ISSN 2318-2377

UFMG

Cedeplar

TEXTO PARA DISCUSSÃO N° 596

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Fevereiro de 2019

http://www.cedeplar.ufmg.br

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Ficha catalográfica

R484i 2019 Ribeiro, Rafael.

The inflation-distribution nexus: a theoretical and empirical approach / Rafael Ribeiro, Stefan D'Amato, Wallace Pereira. - Belo Horizonte: UFMG/CEDEPLAR, 2019.

23 p. : il. - (Texto para discussão, 596)

Inclui bibliografia (p. 19-21) e apêndices.

ISSN 2318-2377

1. Inflação. 2. Renda - Distribuição. I. D'Amato, Stefan. II. Pereira, Wallace. III. Universidade Federal de Minas Gerais. Centro de Desenvolvimento e Planejamento Regional. IV. Título. V. Série.

CDD: 332.41

Elaborada pela Biblioteca da FACE/UFMG – FPS018/2019

UNIVERSIDADE FEDERAL DE MINAS GERAIS
FACULDADE DE CIÊNCIAS ECONÔMICAS
CENTRO DE DESENVOLVIMENTO E PLANEJAMENTO REGIONAL

THE INFLATION-DISTRIBUTION NEXUS: A THEORETICAL AND EMPIRICAL APPROACH

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CEDEPLAR/FACE/UFMG
BELO HORIZONTE
2019

SUMÁRIO

ABSTRACT

There are two unconnected strands of the inflation-distribution literature, one that studies the impact of inflation on income distribution and the other the impact of distribution on inflation. This paper is an attempt to fill a gap in this literature, by taking into account the simultaneous determination between inflation and income distribution. We set forth a Post-Keynesian model in which inflation and income distribution are jointly determined in a dynamical system of difference equations. The theoretical framework advanced in the paper allows us to show that conflicting claims on income, expectation formation and the realisation of increasing returns to scale ascribed to demand-pull and distributive factors also play a key role in the determination of the inflation and income distribution dynamics. Then, we conducted an empirical investigation of the relationship between inflation and distribution. Both empirical exercises were done using GMM estimator. This econometric technique is robust to reverse causality as it uses lagged observations in difference and level of endogenous variables as instruments and hence is the preferred method of estimation. Our findings corroborate our theoretical model by showing that, in average, increases in the wage share tend to exert a downward pressure in future inflation. Our estimates also show that the wage share is highly dependent of its past values, thus suggesting that income distribution may be only sensitive to autonomous (political) factors.

Key words: Cost-push inflation, income distribution, Kaleckian models, GMM.
JEL code: C33, C60, D33, E12, E31.

RESUMO

Há duas vertentes desconexas da literatura de distribuição da inflação, uma que estuda o impacto da inflação na distribuição de renda e a outra o impacto da distribuição sobre a inflação. Este artigo é uma tentativa de preencher uma lacuna nesta literatura, levando em conta a determinação simultânea entre inflação e distribuição de renda. Estabelecemos um modelo pós-keynesiano no qual a inflação e a distribuição de renda são determinadas em conjunto em um sistema dinâmico de equações de diferença. O arcabouço teórico apresentado no artigo permite mostrar que reivindicações conflitantes sobre renda, formação de expectativas e a realização de retornos crescentes de escala atribuídos a fatores de demanda e distribuição também desempenham um papel fundamental na determinação da dinâmica de inflação e distribuição de renda. Em seguida, conduzimos uma investigação empírica da relação entre inflação e distribuição. Ambos os exercícios empíricos foram feitos usando o estimador GMM. Essa técnica econométrica é robusta para reverter a causalidade, pois utiliza observações defasadas na diferença e nível de variáveis endógenas como instrumentos e, portanto, é o método preferido de estimação. Nossos achados corroboram nosso modelo teórico ao mostrar que, em média, aumentos na participação dos salários tendem a exercer pressão descendente na inflação futura. Nossas estimativas também mostram que a participação dos salários é altamente dependente de seus valores passados, sugerindo que a distribuição de renda pode ser apenas sensível a fatores autônomos (políticos).

Palavras-chave: Inflação de custos, distribuição de renda, modelos Kaleckianos, GMM**.**

1. INTRODUCTION

There is a vast literature investigating the transmission mechanisms through which inflationary processes may affect income inequality. By and large, the redistributive consequences of inflation are threefold. First, since price rises are followed by increases in money wages with a lag, higher inflation reduces real wages and hence redistributes income from workers to capitalists. This is the wages-lag hypothesis that may be traced back at least as far as David Hume in the 18th century (Laidler and Parkin, 1975). In the same vein, inflation is seen by many as a form of regressive taxation since low-income individuals often pay disproportionally more inflationary taxes than high-income ones (Cysne *et al*, 2005). However, both Bach and Stephenson (1974) and Blinder and Esak (1978) have shown that inflation has shifted income from profits to wages in the US economy. Second, inflationary pressures tend to squeeze disposable income and household savings of the middle class, thus increasing poverty and income inequality (Cardoso *et al*., 1995). Conversely, empirical evidence on the relationship between inflation and household saving is mixed. Loayza et al (2000) found that inflation tends to increase personal savings, while Feldstein's (1982) results suggest otherwise. Third, as prices rise, debtors lose and creditors gain unless the nominal interest rate set on monetary assets fully accommodates unanticipated increases in inflation until maturity (Bach and Stephenson, 1974). Nevertheless, since the rich have better information and more access to technical advice compared to the poor, they also get less affected by unexpected positive changes in inflation.

