepsilon_t}\right)$: $P_t\, MP_{Lt}\left(\frac{1+\varepsilon_t}{\varepsilon_t}\right) = W_t$.

As pointed out earlier, we propose that the mark-up depends on the amount of competitive pressure from foreign firms. This approach is in line with Chen *et al.* (2004), who consider that economic integration can increase competition and price flexibility, and it is also in line with the idea that foreign competition will affect inflation dynamics, as suggested, for example, by Bean (2006), Carney (2015), Andrews *et al*. (2018), Gilchrist and Zakrajsek (2019) or by IMF (2019). In this paper, we assume that such pressure is stronger in economies that are most open to imports, and where the degree of substitution between domestic and foreign goods is high. Therefore, if there is easy access to competitive foreign goods, the market power of the domestic firm will be limited. On the other hand, if domestic production is not tradable or if importing is difficult or expensive, then domestic firms will enjoy strong market power.

The relationship between external competition and the mark-up of domestic firms facilitates the representation of the mark-up as a function of external competition. Hence, we propose that the mark-up depends on the presence of imported goods in relation to the size of the economy in period *t*, which we denote $\left[\frac{M_t}{Y_t}\right]^{\varphi}$, where M_t stands for imports in period *t*, which we assume are final consumer goods, and, as before, Y_t is the production in period *t*. This imports-to-GDP ratio is adjusted by parameter φ which comprises the structural aspects in the relationship of an economy with foreign markets, such as preferences for imported goods and services, as well as international trade regulations, tariffs, transport costs and other import costs.

The level of competitive pressure will also depend on the real exchange rate, which measures the relative price of the foreign goods with respect to the domestic goods. The real exchange rate is a common component of Phillips curves in open economies (for instance, Galī and Monacelli 2005 and Forbes 2019), but in our case it is not the transmission channel of price variations in imported inputs on the costs of domestic firms, but rather the relative price of domestic goods compared to foreign ones. Q_t stands for the real exchange rate, and its influence is adjusted by parameter α, which reflects the impact of the real exchange rate on foreign competitive pressure. An increase in Q_t represents an appreciation of the real exchange rate that causes a loss of competitiveness in domestic goods and, consequently, an increase in the competitive pressure exerted by foreign products.

The parameters α and φ that accompany $\left[\frac{M_t}{Y_t}\right]$ and Q_t play a key role. The values of α and φ are very sensitive to, respectively, the proportion of tradable goods in the economy, and to the substitutability between imported and domestically produced goods. We assume that an economy with a high degree of tradable goods and high substitutability between imported and domestic products exhibits high values of α and φ, and suffers strong competitive pressure from abroad that shrinks the mark up of their firms.

Finally, we define μ as the other domestic structural elements that affect the mark-up, such as domestic market regulations, competition enforcement policies or other local aspects that influence competition levels. We assume that it is stable in time and, therefore, constant.

According to the above reasoning, we assume that the mark-up obeys the following expression:

$$v_t = \mu \left[\frac{M_t}{Y_t} \right]^{\varphi} Q_t^{\alpha} \tag{13}$$

Combining equations (13), (12) and (11) and solving for labor, we obtain labor demand:

$$L_t = \left(\frac{P_t \sigma A \mu \left[\frac{M_t}{Y_t} \right]^{\varphi} Q_t^{\alpha}}{W_t} \right)^{1/1-\sigma} \tag{14}$$

Therefore, labor demand in period t has a positive relationship with domestic prices, technology and productivity, and a negative relationship with nominal wages. It also depends positively on foreign competitive pressure, represented by equation (13), since greater competition levels reduce market power and boost production.

2.3. The open economy Phillips curve

We can then introduce labor demand, in equation (14), into the production function represented in equation (8) $Y_t = AL_t^{\sigma}$ to obtain the production level of the economy:

$$Y_t = A \left(\frac{P_t \sigma A \mu \left[\frac{M_t}{Y_t} \right]^{\varphi} Q_t^{\alpha}}{W_t} \right)^{\sigma/1-\sigma} \tag{15}$$

Denoting the equilibrium values in period t of production, nominal wages, domestic price level, imports and real exchange rate by Y_t^*; W_t^*; P_t^*; M_t^*; and Q_t^* respectively, and considering that parameters σ, α and φ are stable in equilibrium, we arrive at the following equation:

$$Y_t^* = A \left(\frac{P_t^* \sigma A \mu \left[\frac{M_t^*}{Y_t^*} \right]^{\varphi} Q_t^{*\alpha}}{W_t^*} \right)^{\sigma/1-\sigma} \tag{16}$$

To examine the relationship between current production and its equilibrium level in period *t*, we divide the two previous equations (15) and (16):

$$\frac{Y_t}{Y_t^*}=\frac{A\left(\dfrac{P_t\,\sigma A\mu\left[\dfrac{M_t}{Y_t}\right]^{\varphi}Q_t^{\alpha}}{W_t}\right)^{\sigma/1-\sigma}}{A\left(\dfrac{P_t^*\,\sigma A\mu\left[\dfrac{M_t^*}{Y_t^*}\right]^{\varphi}Q_t^{*\alpha}}{W_t^*}\right)^{\sigma/1-\sigma}} \quad (17)$$

Simplifying (17), we obtain:

$$\frac{Y_t}{Y_t^*}=\left(\frac{Y_t^{*\varphi}P_tW_t^*M_t^{\varphi}Q_t^{\alpha}}{Y_t^{\varphi}P_t^*W_tM_t^{*\varphi}Q_t^{*\alpha}}\right)^{\left(\frac{\sigma}{1-\sigma}\right)} \quad (18)$$

In order to put the equation above in rates of change, we take logs on both sides of the equation and take derivatives with respect to time. As a result, we obtain the following equation (19), where capital letters with hat denote the rate of change in period *t* of the respective variable, while π_t is domestic inflation in *t*, and π_t^* represents the long-term equilibrium rate of inflation:

$$\hat{Y}_t-\hat{Y}_t^*=\left(\frac{\sigma}{1-\sigma}\right)(\varphi\hat{Y}_t^*+\pi_t+\hat{W}_t^*+\varphi\hat{M}_t+\alpha\hat{Q}_t-\varphi\hat{Y}_t-\pi_t^*-\hat{W}_t-\varphi\hat{M}_t^*-\alpha\hat{Q}_t^*) \quad (19)$$

According to equation (7) $\hat{W}_t=E\{\pi_t^c\}$. And, since the real wage remains constant in equilibrium ($(\hat{W}_t^*=\pi_t^*)$), we can simplify equation (19) to obtain the following expression:

$$\hat{Y}_t-\hat{Y}_t^*=\left(\frac{\sigma}{1-\sigma}\right)\left[\pi_t-E\{\pi_t^c\}+\varphi\left(\hat{Y}_t^*-\hat{Y}_t\right)+\varphi\left(\hat{M}_t-\hat{M}_t^*\right)+\alpha\left(\hat{Q}_t-\hat{Q}_t^*\right)\right] \quad (20)$$

For simplicity of notation of the parameters, we establish that $\gamma=\varphi+\left(\frac{1-\sigma}{\sigma}\right)$, and solve for the rate of inflation:

$$\pi_t=E\{\pi_t^c\}+\gamma\left(\hat{Y}_t-\hat{Y}_t^*\right)-\varphi\left(\hat{M}_t-\hat{M}_t^*\right)-\alpha\left(\hat{Q}_t-\hat{Q}_t^*\right) \quad (21)$$

Note that, for the case of output, the difference between the two rates of growth is:

$$\left(\hat{Y}_t-\hat{Y}_t^*\right)=\frac{Y_t-Y_{t-1}}{Y_{t-1}}-\frac{Y_t^*-Y_{t-1}^*}{Y_{t-1}^*} \quad (22)$$

Assuming that the economy is in equilibrium in the initial period t ($Y_{t-1} = Y_{t-1}$*), we have:

$$\frac{Y_t - Y_{t-1}}{Y_{t-1}} - \frac{Y_t^* - Y_{t-1}^*}{Y_{t-1}^*} = \frac{Y_t - Y_{t-1}^* - Y_t^* + Y_{t-1}^*}{Y_{t-1}^*} = \frac{Y_t - Y_t^*}{Y_{t-1}^*} = \left(y_t - y_t^*\right) \quad (23)$$

where y_t and y_t^* are the log of Y_t and Y_t^*, respectively. Consequently:

$$\left(\hat{Y}_t - \hat{Y}_t^*\right) = \left(y_t - y_t^*\right)$$

The same procedure can be applied to the difference between the growth rates of the real effective exchange rate (REER) and of the imports:

$$\left(\hat{M}_t - \hat{M}_t^*\right) = \left(m_t - m_t^*\right)$$
$$\left(\hat{Q}_t - \hat{Q}_t^*\right) = \left(q_t - q_t^*\right)$$

Where lowercase letters denote logs of the corresponding variables.