More recent empirical works have extensively examined the redistributive effects of inflation. Galli and Hoeven (2001) tested relationship between inflation and inequality first for the United States over the period 1967-1999 using time-series analysis and then for 15 OECD countries over the period 1973-1996 using fixed-effects models. The authors find a long-term U-shaped relationship between inflation and income inequality for both samples. Bulíř (2001) investigates the impact of changes in the inflation rate on income inequality using both ordinary least square (OLS) and instrumental variables (IV) techniques for 75 countries for the period 1970 to 1991. The author suggests that lower inflation rates are associated with a reduction in income inequality for all levels of GDP per capita. Similarly, Li and Zou (2002) use the same econometric methods for a sample of 46 countries over the period 1950-92 and find that an increase in inflation is positively linked to higher levels of income inequality. For a sample of 51 industrialised and developing countries over the period 1966-1990, Albanesi (2007) also finds that a price rise is positively correlated to inequality due to the relative vulnerability of low-income households to inflation. These results were obtained from a sample of 51 industrialised and developing countries over the period 1966-1990. Thalassinos et al. (2012) also analyse the impact of inflation on the distribution of income using a fixed-effect panel data model for 13 European countries for the period 2000 to 2009. Their results suggest that increasing inflation tends to increase income inequality. Having said that, it seems that the impact of inflation on income distribution remains an open empirical question.

On the other hand, there exists a long-standing tradition that sees inflation, not as the cause, but as the effect of changes in income distribution. From a political economy perspective, there are two opposing theories of inflation concerning the effects of income inequality on price behaviour. In the "populist" view, inflation is a result of the need for growing revenues financed by inflation tax to meet public demand from the poor for distributive policies. In the "state-capture" approach, on the other hand, the demand for high inflation comes from the elites seeking to derive private benefits from money and credit creation channeled to favour themselves. There is not consensus in this literature whether the demand for high inflation comes from the poor or from the rich. However, the proponents of both views agree that high inequality is closely associated with high inflation. In economic theory, the cost-push effect of wages on inflation is well stablished in the history of heterodox macroeconomic literature (Arestis and Sawyer, 2005; Dutt, 1992; Lima, 2004; Rowthorn, 1977; Sarantis, 1990; Skott, 1992). Unlike the mainstream demand-pull inflation theory, conflicting claims models of inflation along Kaleckian lines do not see excess demand as the primary cause of inflation. By taking into account the stylised fact of modern economies that oligopolistic firms tend to operate with excess capacity of utilisation under normal conditions, the proponents of the heterodox inflation theory point out that imperfectly competitive firms set prices as a mark-up over prime costs of production (which includes unit labour costs), thus implying that, holding everything else constant, increases in the wage bill tend to pass through into prices as capitalists react to defend their profit margins. The degree of wage pass-through, however, for each firm depends on several factors such as the demand elasticity for its goods and competition pattern within the industry. In general, the capacity to pass increases in the wag bill on to prices is smaller for firms producing goods that have a high degree of substitutability. In this case, firms may also respond to increases in the labour cost by either reducing employment or lowering profits instead of raising prices, which may provoke changes in the functional income distribution. That said, it can be convincingly argued that, by and large, an industry-wide increase in wages is likely to be followed by an increase in inflation.

However, the empirical evidence assessing the impact of changes in wages and income distribution on inflation rate is rather scant. Frye and Gordon (1981) conducted a time-series analysis for US quarterly data from 1954 to 1980 and found a very small and positively signed coefficient accounting for the impact of minimum wages on inflation. Aaronson (2001) uses OLS and IV techniques to estimate a model for data on restaurant prices from the US and Canada. The author finds that restaurant prices rise with increases in the labour cost. Card and Krueger (1995) and Macdonald and Arasonson (2000) also analysed restaurant prices in the US and found similar results. Using household and firm data of Brazil from 1982 to 2000, Lemos (2006) also finds a positive impact of wages on prices. Even though the wage pass-through for the Brazilian economy is higher compared to the estimates found in the previous works for the US economy, the author concludes that the minimum wage can serve as a policy tool to reduce inequality without hurting the poor in a context of sufficiently low inflation. Nguyen (2011) employs time-series OLS regressions to analyse the impact of wages on prices for monthly data of the Vietnamese economy over the 1994-2008 period. The author found no statistical evidence that increases in wages result in price rises. In the empirical literature of political theory of inflation Beetsma and Ploeg (1996) show that increases in income inequality levels raise the rates of inflation in democratic countries using an OLS model for a sample of 66 countries in the year of 1960. Dolmas et al. (2000) replicate the work of Beetsma and Ploeg (1996) and find similar results by applying the OLS technique in a sample consisting of 44 countries over the 1960-80 period. Using a GMM panel data model for over 100 countries from 1960 to 1990, Desai et al. (2003) show that the increase in income inequality also tends to raise inflation.

The aim of this paper is twofold. First, we contribute to the literature by advancing a theoretical model along Post Keynesian lines that takes into account that the economic dynamics of inflation and distribution may be closely intertwined. To model the simultaneous determination between inflation and distribution, we develop a dynamical system of difference equations and analyse the determinants of the equilibrium values of inflation and wage share. It is also shown that conflicting claims on income and demand-pull factors affecting labour productivity (extended Verdoorn's Law) also play a key role in the determination of the time paths of inflation and income distribution. Second, we provide further empirical evidence by testing our model for a sample of 134 countries over the 1990-2014 period using the Generalised Method of Moments (GMM) technique which is robust to reverse causality. Our findings corroborate most of the testable hypothesis drawn from the theoretical model.

The remainder of this paper consists of section 2 in which we introduce the theoretical model. In section 3 we present the data, methodology and the empirical exercise. Lastly, we conclude.

2. INFLATION AND INCOME DISTRIBUTION: AN EXTENDED THEORETICAL MODEL

2.1. The system dynamics

The model assumes a one-sector closed economy without government activities. There are two classes in the economy, workers and capitalists. Workers earn only wages and capitalists earn profits, thus implying that national income is equal to the sum of total wages and total profits. Drawing upon the Kaleckian price theory, assume that firms operate with excess capacity utilisation in an oligopolistic market and forms prices based on the standard mark-up pricing equation, which consists of a mark-up rate set over prime costs (the labour cost is the only component of the variable cost of domestic firms in this model). For simplicity, inflation and distribution dynamics are described as a linear approximation in the model by the following difference equations:

$$p_t = \alpha_{10} + \alpha_{11}\sigma_t + \alpha_{12}p_{t-1} - \alpha_{13}r_t \tag{1}$$

$$\sigma_t = \alpha_{20} - \alpha_{21}p_t + \alpha_{22}p_t^e - \alpha_{23}r_t \tag{2}$$

where $\alpha_{10}, \alpha_{11}, \alpha_{12}, \alpha_{13}, \alpha_{20}, \alpha_{21}, \alpha_{22}, \alpha_{23} > 0$ are parameters; p_t denotes the inflation rate in time t; p_{t-1} accounts for the lagged observations of inflation; p_t^e is the one-period-ahead inflation expectation formed by households in time t; σ_t consists of the wage share of income in time t; and r_t is the growth rate of labour productivity in time t.

By equation (1), it is assumed that current inflation is associated with the degree of inflation persistence, p_{t-1}. The wage share, σ_t, is also positively linked to the inflation rate through the cost-push channel since higher wages tend to pass-through into prices. Kaleckian models also assume that when the current wage share is above the wage share desired by workers, prices go up (Dutt, 1992; Lima, 2004; Rowthorn, 1977). We also assume that the growth rate of labour productivity, r_t, is inversely related to the inflation rate since productivity gains create space for price cuts by reducing unit labour costs. Regarding the distribution equation (2), it is assumed for simplicity that inflation, p_t, and wage share, σ_t, are inversely related because higher inflation reduces the purchasing power of workers by cutting real wages. Suppose also that expected inflation, p_t^e, is directly related to the wage share, σ_t, as workers take in to account expected future prices in the wage decision-making process. Lastly, the elasticity of the rate of change of labour productivity, r_t, in equation (2) is also negatively signed because increases in the labour productivity may encourage firms to cut employment, thus reducing the capacity of workers to bargain for higher wages.

Next, we define the labour productivity and the expected inflation equations:

$$r_t = \lambda_0 + \lambda_1 g_{t-1} + \lambda_2 \sigma_{t-1} \tag{3}$$

$$p_t^e = \rho p_{t-1} \tag{4}$$

where $\lambda_0, \lambda_1, \lambda_2, \rho > 0$ are parameters; g_{t-1} is the lagged output growth rate; σ_{t-1} is the lagged wage share.

By equation (3), labour productivity growth is an increasing function of lagged observations of output growth wage share. The coefficient $\lambda_1 > 0$ captures the widely known Kaldor-Verdoorn effect which accounts for the impact of demand-led output growth on productivity growth through the mechanism of dynamic increasing returns to scale. Here we draw upon the work of Setterfield (1997) and define the productivity growth, r_t, as a function of lagged output growth, g_{t-1}. Setterfield (1997) states that "the realisation of induced technical progress through the Verdoorn Law may require the accumulation of specific new capital, which will only come into productive use, and so enhance productivity, in some future period". We also follow Storm and Naastepad (2012) by arguing that higher wages lead to higher technological progress and productivity growth as increased unit labour costs encourage firms to adopt labour-saving technologies. Authors state that "[h]igher wages thus stimulate capital deepening, drive inefficient firms off the market and encourage structural change, increase the proportion of high-skilled workers in the labour force, and, in general, promote labour-saving technological progress" (Storm and Naastepad, 2012, p. 4). Formally, Storm and Naastepad (2012) develop an extended version of the Kaldor-Verdoorn's Law by defining the productivity growth as a function of the growth of real wages instead of the wage share as follows: $r_t = \lambda_0 + \lambda_1 g_t + \lambda_2 w_t$, where w_t denotes the growth of real wages. The problem with this specification is that, in the long-run equilibrium, the productivity growth rate must equal the real wage growth rate, $r_t = w_t$. Thus, the productivity equation by Storm and Naastepad (2012) becomes $r_t = [\lambda_0/(1-\lambda_2)] + [\lambda_1/(1-\lambda_2)]g_t$. Therefore, as the economy converges towards its long-run equilibrium, the wage effect disappears and the extended Kaldor-Verdoorn equation returns to the canonical Kaldor-Verdoorn equation in which productivity growth is a function of demand growth only. In order to overcome this problem, we define the productivity growth as a function of the lagged wage share, σ_{t-1}, instead of real wages growth, w_t. Here we also assume that the wage share only affects productivity growth with a lag. In equation (4) we assume that, under normal conditions, workers form their expectations regarding future inflation based on what happened in the past. The parameter $\rho > 0$ captures how much of past inflation influences the formation of future prices expectation.

Substituting (3) into (1)-(2), and then (4) into (2), and rearranging the terms yields:

$$p_t = \beta_{10} + \alpha_{11}\sigma_t + \alpha_{12}p_{t-1} - \beta_{13}\sigma_{t-1} \tag{5}$$

$$\sigma_t = \beta_{20} - \alpha_{21}p_t + \beta_{22}p_{t-1} - \beta_{23}\sigma_{t-1} \tag{6}$$

where $\beta_{10} = \alpha_{10} - \alpha_{13}(\lambda_0 + \lambda_1 g) \gtrless 0$; $\beta_{13} = \alpha_{13}\lambda_2 > 0$; $\beta_{20} = \alpha_{20} - \alpha_{23}(\lambda_0 + \lambda_1 g) \gtrless 0$; $\beta_{22} = \alpha_{22}\rho > 0$; $\beta_{23} = \alpha_{23}\lambda_2 > 0$. It is assumed for simplicity that the output growth rate is exogenously determined by the growth rate of the autonomous component of aggregate demand, so that $g_{t-1} = g_t = g$.