Taking into account the above derivations, equation (21) can be written as:

$$\pi_t = E\left\{\pi_t^c\right\} + \gamma\left(y_t - y_t^*\right) - \varphi\left(m_t - m_t^*\right) - \alpha\left(q_t - q_t^*\right) \quad (24)$$

Equation (24) is the open economy Phillips curve (OEPC), with the activity slack represented by the output gap instead of the unemployment differential.

The most conventional Phillips curve for a closed economy can be derived from equation (24) - as a particular version of it – by making $\alpha = 0$, $\varphi = 0$.

This OEPC innovates including two factors that explicitly capture the influence of foreign competition: the imports gap term $\varphi\left(m_t - m_t^*\right)$ and the real exchange-rate misalignment. The rationale is that when imports deviate upwards from their equilibrium level or the domestic currency appreciates excessively in real terms mark-ups shrink as domestic firms perceive greater threat of losing market share. Thus, a positive deviation in these variables could foster price contention of domestic firms, and vice versa.

3. Quantitative analysis of the open economy Phillips curve

3.1. Methodology, data and its statistical properties

In this section, we perform a quantitative analysis of the OEPC presented in this paper. The relationship that we estimate with a sample of i countries, based on equation (24), contains the variables included in that equation: domestic inflation, expected inflation, output gap, imports gap and REER misalignment (details of data definition and sources in Annex):

$$\pi_{it} = \theta_i + \beta_1 E\left\{\pi_{it}^c\right\} + \beta_2\left(y - y^*\right)_{it} + \beta_3\left(m - m^*\right)_{it} + \beta_4\left(q - q^*\right)_{it} + \rho_{it} \quad (25)$$

The term ρ_i is the random error, which is distributed with zero average and constant variance, and θ_i is a fixed effect. Finally, $\beta_1, \beta_2, \beta_3, \beta_4$ are the model parameters to estimate. Hence, the two parameters that affect the imports gap and the REER misalignment, β_3 and β_4, reflect how much inflation reacts when these variables deviate from their equilibrium level. Additionally, as indicated in the theoretical development, their value depends on structural factors such as preferences for imported products, trade regulations and tariffs, import costs, etc. in the case of β_3, and the REER misalignment pass-through to inflation in the case of β_4.

The fact that, according to some studies (Blanchard 2016, Leduc and Wilson 2010 or IMF 2019), the Phillips curve has remained stable since the early 1990s, has led us to use a sample that begins then. We choose 1994 as the initial year because it is the first year after the crisis of the European Monetary System. So, our time sample is 1994-2017. We include 15 advanced economies in the analysis: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, UK and US. These are major advanced economies for which there is sufficient information of the required variables in data sources of recognized institutions (full details of data sources in the Annex).

We obtain most of the data from the International Monetary Fund (IMF), including domestic inflation, expected inflation[3] and imports growth data, which are expressed as interannual percentage change rates, and output gap, which is presented as a percentage of potential GDP. Finally, we obtain REER misalignment from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) Exchange database of Couharde, Delatte, Grekou, Mignon and Morvillier (2018) [4], which is expressed as a percentage of its equilibrium level, and an increase represents an appreciation of the domestic currency.

Regarding imports gap $(m-m^*)_{it}$, the data series is constructed as follows: for each period we subtract from the imports growth the equilibrium imports growth rate, which we approximate by the potential output growth expressed as interannual percentage change rate, obtained from the Organisation for Economic Co-operation and Development (OECD) database (details on how it is estimated in Chalaux and Guillemette, 2019)[5].

In the following sub-section, we perform tests on the data to verify its statistical properties.

[3] Expected inflation is obtained from the IMF fall forecasts in its 'World Economic Outlook' dating from October 1990 to 2017, using the year after the corresponding publication as the data for expected inflation in the current year. This approach to expected inflation is in line with other authors such as Paloviita (2007), which uses OECD inflation expectations data, or Forbes (2019) which uses five years expected inflation from the IMF.

[4] Specifically, we use the REER misalignment data with a moving weighting scheme based on 5-year non-overlapping averages. More details in http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=34

[5] The use of potential GDP growth as a proxy of m^* assumes that, in equilibrium, imports growth rate is equal to that of production, so that imports weight with respect to production remains stable.

3.1.1. Cross-sectional dependence

Cross-sectional dependence is common in international panels due to unobservable factors, external effects or contagions between countries (more details in Baltagi and Pesaran, 2007). It can reduce estimator's efficiency and it can skew, or even invalidate, test results. To verify its existence in the data, we apply four tests: the Breusch-Pagan LM test (1980), the Pesaran LM scaled test (2004), the Pesaran CD test (2004), and the Baltagi, Feng, and Kao bias-corrected scaled LM test (2012). The results, shown in columns 2 and 3 of Table A-I (in Annex), indicate that there is cross-sectional dependence with a 1% significance level in all cases.

3.1.2. Stationarity

To analyze whether the variables are stationary in this balanced panel with cross-sectional dependence, we use the CADF unit root test (Pesaran, 2007). This test, which is part of the second-generation unit root tests, is specifically designed to address the problem of cross-sectional dependence. The test is performed for 1 and 2 lags with a constant and a trend. The results, shown in Table A-II (in Annex), indicate that for 1 lag we can reject the null of no stationarity at 10% significance level for all the variables both with constant or with constant and trend, indeed at 1% for most of them, only excepting REER misalignment with constant and no trend. For 2 lags the results are mixed: we can reject the null at 5% for the output gap and imports gap both with constant and with constant and trend, while we cannot reject it for the rest. All in all, we consider that these results in general indicate that the variables are stationary, and thus they are integrated of order zero, as would be theoretically expected.

3.2. Estimation with fgls panel regressions

Since the variables in equation (25) are integrated of order zero, we can estimate the OEPC by creating a panel with these variables and estimating a panel model. Since there is cross-sectional dependence, we use a feasible generalized least square (FGLS) estimation, which is appropriate to handle cross-sectional dependence, in particular in situations, as this case, where the number of time periods is higher that the number of cross-sections. Results are shown in Table I.

In the second column of Table I (coefficient column), we observe that all of the coefficients have the signs predicted by the theory presented in this paper. In addition, the coefficients are statistically significant at 5%; indeed, most of them at 1%. The results indicate that a 1 percentage point increase of the output gap rises inflation by 0.03 percentage points, the same increase in imports gap reduces inflation by 0.02 percentage points and, finally, a 1 percentage point increase in REER overvaluation decreases inflation by 0.01 percentage points.

Table 1. OEPC FGLS estimation

Dependent Variable: Domestic inflation			
Coefficient (variable)	Coefficient	Prob.	
θ	0.169453	0.026	**
β1 (expt. Inflation)	0.9634444	0.000	***
β2 (output gap)	0.0292835	0.021	**
β3 (imports gap)	-0.0222545	0.000	***
β4 (REER misalign.)	-0.0117945	0.000	***

Method: FGLS with heteroskedastic and correlated error structure. Balanced panel. N: 15. t: 24 (1994-2017). Obs.: 360. *** indicates significance at 1% level; ** 5% level; * 10% level.