The system formed by equations (5) ad (6) can be rewritten in matrix format, as follows:

$$\underbrace{\begin{bmatrix} 1 & -\alpha_{11} \\ \alpha_{21} & 1 \end{bmatrix}}_{\equiv A} \begin{bmatrix} p_t \\ \sigma_t \end{bmatrix} = \underbrace{\begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix}}_{\equiv B_0} + \underbrace{\begin{bmatrix} \alpha_{12} & -\beta_{13} \\ \beta_{22} & -\beta_{23} \end{bmatrix}}_{\equiv B_1} \begin{bmatrix} p_{t-1} \\ \sigma_{t-1} \end{bmatrix} \quad (7)$$

To solve the system for the price-distribution vector, we need to multiply both sides of (7) for the inverse of matrix A, as follows:[1]

$$A^{-1}B_0 = \underbrace{\begin{bmatrix} \frac{1}{1+\alpha_{11}\alpha_{21}} & \frac{\alpha_{11}}{1+\alpha_{11}\alpha_{21}} \\ \frac{-\alpha_{21}}{1+\alpha_{11}\alpha_{21}} & \frac{1}{1+\alpha_{11}\alpha_{21}} \end{bmatrix}}_{\equiv A^{-1}} \underbrace{\begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix}}_{\equiv B_0} = \begin{bmatrix} \frac{\beta_{10} + \alpha_{11}\alpha_{20}}{1+\alpha_{11}\alpha_{21}} \\ \frac{-\alpha_{21}\beta_{10} + \beta_{20}}{1+\alpha_{11}\alpha_{21}} \end{bmatrix} = \begin{bmatrix} \gamma_{10} \\ \gamma_{20} \end{bmatrix}$$

$$A^{-1}B_1 = \underbrace{\begin{bmatrix} \frac{1}{1+\alpha_{11}\alpha_{21}} & \frac{\alpha_{11}}{1+\alpha_{11}\alpha_{21}} \\ \frac{-\alpha_{21}}{1+\alpha_{11}\alpha_{21}} & \frac{1}{1+\alpha_{11}\alpha_{21}} \end{bmatrix}}_{\equiv A^{-1}} \underbrace{\begin{bmatrix} \alpha_{12} & -\beta_{13} \\ \beta_{22} & -\beta_{23} \end{bmatrix}}_{\equiv B_1} =$$

$$\begin{bmatrix} \frac{\alpha_{12} + \alpha_{11}\beta_{22}}{1+\alpha_{11}\alpha_{21}} & \frac{-(\beta_{13} + \alpha_{11}\beta_{23})}{1+\alpha_{11}\alpha_{21}} \\ \frac{-\alpha_{12}\alpha_{21} + \beta_{22}}{1+\alpha_{11}\alpha_{21}} & \frac{\alpha_{21}\beta_{13} - \beta_{23}}{1+\alpha_{11}\alpha_{21}} \end{bmatrix} = \begin{bmatrix} \gamma_{11} & -\gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$$

After some mathematical manipulations, we have:

$$p_t = \gamma_{10} + \gamma_{11}p_{t-1} - \gamma_{12}\sigma_{t-1} \quad (8)$$

$$\sigma_t = \gamma_{20} + \gamma_{21}p_{t-1} + \gamma_{22}\sigma_{t-1} \quad (9)$$

where $\gamma_{10} \gtrless 0, \gamma_{11} > 0, \gamma_{12} > 0, \gamma_{20} \gtrless 0, \gamma_{21} \gtrless 0$ e $\gamma_{22} \lesseqgtr 0$. In order to keep the model tractable and avoid the proliferation of multiple scenarios, let us impose some constraints on the coefficient of equations (8) and (9) by assuming that $\gamma_{10}, \gamma_{20}, \gamma_{21}, \gamma_{22} > 0$ without loss of generality. Next, we analyse the steady-state values of inflation and wage share.

[1] $A^{-1} = [1/D(A)]\ AdjA$; where $D(A)$ is the determinant of A and; $AdjA$ denotes the adjoint of A.

2.2. The long-run equilibrium

Now we seek to determine the long-run values of both the inflation rate and the wage share. Assume that in equilibrium we have $p_p = p_t = p_{t-1}$ and $\sigma_p = \sigma_t = \sigma_{t-1}$. Substituting p_p and σ_p into equations (8) and (9) and rearranging the terms we obtain:

$$p_p = \frac{(1-\gamma_{22})\gamma_{10} + \gamma_{20}\gamma_{12}}{1-(\gamma_{11}+\gamma_{22}) + (\gamma_{11}\gamma_{22} - \gamma_{12}\gamma_{21})} \tag{10}$$

$$\sigma_p = \frac{(1-\gamma_{11})\gamma_{20} + \gamma_{10}\gamma_{21}}{1-(\gamma_{11}+\gamma_{22}) + (\gamma_{11}\gamma_{22} - \gamma_{12}\gamma_{21})} \tag{11}$$

Suppose that the following inequalities are satisfied:

$$1-(\gamma_{11}+\gamma_{22}) + (\gamma_{11}\gamma_{22} - \gamma_{12}\gamma_{21}) > 0$$
$$(1-\gamma_{22})\gamma_{10} + \gamma_{20}\gamma_{12} > 0$$
$$(1-\gamma_{11})\gamma_{20} + \gamma_{10}\gamma_{21} > 0$$

These conditions jointly ensure the existence of strictly positive equilibrium values of inflation rate and wage share.