The moderating effect of the two external factors considered here is consistent with the findings of Auer *et al.* (2017), Ferroni and Mojon (2017), Forbes (2019) and Moretti *et al.* (2019), using a different set of external variables, and are also in line with Romer (1993) and Rumler (2007) in that there is a negative relationship between the degree of openness and inflation. It also supports that exposure to international trade flattens the Phillips curve, as Gilchrist and Zakrajsek (2019) found for the US economy.

Some recent analysis, such as Leduc and Wilson (2017), Forbes (2019) and IMF (2019), suggest that the Phillips curve might have reduced its slope after the 2009 crisis. In order to test this hypothesis, we repeat the last estimation introducing a multiplicative dummy with value 0 between 1994-2009 and 1 between 2010 and 2017 on the output gap's coefficient, which we call "output gap*d10-17", to examine whether this coefficient changed and, if so, ascertain how and to what extent.

Results, presented in Table II, show that all the variables again have the sign predicted by this paper's theoretical proposals, and are statistically significant at 1% level, including the "output gap*d10-17" variable. The output gap has a coefficient of nearly 0.09 until 2009, but its influence on inflation wanes in the 2010-2017 period, where it becomes close to zero. Therefore, these results clearly indicate that the slope of the Phillips curve decreased remarkably from 0.09 to nearly zero from that year 2010, a result consistent with Forbes (2019).

Table 2. OEPC FGLS estimation with a time dummy for 2010-2017

Dependent Variable: Domestic inflation			
Coefficient (variable)	Coefficient	Prob.	
θ	0.147206	0.063	*
β1 (expt. Inflation)	0.961216	0.000	***
β2 (output gap)	0.0864108	0.000	***
β3 (imports gap)	-0.0256644	0.000	***
β4 (REER misalign.)	-0.0137117	0.000	***
β5 (output gap*d10-17)	-0.0918362	0.000	***

Method: FGLS with heteroskedastic and correlated error structure. Balanced panel. N: 15. t: 24 (1994-2017). Obs.: 360. *** indicates significance at 1% level; ** 5% level; * 10% level.

Since the slope of the Phillips curve derived from our theoretical model depends negatively on the productivity of labor, we may infer from our second empirical result – with the multiplicative dummy for 2010-2017- that globalization has probably increased the efficiency and productivity of domestic firms in the years after the Great Recession. Two likely explanations can be provided: first, international competition leads firms to adopt more efficient technologies and, second, the expanded pool of available labor – through immigration and potential offshoring- induces employees to work with more interest and productivity, and firms to engage the most productive workers.

It could be highlighted that estimations of the external variables in Tables I and II remain very similar in both cases. Finally, these results are also consistent with the idea that foreign competition could be one of the factors encouraging recent price moderation, in line with the findings of different authors as Auer *et al.* (2017), Ferroni and Mojon (2017), Gilchrist and Zakrajsek (2019), Forbes (2019) and Moretti *et al.* (2019).

3.3. PVAR estimation

In this section we estimate a panel VAR (PVAR), in which inflation, output gap, imports gap and REER misalignment are endogenous variables. The time sample in this estimation starts two years earlier (1992-2017) in order to incorporate the data of the two lagged variables with which we work in our PVAR. We consider inflation expectations exogenous since the process by which the IMF elaborates inflation expectations has no relationship to the structure and functioning of our model[6].

We use the information criteria of Akaike, Hannan-Quinn, Schwarz and on the final prediction error to choose the number of lags of the PVAR, and all of them coincide in 2 lags (results in Table A-III, in Annex). Therefore, we use 2 lags to estimate the PVAR.

Afterwards, we test if there is residual autocorrelation in the PVAR with 2 lags. First, we perform a visual analysis (residual graphs in Annex) which does not show residual autocorrelation, and then we apply a Residual Serial Correlation LM Test based on Breusch-Godfrey with the Edgeworth corrective expansion, using from one to four lags. The results of this test, available in Table A-IV (in Annex), indicate that the residuals of the OEPC estimation do not suffer from autocorrelation.

6 Moreover, IMF estimates are produced long before the actual data of a given year is available, through a complex process which has gone through significant changes over the last 30 years. Nowadays, the IMF mixes different estimation methods: on the one hand, the respective country analysts choose the forecast method that best adapts to each country context. On the other hand, the departments of financial markets, global commodities, and global macroeconomics also develop their own forecasts. All these estimations are put in common, and then a coordination and review process are carried out until the results converge and are consistent. The elaboration of these estimates can take from 3 to 6 months (more details in Genberg, Martinez and Salemi, 2014).

To test whether the OEPC PVAR is stationary, we analyze the inverse roots of its characteristic polynomials, and we find that all of them are inside the unit circle. Thus, we confirm that the PVAR is stationary.

We now analyze the results of the estimated PVAR, which are presented in Table A-V, in Annex. As observed in the four columns of this Table, the high t-statistics in most of the OEPC estimates, particularly in the case where inflation is the dependent variable, are statistically significant. If we focus on column 2, where inflation is the dependent variable, we find that the estimates' signs are consistent with our theoretical approach, since expected inflation and output gap have a positive influence, while the external variables have a negative one. Adding up the coefficients of both retarded estimations for each variable in that column, we find that the combined effect of inflation is 0.3, of the output gap is 0.08, of imports gap is -0.05, and of the REER misalignment is -0.01. The robustness of the results is enhanced by the similarities between our theoretical approach and both the Panel and the PVAR results.

We apply a VAR Granger Causality/Block Exogeneity Wald Test to analyze the structure of the causal links between these variables. This test allows to determine whether one variable is useful for forecasting another. We present the results in Table III, where the null hypothesis is that the excluded variable does not Granger cause the dependent variable, with the excluded variables listed in the first column under the heading "Excluded", and the dependent variables heading the rest of the columns. Thus, if the null is rejected, the results from this test verify that the excluded variable Granger causes the variable on the corresponding column. Results of this test verify that in most cases these variables have causal links between them and, in particular, that all the studied variables Granger-cause inflation at a 1% significance level.

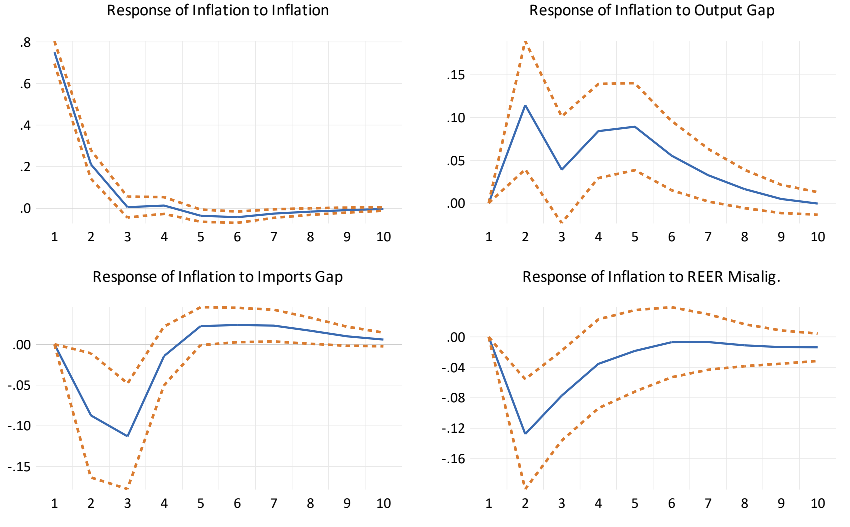
Table 3. VAR Granger Causality/Block Exogeneity Wald Tests

	Dependent							
	Domestic inflation		Output Gap		Imports Gap		REER Misalign.	
Excluded	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
Domestic inflation	N.A.	N.A.	152.26	***	103.09	***	16.08	***
Output Gap	27.10	***	N.A.	N.A.	17.67	***	4.52	
Imports Gap	18.80	***	4.58		N.A.	N.A.	7.45	**
REER Misalign.	13.00	***	9.38	***	2.00		N.A.	N.A.
All	45.53	***	156.56	***	153.06	***	25.12	***

N: 15; t: 26 (1992-2017); obs.: 390. Null: Excluded variable does not Granger-cause the dependent variable.
***indicates significance at 1% level; **5% level; *10% level.