3. THE EMPIRICAL ASSESSMENT

3.1. The inflation and distribution equations

The idea of the empirical work is to estimate equations (8) and (9) and discuss our findings in light of the theoretical model advanced in the previous section. The equations tested are the following ones:

$$p_{i,t} = \delta_{10} + \delta_{11}p_{i,t-1} + \delta_{12}\sigma_{i,t-1} + \delta_{13}X_{i,t} + \nu_i^p + \kappa_t^p + e_{i,t}^p \tag{12}$$

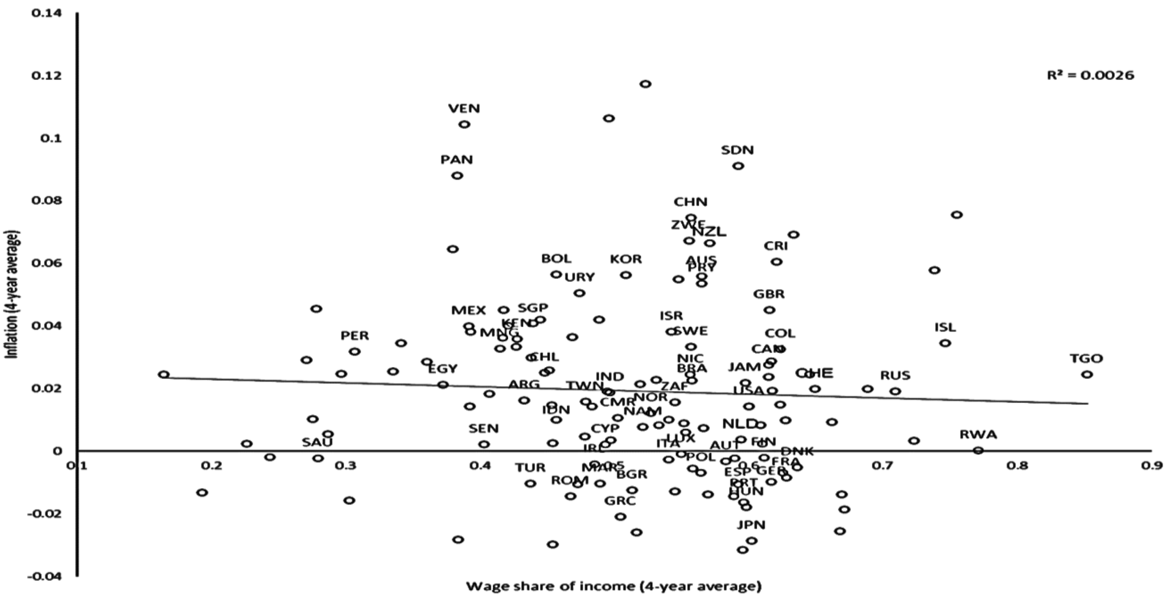
$$\sigma_{i,t} = \delta_{20} + \delta_{21}p_{i,t-1} + \delta_{22}\sigma_{i,t-1} + \delta_{23}X_{i,t} + \nu_i^\sigma + \kappa_t^\sigma + e_{i,t}^\sigma \tag{13}$$

where $\delta_{10}, \delta_{11}, \delta_{12}, \delta_{13}, \delta_{20}, \delta_{21}, \delta_{22}, \delta_{23}$ are the estimators; subscripts i and t denote country and time periods, respectively; $X_{i,t}$ is a set of control variables; ν_i^p and ν_i^σ represent unobserved country-specific effects of the price and distribution equations, respectively; κ_t^p and κ_t^σ are period-specific effects of the price and distribution equations, respectively; and $e_{i,t}^p$ and $e_{i,t}^\sigma$ are the regression residual of the price and distribution equations, respectively.

3.2. The dataset

The dataset consists of a sample of 133 countries over the 1990-2014 period (see the list of countries in Appendix 1). We take the data from the Penn World Table 9.0. The two variables of interest in the model are inflation and income distribution. The inflation rate is calculated as the rate of change of the 'price level of household consumption'. Income distribution is the 'share of labour compensation in GDP at current national prices'. Simple descriptive statistics reveal that more unequal countries are prone to have higher levels of inflation than more equal countries (see Figure 1).

FIGURE 1
Inflation and wage share of income for 133 countries averaged over the 2010-2014 period



Source: Penn World Table 9.0. Authors' own elaboration.

A set of control variables is also included in the model in order to improve our estimates. In the mainstream inflation theory, low levels of inflation are attributed to the credibility of governments and improved central bank institutions and practice (Rogoff, 2003). The 'GDP per capita' is used as a proxy for the level of economic development of the country. This variable also accounts for governance quality, given that it is plausibly expected that higher levels of governance quality of the economy are often associated with higher GDP per capita. Therefore, an inverse relationship between GDP per capita and inflation rate is expected. The GDP per capita is also included as a control in the distribution equation. If higher GDP per capita is linked to lower inflation, then higher GDP per capita may lead to higher real wages and hence to a higher wage share.

The 'Human capital index' is considered as a contributing factor to productivity growth. A more educated labour force enhances technological progress and productivity growth, thus creating space for price cuts and reduced wage share. On the other hand, skilled workers also earn higher wages compared to unskilled workers. Therefore, a higher share of the labour force with a college degree (or above) may be associated with higher wages and hence a higher wage share and higher prices through the cost-push channel. Thus, the impact of human capital on prices and income distribution can go either way depending on its net effect on unit labour costs and real wages and then onto both prices and wage share.

The last control variable is the capital-labour ratio. A stablished wisdom in growth theory is that higher capital-labour ratio leads to higher labour productivity. Therefore, we expect that an increased capital-labour ratio reduces unit labour costs by boosting labour productivity and hence exerts a downward pressure on both inflation and wage share.

3.3. Methodology

In this subsection we outline the econometric technique used to estimate the inflation and distribution equations. The equations (12) and (13) presents some challenges due to the existence of unobserved time- and country-specific effects. Normally, this problem can be solved by allowing into the baseline model period- and country-specific dummy variables. However, the methods used to account for time- and country-specific effects, that is, the fixed-effect or difference estimators, are biased when an auto-regressive term is included in the baseline equation (Pesaran, 2015). In addition, the control variables of both models may exhibit a certain degree of endogeneity with respect to the inflation and wage share and hence simultaneity or reverse causality must be properly controlled for.

In order to deal with these problems, we follow Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998), and use the Generalised Method of Moments (GMM) to estimate the parameters of the model. These estimators are based on differencing regressions and instruments to control for unobserved period- and country-specific effects. Moreover, it also uses previous observations of dependent and explanatory variables as instruments. There are two types of GMM estimation techniques: first-difference GMM and the system GMM.

The GMM difference method represents a great improvement with respect to the standard fixed-effects and first difference estimators. The first-difference GMM estimator by Arellano and Bond (1991) seeks to eliminate country-specific effects and also uses lagged observations of the explanatory variables as instruments. However, the first-difference GMM method has a disadvantage in dealing with variables that tend to have a high degree of persistence over time within a country, like income distribution for instance. This implies that we eliminate most of the variation in the variable(s) by taking the first difference. In this context, lagged observations of the explanatory variables tend to be weak instruments for the variables in difference, thus yielding also weak estimators.

To overcome this problem, we also employ the system GMM by Arellano and Bover (1995) and Blundell and Bond (1998). This method creates a system of stacked regressions both in difference and in level format. The instruments of the regressions in first difference remain the same as in the GMM difference. However, the instruments used in the regressions in level are the lagged differences of the endogenous variables. In the system GMM, even if the regressors in level are still correlated with the country-specific effects, the lagged difference of these variables used as instruments are more likely to be uncorrelated with these country-specific effects.

The validity of the GMM estimators depends greatly on the exogeneity of the instruments used in the baseline model. The exogeneity of the instruments can be tested by the *J* statistics of the commonly used Hansen test. The null hypothesis implies the joint validity of the instruments. In other words, a rejection of the null hypothesis indicates that the instruments are not exogenous and hence the GMM estimator is not consistent. Roodman (2009) advises researchers not to take comfort in a Hansen test *p*-value below 0.1. Another test is the Arellano-Bond test for AR(2) in first difference. The null hypothesis of this test examines if the residual of the regression in difference is second-order serially correlated. First-order serial correlation of the differenced error term is usually observed even when the error term in level is uncorrelated. Second-order serial correlation of the residual term in difference implies that the error term is serially correlated. Therefore, the rejection of the null hypothesis indicates that the residual term is serially correlated and follows a moving average process of, at least, order one. A rejection of the null hypothesis suggests that the instruments used are inappropriate and hence higher-order lags as instruments might be required. As for the instruments, a large number of instruments is likely to overfit the endogenous variables. The literature is not very specific in determining the maximum number of instruments to be used in each case. Roodman (2009) suggests, as a relatively arbitrary rule of thumb, that instruments should not outnumber individual units in the panel (or countries in our case). Here we tried to keep the number of instrumental variables to a minimum. In the inflation equation we used up to 2 lags of the endogenous variables with the collapse function in order to limit the proliferation of instruments. In the distribution equation up to 3 lags of the endogenous variables were used as instruments without collapsing the matrix of instruments.

The variables were averaged over 4-year periods. This is a standard procedure in panel data analysis, as it reduces the unwanted effects caused by the likely existence of unit roots and also adjusts the structure of the panel with the aim to satisfy the consistency properties of the GMM estimators. We have two types of variables: endogenous and exogenous. We considered as exogenous variables in both models the ‘human capital’, ‘capital-output ratio’ and the time-period dummies.

3.4. Empirical findings

First, we estimate the inflation equation (12) in which inflation is regressed against lagged observations of both inflation and wage share and a set of control variables. The results are displayed in Table 1 below:

TABLE 1
The inflation equation

Variables	Pooled OLS	Fixed Effects	GMM-Difference	GMM-System
Inflation, lagged	-0.1098**	-0.1642***	0.0176	0.0450
	(0.04)	(0.04)	(0.07)	(0.08)
Wage share, lagged	-0.0233	-0.1789**	-0.4620	-0.3504*
	(0.02)	(0.07)	(0.33)	(0.16)
Capital-labour ratio	-0.0071	-0.0402*	-0.0704*	-0.0355*
	(0.01)	(0.02)	(0.03)	(0.02)
GDP per capita	-0.0029	0.0462*	0.1238	0.0175
	(0.01)	(0.02)	(0.08)	(0.02)
Human capital	0.0430**	0.0078	0.0385	0.0896
	(0.01)	(0.07)	(0.13)	(0.05)
Constant	0.1139***	0.1498		
	(0.03)	(0.21)		
Observations	580	580	464	580
Instruments			12	16
R^2 Adjusted	0.0219	0.2627		
Test for AR(2) in first difference (p-value)			0.5728	0.8883
Hansen test (p-value)			0.1289	0.2141