We perform an impulse response analysis based on this estimated OEPC, focusing on inflation's response. We apply a shock of one standard deviation, with confidence margins projected using Monte Carlo simulations with 10,000 repetitions and $\pm$ 2 standard deviations. Results, in Figure I, show that the responses are again consistent with both our theoretical approach and with the previous results: a shock in inflation creates a positive response in inflation that starts with an impact of 0.8 in the first period, then adds another 0.2 in the second period, and stops having additional impacts in period 3. A shock in the output gap also creates an increase in inflation that adds between 0.04 and 0.12 each period for 5 initial periods, and afterwards reduces its impact gradually over the next 5 periods.

Figure 1. Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

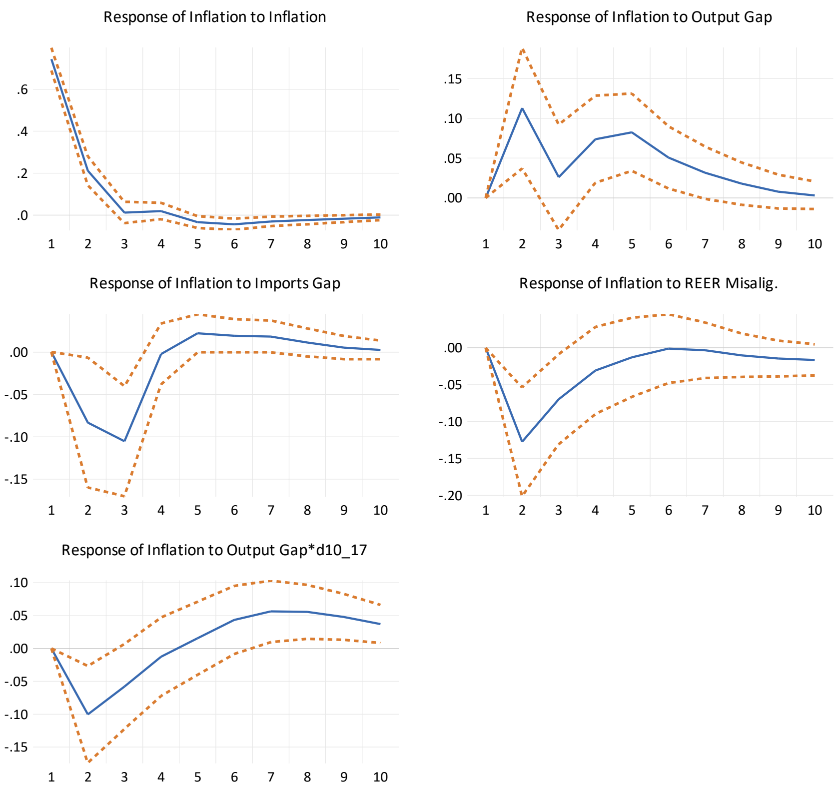


Solid lines represent impulse responses and dashed lines are standard error bands created by Monte Carlo simulations with 10,000 repetitions.

Regarding the external variables, the impulse analysis shows that they both have statistically significant disinflationary effects that accumulate for 4-6 periods after the initial shock. Specifically, the results indicate that an increase of one standard deviation of imports gap reduces inflation for 3 periods, with a maximum effect of -0.11 in the third period, and then the effect wanes or even reverts slightly, a result consistent with our theoretical development, in which causality runs from import shocks to inflation. Finally, a shock on REER misalignment is associated with a disinflationary effect with a maximum annual average fall of 0.13 percentage points after two periods, and afterwards it keeps having additional disinflationary effects that decrease gradually until period 6, a result also consistent with our theoretical development. These results are in line with Auer *et al.* (2017), Gilchrist and Zakrajsek (2019) and Forbes (2019) in that external factors influence inflation. They also coincide with Romer (1993) and Rumler (2007) in that there is a negative relationship between the degree of openness and inflation, although we did not explicitly consider the degree of openness in this estimation, as these authors do.

To test the hypothesis of a reduction of the Phillips curve's slope, we proceed to re-estimate the OEPC, but with the same multiplicative dummy on the output gap used in the panel estimation (output gap*d10-17). Once estimated (in Table A-VI, available in Annex), we confirm that the inverse roots of the characteristic polynomials lay within the unit circle, so that this new PVAR is stationary. To check for residual autocorrelation, we perform a visual analysis, and then apply a Residual Serial Correlation Test based on Breusch-Godfrey with the Edgeworth corrective expansion. Results from both types of analysis support the absence of residual correlation. Focusing on the results where domestic inflation is the dependent variable, we find that the estimates' signs are again consistent with our theoretical approach and the previous PVAR and panel estimations. We find that the impact of the output gap on inflation is halved after 2010. Hence, the PVAR

Figure 2. OEPC with a 2010-2017 dummy - Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E



Solid lines represent impulse responses and dashed lines are standard error bands created by Monte Carlo simulations with 10,000 repetitions.

estimations confirm again the flattening of the Phillips curve since 2010, in line with Forbes (2019) and Gilchrist and Zakrajsek (2019).

We perform an impulse response analysis repeating the previous procedure applied to the newly estimated PVAR, focusing again on inflation's response. Results, in Figure II, show that the responses are very similar to the ones in Figure I, and again consistent with both our theoretical approach and with the previous results. In regard of the output gap dummy for 2010-2017, the impulse analysis shows a negative effect for each period until the 4^{th} one. Afterwards, the effects become slightly positive, reversing partially, but in coincidence when the output gap effects are also decreasing, which suggests that the global effects of the output gap after 2010 are smaller but could last longer than before. All in all, this impulse analysis shows that the effects of the output gap on inflation are smaller since 2010, and thus the slope of the Phillips curve is smaller. The output we obtain from this PVAR estimation can be considered a robustness proof of the Phillips curve for an open economy proposed in this paper, since it reinforces the regression findings obtained in Section 3.2.

At this stage, some considerations regarding trade openness are in order. Since the economies of our sample have different degrees of *total* trade openness -even though they are relatively homogeneous in many other aspects– we find justified to check whether not considering explicitly total trade openness in our estimations has affected our results. For this purpose, we repeat the PVAR estimations presented in Table A-V, including trade openness as an exogenous variable. Data on trade openness comes from the World Bank (details in the Annex). In the new estimation (available in Table A-VII, in Annex), the variables maintain the sign and significance as in Table A-V, with no relevant change in the value of the estimated parameters and, most important, the degree of trade openness is not significant. In addition, the Impulse response analysis based on this VAR estimation (which follows the same methodology presented in the previous impulse response analysis in this paper and which is available in Figure A-1 in the Annex), is very similar to the one represented in Figure I.

Finally, in order to gain additional robustness for our results, we have performed an alternative estimation using REER variations instead of REER misalignment, as considered in more traditional Phillips curves for open economies. Interannual REER changes were obtained from the World Bank database, details provided in the Annex. Results and the impulse-response analysis (available in Table A-VIII and in Figure A-2 in Annex), are very similar to ones in Table A-V, including signs and statistical significance levels, which implies that most of the REER changes of the sample correspond to real exchange rate misalignment. The rest of the variables maintain their explanatory power, providing consistence to the Phillips curve estimated in this paper.

4. Main conclusions and policy implications

The main task in this paper has been to derive a Phillips curve for a small open economy in which, in addition to the traditional output gap and inflation expectations, two external variables play an important role: the gap between current and long-term imports growth, which we call the imports gap, and misalignment of the real exchange rate, the REER misalignment. The two econometric methodologies applied in the frame of 15 industrialized countries, panel regressions and PVAR estimations accompanied by impulse response analysis, coincide to show that the degree of imports opening, and international relative prices have been key in making inflation quiescent in advanced countries over the last three decades. They also indicate that the sensitivity of inflation to domestic slack has decreased after the Great Recession, thus flattening the Phillips curve during this period, probably as a result of the globalization's drive in recent years.

Flat Phillips curves have important implications for the design and implementation of monetary and fiscal policies. In principle, as inflation is less sensitive to output, it is less likely to spiral out of control when output deviations occur. But, by the same token, raising inflation to bring it closer to the central bank's target would require very large changes in cyclical output and employment. These outcomes point to the desirability of extra flexibility in the inflation targeting framework in the sense of granting additional weight to output stabilization. Finally, the influence of external factors on the Phillips curve also highlights the relevance of a careful design of trade policy, which takes into consideration not only sectorial effects, but also the structural impact on price formation and other macroeconomic outcomes.

Additional policy implications emerge when, as seen in advanced countries in the post crisis period, flat Phillips curves are coupled with interest rates that are at, or near to, the zero lower bound (ZLB). In that situation, the central banks' ability to fight recession with conventional monetary weapons – i.e. cutting the interest rate – is seriously curtailed. Moreover, if the inflation target is maintained, flatter Phillips curves make it difficult for central banks to meet their inflation objectives since monetary policy alone cannot lift inflation by boosting economic activity. These features warrant raising the inflation target and/or, as suggested by Rogoff (2020), finding ways to strengthen the effectiveness of monetary policy in a low interest-rate environment, including using negative rates more fairly and effectively.

On the other hand, recent works show that the government spending multiplier increases significantly as the Phillips curve flattens and when interest rates are at, or near, the ZLB. In that case, fiscal policy is particularly effective in shifting the aggregate demand[7]. In addition, the effectiveness and usefulness of a decidedly expansionary fiscal policy has gained even more strength in all advanced countries after the recessionary impact created by the coronavirus pandemic.

[7] Using a panel with many countries for a large temporary sample, Klein and Winkler (2018) demonstrate that the public spending multiplier is approximately 1.5 when interest rates remain at, or near, the zero-lower bound, and fall below 1 when economies are out of that context. Miyamoto, Lan Nguyen and Sergeyev (2018) get very similar results for Japan.

5. References

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., & Price, B. (2016), "Import Competition and the Great US Employment Sag of the 2000s". *Journal of Labor Economics*, Vol.34(S1), pp.141-S198.

Andrews, D., P. Gal and W. Witheridge (2018), "A Genie in a Bottle?: Globalisation, Competition and Inflation", OECD Economics Department Working Papers, No. 1462, OECD, Paris.

Auer, R., Borio, C.E.V. and Filardo, A.J., (2017), "The Globalisation of Inflation: The Growing Importance of Global Value Chains"*, CEPR Discussion Paper No. DP11905*.

Autor, D. H., Dorn, D., & Hanson, G. H. (2016), "The China Shock: Learning from Labor-market Adjustment to Large Changes in Trade", *Annual Review of Economics*, Vol.8, pp.205-240.

Baltagi, B.H., Feng, Q., and Kao, C., (2012), "A Lagrange Multiplier Test for Cross-sectional Dependence in a Fixed Effects Panel Data Model", *Journal of Econometrics*, Vol.170 Issue 1, pp.164-177.

Baltagi, B.H. and Hashem Pesaran, M., (2007), "Heterogeneity and Cross Section Dependence in Panel Data Models: Theory and Applications Introduction"*, Journal of Applied Econometrics*, Vol.22 Issue 2, pp.229-232.

Bean, C., (2006), "Commentary: Impact of Globalization on Monetary Policy", *Federal reserve bank of Kansas City. The new economic geography: effects and policy implications.* Kansas City: Federal Reserve Bank of Kansas City.

Blanchard, O., Cerutti, E., and Summers, L. (2015), "Inflation and Activity – Two Explorations and their Monetary Policy Implications", working paper No. 21726, National Bureau of Economic Research, Cambridge, Massachusetts.

Blanchard, O., (2016), "The U.S. Phillips Curve: Back to the 60s?", Policy Brief Number PB16-1, Peterson Institute for International Economics, Washington, January.

Bobeica, E., and Jarocinski, M., (2019), "Missing Disinflation and Missing Inflation: a VAR Perspective." *International Journal of Central Banking*, Vol.15 No.1, pp.199-232.

Borio, Claudio E.V. and Filardo, Andrew J., (2007), "Globalisation and Inflation: New Cross-Country Evidence on the Global Determinants of Domestic Inflation", working paper No. 227, Bank for International Settlements, Basel, Switzerland.

Breusch, T.S., and Pagan, A.R., (1980), "The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics.", *The Review of Economic Studies*, Vol.47 Issue 1, pp.239-253.

Carney, M., (2015), "Inflation in a Globalised World", Remarks at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming.

Cavallo, A. (2018), "More Amazon effects: Online Competition and Pricing Behaviors", working paper No. 25138, NBER, Cambridge, Massachusetts.

Chalaux, T. and Y. Guillemette (2019), "The OECD Potential Output Estimation Methodology", Working Papers, No. 1563, OECD Economics Department.
Chen, N., Imbs, J. M., and Scott, A. (2004), "Competition, Globalization and the Decline of Inflation", CEPR Discussion paper 4695, Center for Economic and Policy Research, Washington, 28 December.
Couharde, C., Delatte, A. L., Grekou, C., Mignon, V., and Morvillier, F., (2018), "EQCHANGE: A World Database on Actual and Equilibrium Effective Exchange Rates.", *International economics*, Vol.156, pp.206-230.
Dix-Carneiro, R. (2014), "Trade Liberalization and Labor Market Dynamics". *Econometrica*, Vol.82(3), pp.825-885.
Dix-Carneiro, R., & Kovak, B. K. (2017), "Trade Liberalization and Regional Dynamics", *American Economic Review*, Vol.107(10), pp.2908-46.
Driver, R.L. and Westaway, P.F. (2004), "Concepts of Equilibrium Exchange Rates," Working Paper No. 248, London: Bank of England.
Eser, F., Karadi, P., Lane, P. R., Moretti, L., & Osbat, C. (2020). "The Phillips Curve at the ECB" Working paper No. 2400. European Central Bank, May.
Ferroni, F. and Mojon, B., (2017), "Domestic and Global Drivers of Inflation in the Euro Area", *ECB Economic Bulletin*, Issue 4/2017, pp.72-96.
Forbes, K. J. (2019). "Has Globalization Changed the Inflation Process?", working paper No. 791, Bank for International Settlements, Basel, Switzerland, 12 August.
Frenkel, R., & Ros, J., (2006), "Unemployment and the Real Exchange Rate in Latin America". *World development*, Vol.34(4), pp.631-646.
Galí, J., and Monacelli, T., (2005), "Monetary policy and Exchange Rate Volatility in a Small Open Economy.", *The Review of Economic Studies*, Vol.72.3, pp.707-734.
Galí, J., (2011), "The Return of the Wage Phillips Curve.", *Journal of the European Economic Association*, Vo.9 Issue 3, pp.436-461.
Genberg, H., Martinez, A., and Salemi, M., (2014), "The IMF/WEO Forecast Process.", IEO Background Paper No. BP/14/03, Independent Evaluation Office of the IMF.
Gereffi, Gary & Luo, Xubei. (2015). "Risks and Opportunities of Participation in Global Value Chains." *Journal of Banking and Financial Economics*. 2. 2015.
Gilchrist, Simon, and Egon Zakraj˘sek (2019). "Trade Exposure and the Evolution of Inflation Dynamics," Finance and Economics Discussion Series 2019-007. Washington: Board of Governors of the Federal Reserve System, 24 January.
International Monetary Fund. Independent Evaluation Office. (2007). "*Background Document 3: The Equilibrium Exchange Rate: Alternative Concepts and Their Applications in IMF Surveillance*" in IEO Evaluation of Exchange Rate Policy.
International Monetary Fund. Research Dept., (2013), "Chapter 3. The Dog That Didn't Bark: Has Inflation Been Muzzled or Was It Just Sleeping?", *World Economic Outlook, April 2013: Hopes, Realities, Risks*, IMF.