Note:
1. Below the coefficients we report the standard errors.
2. Two-step standard errors are robust to the Windmeijer (2005) heteroscedasticity correction, which greatly reduces the downward bias of the one-step standard error.
3. Unobserved individual effects are removed by first differencing in the Fixed-Effects, the GMM-diff and -system models.
4. In both GMM-diff and -system only human capital, capital-labour ratio and time dummies are strictly exogenous variables.
5. The first and the second lags of the endogenous variables were used as instruments for the endogenous variables in the GMM-diff and -system.
6. We have collapsed the instruments in order to restrict the number of instruments (Roodman, 2006).
7. The Hansen test: the null hypothesis is that the instruments are not correlated with the residuals.
8. The Arellano-Bond test for AR(2) in first difference: the null hypothesis is that the errors in the first difference regression has no second order serial correlation.
9. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The first column shows the results of the pooled OLS estimator and the second column shows the results of the fixed effects (within) OLS estimator. As previously mentioned, both methods are inconsistent in dynamical panel models. The third and fourth columns present the results of the GMM difference and system, respectively. Our analysis will focus on the estimates displayed in the fourth column, since the GMM-system is robust to accounting for reverse causality by using lagged observations in difference and level of endogenous variables as instruments and hence is the preferred method of estimation.

As for the variables of interest, lagged inflation is positively signed, but not statistically significant. By equation (8), the parameter capturing the degree of inflation persistence is given by $\gamma_{11} = (\alpha_{12} + \alpha_{11}\beta_{22})/(1 + \alpha_{11}\alpha_{21})$. The fact that the auto-regressive component of the inflation equation is not statistically significant does not imply that past inflation is irrelevant as an explanatory variable for current inflation. We can only infer that, in average, this coefficient is not statistically different from zero for the entire sample. In other words, the result obtained in Table 1 does not imply that the degree of inflation persistence may be statistically significant for a number of individual countries or groups of countries. The lagged wage share is negatively signed, as expected, and statistically significant at 5% of significance. From (8), we have $\gamma_{12} = (\beta_{13} + \alpha_{11}\beta_{23})/(1 + \alpha_{11}\alpha_{21}) > 0$, thus implying that the impact of lagged wage share on inflation is negatively signed. The GMM system model suggests that an increase in one percentage point in the wage share reduces the inflation rate in 0.35 percentage point. This result corroborates that testable hypothesis of our theoretical model that an increase in the wage share is likely to reduce inflation in the next period. As for the control variables, only the capital-labour ratio is statistically significant. This variable also has the expected negative sign, which suggests that higher capital-labour ratio leads to higher labour productivity, thus lowering inflation.

In short, what the empirical model shows is that, in average, increases in the wage share do not create inflationary pressures in the future. In light of our theoretical framework we argue that the cost-push effect of wages on inflation is mitigated over time as the productivity gains attributed to increases in the wage share (through the extended Verdoorn's mechanism) lead to a drop in the unit labour cost and then in the inflation rate.

Next, we estimate the distribution equation (13) in which the wage share is the regressand and lagged observations of both inflation and wage share (plus a set of control variables) are the regressors. The results are shown in Table 2 below:

TABLE 2
The income distribution equation

Variables	Pooled OLS	Fixed Effects	GMM-Difference	GMM-System
Inflation, lagged	0.0181	0.0049	-0.0010	0.0175
	(0.02)	(0.02)	(0.02)	(0.03)
Wage share, lagged	0.9546***	0.4795***	0.2718	0.9581***
	(0.01)	(0.04)	(0.16)	(0.04)
Capital-labour ratio	-0.0002	-0.0164	-0.0313	0.0013
	(0.00)	(0.01)	(0.02)	(0.01)
GDP per capita	-0.0012	-0.0098	0.0147	-0.0032
	(0.00)	(0.01)	(0.03)	(0.01)
Human capital	0.0075	-0.0155	-0.0400	0.0159
	(0.01)	(0.04)	(0.08)	(0.02)
Constant	0.0230	0.5698***		
	(0.02)	(0.13)		
Observations	580	580	464	580
Instruments			55	79
R^2 Adjusted	0.9343	0.2461		
Test for AR(2) in first difference (p-value)			0.8281	0.9376
Hansen test (p-value)			0.2388	0.2994

Note:
1. Below the coefficients we report the standard errors.
2. Two-step standard errors are robust to the Windmeijer (2005) heteroscedasticity correction, which greatly reduces the downward bias of the one-step standard error.
3. Unobserved individual effects are removed by first differencing in the Fixed-Effects, the GMM-diff and -system models.
4. In both GMM-diff and -system only human capital, capital-labour ratio and time dummies are strictly exogenous variables.
5. The first, the second and the third lags of the endogenous variables were used as instruments for the endogenous variables in the GMM-diff and -system.
6. The Hansen test: the null hypothesis is that the instruments are not correlated with the residuals.
7. The Arellano-Bond test for AR(2) in first difference: the null hypothesis is that the errors in the first difference regression has no second order serial correlation.
8. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Once again, we focus the discussion on the estimates of the system GMM presented in the fourth column of Table 2 since this econometric technique is the preferred method of estimation. The system GMM model suggests that, in average, the wage share is only explained by its past values. From (9), we know that the auto-regressive coefficient in the distribution equation is given by $\gamma_{22} = (\alpha_{21}\beta_{13} - \beta_{23})/(1 + \alpha_{11}\alpha_{21}) > 0$, which is strictly positive. The empirical model shows that the wage share has a high degree of persistence (which favours the use of the system GMM technique) since an increase in one percentage point in the lagged wage share leads to a raise of 0.95 percentage point in the current wage share, thus suggesting that income distribution may be only sensitive to autonomous (political) factors. The other variable of interest, i.e. lagged inflation, is positively signed, but statistically non-significant. By equation (9), we obtain the coefficient that captures the ambiguously signed partial effect of the inflation rate on the wage share, $\gamma_{21} = (-\alpha_{12}\,\alpha_{21} + \beta_{22})/(1 + \alpha_{11}\alpha_{21}) \gtreqless 0$. Therefore, the fact that the coefficient of lagged inflation is not statistically significant suggests that the opposing partial effects of lagged inflation (i.e. the negative effect of inflation on real wages, on the one hand, and the positive effect of expected inflation on nominal wages in the wage decision-making process, on the other hand) on the wage share may be cancelling each other out for the entire sample. This possibility is accounted for in our theoretical model. Lastly, it is also worth noting that none of the control variables are statistically significant in the distribution equation.

To sum up, the empirical model for the distribution equation also corroborates the testable hypothesis of our theoretical model. Our findings show that the wage share is highly dependent of its past trajectory. Regarding the coefficient of the lagged inflation rate, we can say that our results do not offer a clear support for any of the opposing strands of the empirical literature. As aforementioned, the impact of inflation on income distribution remains as an open empirical question.

4. CONCLUDING REMARKS

This paper seeks to contribute to the literature by assessing the simultaneous determination between inflation and income distribution. First, we advance a dynamical system of difference equations in which inflation and income distribution are jointly determined. Conflicting claims on income, expectation formation and demand-pull factors affecting productivity growth are key contributing features in the determination of the inflation and income distribution dynamics. An empirical exercise is also carried out to test the relationship between inflation and distribution. The econometric technique used is robust to reverse causality as it considers lagged observations in difference and level of endogenous variables as instruments. Our findings corroborate our theoretical model by showing that, in average, increases in the wage share tend to exert a downward pressure in future inflation. Our estimates also show that the wage share is highly dependent of its past values, thus suggesting that income distribution may be only sensitive to autonomous (political) factors.

Our theoretical model brings some important implications in terms of policy. It shows that redistributive measures that increase the labour share in income do not exert a long-lasting upward pressure on prices. In fact, our model suggests that an increase in the wage share leads to lower inflation in the future. The realisation of this mechanism operates essentially through the positive impact of higher wage share on productivity growth which in turn improves competitiveness of the firms and creates space for price reduction. Nevertheless, it is worth pointing out that our model is a very simple theoretical framework. Extensions including the government sector and the use of taxes levied on consumption goods and services as well as the consequences of more (less) progressive tax systems in the inflation-distribution dynamics may greatly improve the model. Another substantial contribution could be done by expanding the model to include the external sector. Analysing the determinants of the exchange rate and foreign trade and then how they might affect the process of price formation may be of paramount importance to fully understand the inflation-distribution dynamics in modern economies. Lastly, our empirical findings also show the necessity of further testing of the relationship between inflation and distribution with different control variables, different datasets and subsamples, and different econometric techniques.

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APPENDIX

APPENDIX 1

List of countries (133)			
Argentina	Cyprus	Lao People's DR	Sao Tome and Principe
Armenia	Czech Republic	Latvia	Saudi Arabia
Aruba	Denmark	Lebanon	Senegal
Australia	Djibouti	Lesotho	Serbia
Austria	Dominican Republic	Lithuania	Sierra Leone
Azerbaijan	Ecuador	Luxembourg	Singapore
Bahamas	Egypt	Malaysia	Slovakia
Bahrain	Estonia	Malta	Slovenia
Barbados	Fiji	Mauritania	South Africa
Belarus	Finland	Mauritius	Spain
Belgium	France	Mexico	Sri Lanka
Benin	Gabon	Mongolia	Sudan
Bermuda	Georgia	Morocco	Suriname
Bolivia	Germany	Mozambique	Swaziland
Bosnia and Herzegovina	Greece	Namibia	Sweden
Botswana	Guatemala	Netherlands	Switzerland
Brazil	Guinea	New Zealand	Taiwan
British Virgin Islands	Honduras	Nicaragua	Tajikistan
Bulgaria	Hungary	Niger	TFYR of Macedonia
Burkina Faso	Iceland	Nigeria	Thailand
Burundi	India	Norway	Togo
Cameroon	Indonesia	Oman	Trinidad and Tobago
Canada	Iran	Panama	Tunisia
Cayman Islands	Iraq	Paraguay	Turkey
Central African Republic	Ireland	Peru	U.R. of Tanzania: Mainland
Chad	Israel	Philippines	Ukraine
Chile	Italy	Poland	United Kingdom
China	Jamaica	Portugal	United States
China (Hong Kong)	Japan	Qatar	Uruguay
China (Macao)	Jordan	Republic of Korea	Venezuela
Colombia	Kazakhstan	Republic of Moldova	Zimbabwe
Costa Rica	Kenya	Romania	
Côte d'Ivoire	Kuwait	Russian Federation	
Croatia	Kyrgyzstan	Rwanda	

APPENDIX 2

Variables	Description	Source
pl_c	Price level of household consumption, price level of USA GDPo in 2011=1	Penn World Table 9.0
Inflation	infl = ((pl_c/L.pl_c)-1)	Authors' calculation
Wage share	Share of labour compensation in GDP at current national prices and used as proxy for income distribution.	Penn World Table 9.0
Rgdpna	Real GDP at constant 2011 national prices (in mil. 2011US$)	Penn World Table 9.0
Pop	Population (in millions)	Penn World Table 9.0
GDP per capita	gdppc = rgdpna/pop	Authors' calculation
Human capital	Human capital index, based on years of schooling and returns to education. We include the log transformation of the Human capital index in the model.	Penn World Table 9.0
Rkna	Capital stock at constant 2011 national prices (in mil. 2011US$)	Penn World Table 9.0
Emp	Number of persons engaged (in millions)	Penn World Table 9.0
Capital-labour ratio	kl = rkna/emp	Authors' calculation