International Monetary Fund. Research Dept., (2019), "Chapter 2: Wage Growth and Inflation in Europe: A Puzzle?", *Regional Economic Outlook: Europe, Facing Spillovers from Trade and Manufacturing, November 2019*, pp.13-26.

Ireland, P. N. (2004), "Technology Shocks in the New Keynesian Model.", *Review of Economics and Statistics*, Vol.86 Issue 4, pp.923-936.

Irwin, D.A., (2019), "Does Trade Reform Promote Economic Growth? A Review of Recent Evidence", *NBER Working Paper* No. 25927.

Klein, M. and Winkler, R., (2018), "The Government Spending Multiplier at the Zero Lower Bound: International Evidence from Historical Data", Working Papers 2018-001, University of Antwerp, Antwerp, January.

Lane, P., (2019), "The Phillips Curve at the ECB", 50th Conference of the Money, Macro and Finance Research Group, London School of Economics, London.

Leduc, Sylvain and Daniel J. Wilson, (2017), "Has the Wage Phillips Curve Gone Dormant?", *Federal Reserve Bank of San Francisco Economic Letter*, Federal Reserve Bank of San Francisco, California, 16 October.

McCallum, B. T. and Nelson, E., (1999), "Nominal Income Targeting in an Open-economy Optimizing Model", *Journal of Monetary economics*, Vol.43.3, pp.553-578.

Miyamoto, W., Nguyen, T. L., & Sergeyev, D., (2018), "Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan.", *American Economic Journal: Macroeconomics*, Vo.10 No.3, pp.247-77.

Moretti, L., Onorante, L. and Saber, S. Z., (2019), "Phillips Curves in the Euro Area", working paper No. 2295, European Central Bank, Frankfurt a. M., July.

Paloviita, M., (2009), "Estimating Open Economy Phillips Curves for the Euro Area with Directly Measured Expectations", *New Zealand Economic Paper*, Vol.43.3, pp.233-254.

Pesaran, M.H., (2004), "General Diagnostic Tests for Cross Section Dependence in Panels", working paper No.1229, Center for Economic Studies and Ifo Institute.

Pesaran, M.H., (2007), "A Simple Panel Unit Root Test in the Presence of Cross-section Dependence", *Journal of applied econometrics*, Vol.22 Issue 2, pp.265-312.

Rogoff, K., (1985), "Can International Monetary Policy Cooperation Be Counterproductive?", *Journal of International Economics*, Vol.18, pp.199-217.

Rogoff, K., (2003), "Globalization and global disinflation.", *Economic Review-Federal Reserve Bank of Kansas City*, Vol.88 No.4, pp.45-80.

Rogoff, K., (2006), "Impact of Globalization on Monetary Policy" In *a symposium sponsored by the Federal Reserve Bank of Kansas City on "The new economic geography: effects and policy implications"*, Jackson Hole, Wyoming, pp.24-26.

Rogoff, K., (2020), "Falling Real Interest Rates, Rising Debt: A Free Lunch?", *Journal of Policy Modeling*, in press, available online 7 April.

Romer, D., (1993), “Openness and Inflation: Theory and Evidence.”, *The quarterly Journal of Economics*, Vol.108 No.4, pp.869-903.

Rumler, F., (2007), “Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries.” *Open economies review*, Vol.18 No.4, pp.427-45.

Seydl, J., & Spittler, M. (2016). “Did Globalization Flatten the Phillips Curve? US Consumer Price Inflation at the Sectoral Level.” *Journal of post keynesian economics*, *39*(3), pp.387-410.

Szafranek, K. (2017). “Flattening of the New Keynesian Phillips Curve: Evidence for an Emerging, Small Open Economy.” *Economic Modelling*, *63*, pp.334-348.

Topalova, P., & Khandelwal, A. (2011). “Trade liberalization and Firm Productivity: The case of India”, *Review of economics and statistics*, Vol.93(3), pp.995-1009.

6. Annex

6.1. Data sources and definitions

- Domestic inflation: consumer prices (CPI) year on year (end of the period) % change. Source: IMF World Economic Outlook January 2019.
- Inflation expectations: consumer prices (CPI) year on year (end of the period) % change. The inflation expectation figure for a given year is the expected inflation of the next year’s inflation published in the October IMF WEO (i.e. 1990 inflation expectation figure is the inflation expectation forecast figure for 1991 published in the IMF WEO of October 1990). Source: IMF Historical WEO Forecasts database.
- Output Gap: actual GDP less potential GDP (in % of potential GDP). Source: IMF World Economic Outlook January 2019.
- Imports: volume of imports of goods and services, year on year (end of the period) % change. Source: IMF World Economic Outlook January 2019.
- Potential output, volume growth, is used as a proxy for potential volume of goods and services growth. Potential output, volume growth is expressed in year on year % change. Source: OECD, Dataset Economic Outlook No 105 – May 2019.
- Real Effective Exchange Rate (REER) misalignments: Source: CEPII Exchange, Couharde *et al.* (2018), currency misalignments are the difference between the observed REER and its equilibrium level, for 186 trading partners, with time-varying weights: 5-year Windows. Data from November 2019.
- REER change: in year on year % change. Source: obtained calculating interannual % change from the REER index from the World Bank World Development Indicators. Data from July 2020.
- Trade openness (in % of GDP): is the sum of exports and imports of goods and services measured as a share of GDP. Source: World Bank World Development Indicators. Data from July 2020.

6.2. Tables

Table A-I. Cross Sectional Dependence Tests

Test	Statistic		Prob.
Breusch-Pagan LM	598,6447	***	0,0000
Pesaran scaled LM	34,0647	***	0,0000
Bias-corrected scaled LM	33,7386	***	0,0000
Pesaran CD	21,8973	***	0,0000

Null hypothesis: no cross sectional dependence.
Balanced panel. N: 15; t: 24 (1994-2017); obs.: 360. *** indicates significance at 1% level; ** 5% level; * 10% level.

Table A-II. Panel Unit Root Pesaran CADF Test

	Statistic Zt-bar With constant				Statistic Zt-bar With constant and trend			
	1 lag		2 lags		1 lag		2 lags	
Domestic inflation	-2,817	***	-0,037		-3,004	***	-0,192	
Expt. Inflation	-2,727	***	-0,716		-1,370	*	1,661	
Output Gap	-2,708	***	-3,087	***	-2,664	***	-2,781	***
Imports gap	-5,183	***	-4,103	***	-2,934	***	-2,022	**
REER misalignment	-0,231		2,701		-2,005	**	1,183	

Null hypothesis: series is no stationary. Balanced panel. N: 15; t: 24 (1994-2017); obs.: 360. *** indicates significance at 1% level; ** 5% level; * 10% level.

Table A-III: VAR Lag Selection Criteria

			Lags		
	0	1	2	3	4
Final prediction error	7310.092	179.4318	135.7091*	138.0727	138.8156
Akaike I.C.	20.24852	16.54128	16.26192*	16.27902	16.28408
Schwarz I.C.	20.34729	16.83758	16.75576*	16.97039	17.17299
Hannan-Quinn I.C.	20.28805	16.65986	16.45956*	16.55571	16.63982

* Indicates number of lags selected by the criterion. Balanced panel. N: 15; t: 26 (1992-2017); obs.: 390.

Table A-IV: OEPC PVAR Residual Serial Correlation LM test 1992-2017

Lags	LRE stat	Prob.	
1	21,12	0,17	
2	19,75	0,23	
3	22,44	0,13	
4	26,60	0,05	**

Null hypothesis: no serial correlation at lag X.
Balanced panel. N: 15; t: 26 (1992-2017); obs.: 390. *** indicates significance at 1% level; ** 5% level; * 10% level.

Table A-V: PVAR Estimates

Open Economy Phillips Curve (OEPC)				
	domestic inflation	output gap	imports gap	REER misalig.
domestic inflation(-1)	0.273459	-0.777414	-2.747880	0.827017
	[6.41568]	[-11.1483]	[-9.94541]	[3.85234]
domestic inflation(-2)	0.026197	0.186485	1.178189	-0.306399
	[0.67806]	[2.95023]	[4.70432]	[-1.57454]
output gap(-1)	0.150394	0.936129	-0.608591	0.408463
	[3.87127]	[14.7286]	[-2.41669]	[2.08754]
output gap(-2)	-0.074633	-0.152957	0.162237	-0.398674
	[-1.93665]	[-2.42601]	[0.64945]	[-2.05398]
imports gap(-1)	-0.021511	0.031983	0.209473	-0.078704
	[-2.18529]	[1.98597]	[3.28283]	[-1.58747]
imports gap(-2)	-0.026244	0.009737	-0.055794	-0.078688
	[-3.81453]	[0.86505]	[-1.25106]	[-2.27083]
REER misalig.(-1)	-0.033881	0.005236	0.035253	1.116091
	[-3.57803]	[0.33801]	[0.57432]	[23.4018]
REER misalig.(-2)	0.026571	-0.029954	-0.072962	-0.299049
	[2.78259]	[-1.91730]	[-1.17871]	[-6.21778]
c	0.061929	-0.603985	0.384290	1.063069
	[0.72614]	[-4.32868]	[0.69512]	[2.47483]
expected inflation	0.750171	0.807546	2.396752	-0.819863
	[13.5288]	[8.90166]	[6.66801]	[-2.93562]
R-squared	0.820683	0.787088	0.307398	0.772612
Adj. R-squared	0.816437	0.782045	0.290994	0.767227
F-statistic	193.2398	156.0857	18.73954	143.4615
Akaike AIC	2.287208	3.271776	6.025347	5.520686
Akaike information criterion			16.54984	
Schwarz criterion			16.95663	

Sample (adjusted): 1992 2017. Included observations: 390. Number of coefficients: 40. t-statistics in [ ].

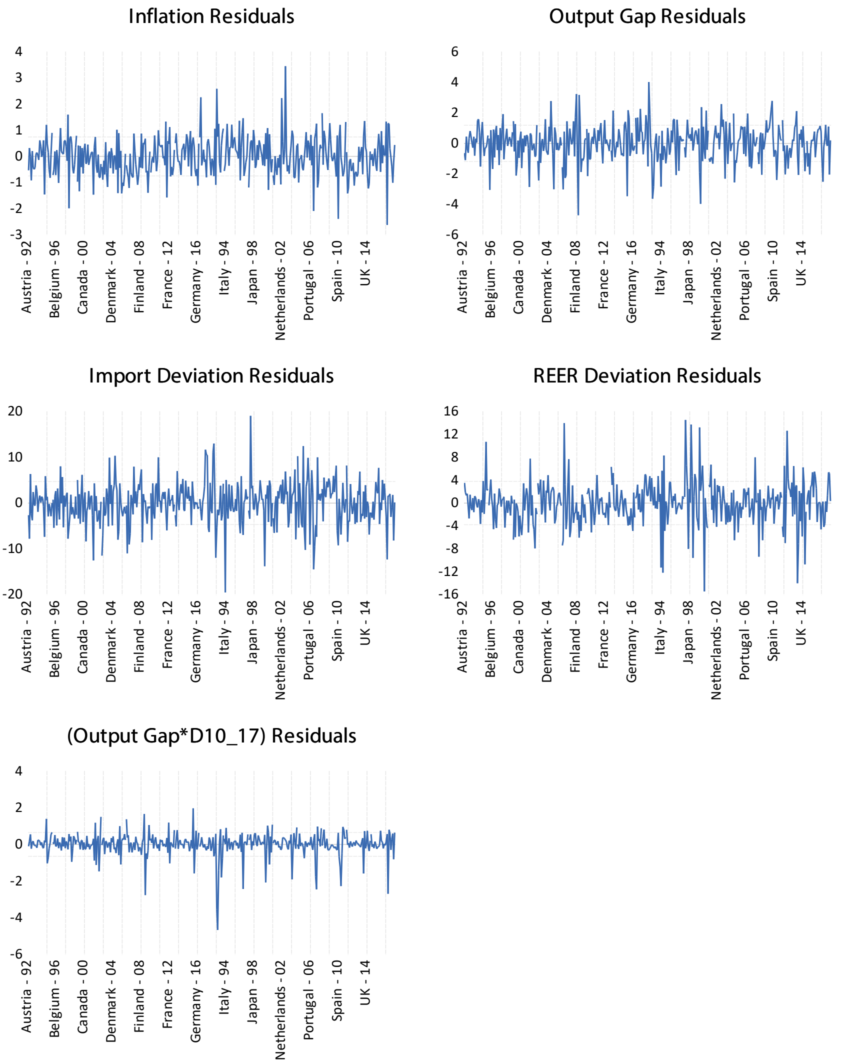
Table A-VI: PVAR Estimates

Open Economy Phillips Curve (OEPC) with a time dummy for 2010-2017					
	domestic inflation	output gap	imports gap	REER misalig.	output gap*d10-17
domestic	0.234780	-0.681391	-2.388915	0.766603	-0.079465
inflation(-1)	[5.27498]	[-9.56948]	[-8.49823]	[3.38960]	[-2.04592]
domestic	0.032945	0.169891	1.116312	-0.295994	0.039064
inflation(-2)	[0.85785]	[2.76516]	[4.60227]	[-1.51677]	[1.16558]
output gap(-1)	0.180151	0.876709	-0.816061	0.442547	0.132223
	[4.51183]	[13.7247]	[-3.23597]	[2.18118]	[3.79466]
output gap(-2)	-0.073279	-0.256877	-0.328240	-0.310332	-0.097950
	[-1.73676]	[-3.80554]	[-1.23174]	[-1.44745]	[-2.66019]
imports gap(-1)	-0.021888	0.020191	0.152482	-0.068379	0.029598
	[-2.18562]	[1.26028]	[2.41081]	[-1.34375]	[3.38684]
imports gap(-2)	-0.020831	0.010101	-0.040436	-0.082068	-0.017482
	[-2.82824]	[0.85724]	[-0.86923]	[-2.19276]	[-2.71989]
reer misalig.(-1)	-0.034349	0.013146	0.071664	1.109574	-0.003499
	[-3.62533]	[0.86728]	[1.19756]	[23.0464]	[-0.42322]
reer misalig.(-2)	0.025957	-0.032084	-0.084635	-0.296873	-0.004173
	[2.73395]	[-2.11232]	[-1.41141]	[-6.15352]	[-0.50371]
output gap*d10-17(-1)	-0.166904	0.264632	0.837442	-0.132313	1.271830
	[-2.77788]	[2.75309]	[2.20683]	[-0.43338]	[24.2564]
output gap*d10-17(-2)	0.121394	-0.005726	0.278430	-0.063898	-0.427977
	[2.01150]	[-0.05931]	[0.73048]	[-0.20837]	[-8.12634]
c	0.011047	-0.476026	0.864311	0.982187	-0.112072
	[0.12761]	[-3.43707]	[1.58075]	[2.23274]	[-1.48345]
expected inflation	0.794082	0.713526	2.060476	-0.764132	0.051016
	[13.8998]	[7.80700]	[5.71056]	[-2.63227]	[1.02330]
R-squared	0.824458	0.800700	0.356339	0.773426	0.897556
Adj. R-squared	0.819349	0.794901	0.337609	0.766832	0.894575
F-statistic	161.3932	138.0582	19.02419	117.3025	301.0746
Akaike AIC	2.276193	3.215962	5.962319	5.527358	2.003793
Akaike information criterion		18.31467			
Schwarz criterion		18.92485			

Sample (adjusted): 1992 2017. Included observations: 390. Number of coefficients: 60. t-statistics in [ ].

6.3. Residual graphs

OEPC with a time dummy PVAR Residuals



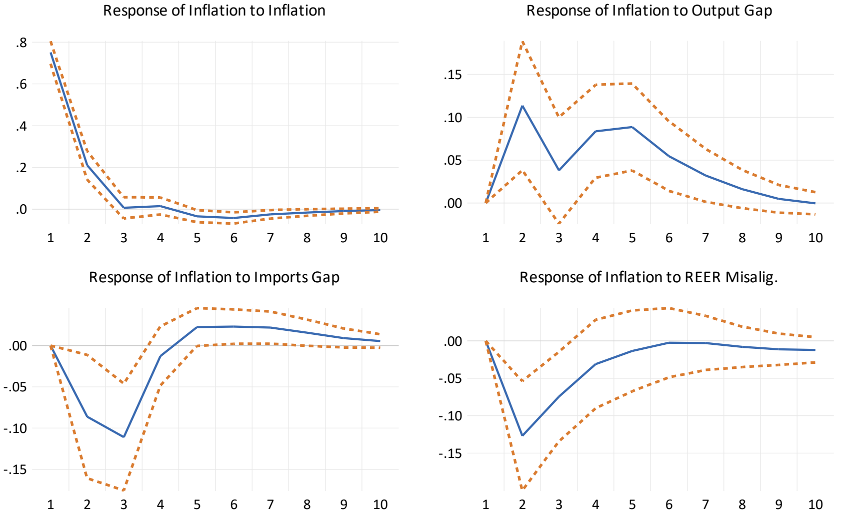
6.4. Robustness check

Table A-VII: PVAR Estimates

Open Economy Phillips Curve (OEPC) with trade openness				
	domestic inflation	output gap	imports gap	REER misalig.
domestic inflation(-1)	0.274118 [6.41298]	-0.773976 [-11.0775]	-2.753631 [-9.93886]	0.807969 [3.76474]
domestic inflation(-2)	0.026834 [0.69242]	0.189806 [2.99632]	1.172634 [4.66827]	-0.324800 [-1.66924]
output gap(-1)	0.149874 [3.84853]	0.933415 [14.6635]	-0.604053 [-2.39305]	0.423497 [2.16589]
output gap(-2)	-0.074472 [-1.92990]	-0.152120 [-2.41167]	0.160837 [0.64303]	-0.403313 [-2.08161]
imports gap(-1)	-0.021394 [-2.16863]	0.032596 [2.02142]	0.208448 [3.25992]	-0.082099 [-1.65751]
imports gap(-2)	-0.026127 [-3.78558]	0.010346 [0.91709]	-0.056813 [-1.26999]	-0.082063 [-2.36816]
reer misalig.(-1)	-0.033697 [-3.54533]	0.006194 [0.39869]	0.033651 [0.54622]	1.110784 [23.2761]
reer misalig.(-2)	0.026678 [2.78803]	-0.029396 [-1.87941]	-0.073895 [-1.19141]	-0.302138 [-6.28870]
c	0.035704 [0.27727]	-0.740775 [-3.51938]	0.613087 [0.73454]	1.820975 [2.81649]
expected inflation	0.749963 [13.5073]	0.806463 [8.88600]	2.398563 [6.66481]	-0.813864 [-2.91943]
trade openness	0.000331 [0.27208]	0.001724 [0.86823]	-0.002884 [-0.36622]	-0.009553 [-1.56610]
R-squared	0.820719	0.787510	0.307643	0.774074
Adj. R-squared	0.815988	0.781904	0.289375	0.768113
F-statistic	173.4994	140.4615	16.84056	129.8542
Akaike AIC	2.292141	3.274918	6.030121	5.519364
Akaike information criterion		16.55820		
Schwarz criterion		17.00567		

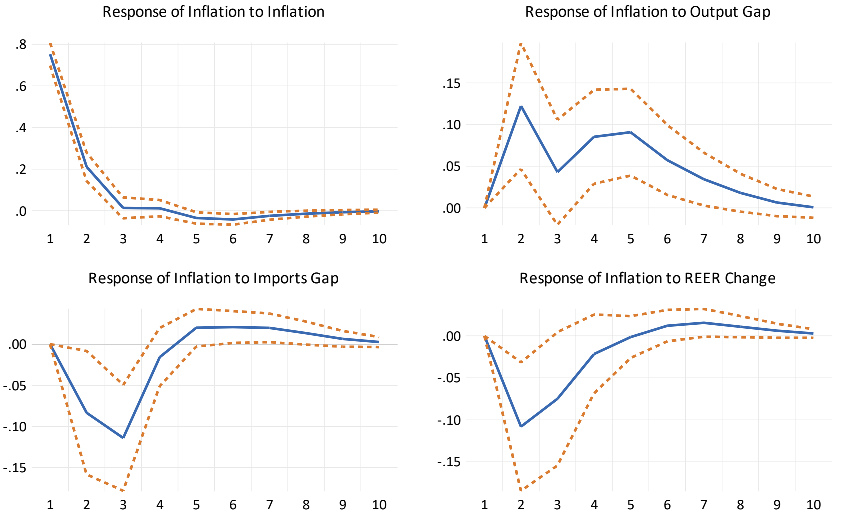
Sample (adjusted): 1992 2017. Included observations: 390. Number of coefficients: 44. t-statistics in [ ].

FIGURE A-1 OEPC WITH TRADE OPENNESS - RESPONSE TO CHOLESKY ONE S.D. (D.F. ADJUSTED) INNOVATIONS ± 2 S.E.



Solid lines represent impulse responses and dashed lines are standard error bands created by Monte Carlo simulations with 10,000 repetitions.

FIGURE A-2 OEPC WITH REER CHANGE - RESPONSE TO CHOLESKY ONE S.D. (D.F. ADJUSTED) INNOVATIONS ± 2 S.E.



Solid lines represent impulse responses and dashed lines are standard error bands created by Monte Carlo simulations with 10,000 repetitions.

Table A-VIII: PVAR Estimates

Open Economy Phillips Curve (OEPC) with REER change				
	domestic inflation	output gap	imports gap	REER change
domestic inflation(-1)	0.269535	-0.761039	-2.651384	0.634735
	[6.22004]	[-10.6651]	[-9.48581]	[2.72858]
domestic inflation(-2)	0.034070	0.193525	1.116167	0.007438
	[0.86299]	[2.97676]	[4.38309]	[0.03509]
output gap(-1)	0.160067	0.959965	-0.575126	0.605022
	[4.14215]	[15.0855]	[-2.30734]	[2.91650]
output gap(-2)	-0.078756	-0.173443	0.104637	-0.442352
	[-2.04449]	[-2.73425]	[0.42113]	[-2.13913]
imports gap(-1)	-0.021911	0.028823	0.195289	-0.049948
	[-2.20993]	[1.76539]	[3.05365]	[-0.93843]
imports gap(-2)	-0.026134	0.009609	-0.052194	-0.094206
	[-3.77331]	[0.84253]	[-1.16831]	[-2.53375]
REER change(-1)	-0.026850	0.017767	0.065303	0.241069
	[-2.91172]	[1.17002]	[1.09792]	[4.86987]
REER change(-2)	-0.006283	-0.006198	0.063683	-0.144582
	[-0.67565]	[-0.40476]	[1.06166]	[-2.89615]
	0.036907	-0.672062	0.325076	0.388919
C	[0.43598]	[-4.82115]	[0.59535]	[0.85583]
expected inflation	0.753487	0.816046	2.410846	-0.774062
	[13.5141]	[8.88800]	[6.70354]	[-2.58614]
R-squared	0.819302	0.782638	0.308940	0.138083
Adj. R-squared	0.815023	0.777490	0.292573	0.117669
F-statistic	191.4399	152.0262	18.87558	6.764170
Akaike AIC	2.294882	3.292459	6.023117	5.655894
Akaike information criterion			16.70235	
Schwarz criterion			17.10914	

Sample (adjusted): 1992 2017. Included observations: 390. Number of coefficients: 40. t-statistics in [ ].