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Labour market reforms and employment hysteresis

PAULO R. MOTA[1,2*] and PAULO B. VASCONCELOS[1,3]

[1] School of Economics and Business, University of Porto, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal

[2] Center for Economics and Finance, University of Porto, Portugal

[3] Center of Mathematics, University of Porto, Portugal

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ABSTRACT

This paper analyses the effects of deregulation of employment in an environment of low interest rates and economic uncertainty. For this purpose, we estimate a switching employment equation based on the play model of hysteresis. As a novel feature, the estimation allows for a possible change in the value of the switching parameter after the implementation of labour market reforms. We use Portuguese monthly industrial data spanning from January 2000 to October 2016. Portugal provides a good case study since it is a country where significant measures towards the deregulation of the labour market were applied after the recent financial crisis. The results show that these measures reduced the hysteresis effects in the dynamics of aggregate employment except in the period where uncertainty increased substantially, when the opposite happened.

KEYWORDS

employment, hysteresis, uncertainty, employment protection legislation

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* Corresponding author. E-mail: mpaulo@fep.up.pt

1. INTRODUCTION

The Great Recession that followed the recent global financial crisis, and the present slow and weak recovery in many developed countries, have provided new evidence that recessions leave long lasting effects on the economy that may operate through hysteresis mechanisms (e.g., Jaimovich – Siu 2012; DeLong – Summers 2012; Ball 2014; Abraham et al. 2016; Bassi – Lang 2016; Yagan 2017).[1]

The problem is not new! It has been experienced already in the past that in the presence of hysteresis there was no unique long-run equilibrium determined solely by the supply side of the economy, and independent of the history of the past shocks, including those caused by monetary and fiscal policies (e.g., Cross et al. 2005; Setterfield 2009; Arestis – Sawyer 2009; Cross 2014; Göcke – Matulaityte 2015; Bassi – Lang 2016). Indeed, the economy can stay after a financial crisis that cause a recession, for a long time in a position of equilibrium with low employment/ high unemployment due to insufficient demand.

Hysteresis may result from institutional characteristics of labour markets, like employment protection legislation that generates non-convex hiring and firing cost functions.[2] This kind of adjustment costs often create a wedge between the marginal revenue of the employment adjustment and the corresponding cost, entailing the presence of separate employment demand triggers for upward and downward adjustment. The difference between these two triggers has been called the *employment band of inaction*, which determines that no adjustment in the number of employees may be the firms' optimal response to the small shocks (Bertola 1990; Dixit 1991; Cross 1994; Belke – Göcke 1999).

It was also established in the literature that uncertainty (of economic, financial and regulatory kind) interacts with the non-convex employment adjustment costs function, widening the employment band of inaction and reinforcing the hysteresis effects (e.g., Dixit 1989; Dixit – Pindyck 1994; Belke – Göcke 1999). The intuition is that in the presence of uncertainty, waiting for more information (instead of immediately decide to adjust the number of employees) has a positive value. The opportunity to hire employees is akin to a financial American call option, while the decision to fire some employees is similar to a put option (Pindyck 1991; Belke – Göcke 2005). Thus, uncertainty introduces an additional (opportunity) cost of adjustment related to the option to wait for more information (Dixit 1989, 1991; Pindyck 1988; Dixit – Pindyck 1994).

Furthermore, the relative importance of non-convex adjustment costs and uncertainty for the width of the employment band of inaction varies with the interest rates. The lower the interest rates the higher is the importance of uncertainty, and the smaller is the importance of non-convex employment hiring and firing costs to generate the hysteresis effects (Belke – Göcke 2003, 2006; Mota et al. 2015). This implies that when interest rates are low, as it was the case

[1] Although hysteresis has been used in economics in different assertions (see e.g., Phelps 1972; Layard et al. 1991; Blanchard – Summers 1986, 1987; Amable et al. 1993, 1994, 1995; Cross et al. 1995), in this paper, hysteresis is regarded as a unifying mathematical concept, firstly applied in the field of physics of magnetism, where the dynamics of an input-output system has the properties of: a) non-linearity; b) remanence; and c) selective memory (Mayergoyz 1986, 2003).

[2] See e.g., Pindyck (1991), Hamermesh – Pfann (1996), and Folta (2006) for an extensive list of employment and physical capital adjustment costs.

until 2021 in the Eurozone, hysteresis can be quite strong even if the government applies measures towards the deregulation of the labour market due to the stronger role of uncertainty. The main contribution of this paper is to analyse the effect of the deregulation of the labour market in the presence of hysteresis on aggregate employment, in a context of zero lower bound for interest rates.

We focus on the employment protection legislation of regular contracts that are related with the magnitude of the hysteresis effects (Mota et al. 2015). This is very important for the Eurozone, and especially for its peripheral countries, given the austerity measures and the structural reforms that were undertaken in the labour market in the context of the financial assistance provided by the *Troika*, to promote employment and to foster economic growth. For that purpose, we estimate a switching employment equation from a computational implementation of the linear play model of hysteresis (also known as the friction-backlash model[3]). This equation describes the behaviour of which for small changes of labour demand there is a weak reaction of employment (due to the presence of adjustment costs), whereas for large changes there is a strong reaction.

As a novel feature, we estimate the model allowing for a possible change in the value of the switching parameter of the employment equation after the application of major labour market reforms, introduced in a context of high uncertainty and very low interest rates.

We use Portuguese monthly industrial data spanning from January 2000 to October 2016. Portugal provides a good case to study this issue since significant measures towards the deregulation of the labour market were applied in this time period. The results show that Portuguese employment responds only to large changes in aggregate demand, corroborating the hypothesis of the presence of hysteresis. In addition, the reforms mitigated the hysteretic effects by reducing the hiring/firing costs of firms. However, these effects were temporarily offset by the economic recession of 2008, during which the highly uncertain economic environment led to the widening of the inaction band. Both results are in line with the theoretical models of employment hysteresis.

The remainder of the paper is organised as follows. Section 2 presents a model of employment adjustment under uncertainty at the firm level and the aggregation procedure up to the macro level. Section 3 describes the main changes in the employment protection legislation since the beginning of the euro. Section 4 describes the details of the empirical strategy and the data set. Section 5 presents the estimation results, and Section 6 concludes.

2. THE MODEL

2.1. Hysteresis at the firm level

Following the standard sunk-costs hysteresis approach to investment and to employment dynamics, we start by describing a non-ideal relay-type hysteresis model for individual firms that

[3]Linear play models, although not standard in the economic literature, are well suited to describe the aggregate dynamics of the economic variables that show characteristics of hysteresis (e.g., Belke – Göcke 1999, 2001; Göcke 2002; Mota et al. 2012; Mota – Vasconcelos 2015).

implies discontinuous employment adjustment due to the presence of non-convex employment adjustment costs.

Let us assume a competitive market where each price taker active firm, j, $j = 1, \ldots J$, employs one unit of employment, $n_{j,t}$, at the unit wage cost w_j, to produce $y_{j,t} = n_{j,t} = 1$ units of output, which it sells at a price per unit of P_t.[4] If inactive, the firm produces no output and employs zero units of employment. Furthermore, every individual firm must pay a fixed and constant cost in time to enter (hire a worker and to acquire firm specific physical assets), H_j, or to leave the market (fire its single worker), F_j. We consider a profit maximising problem of the individual firm, with discrete time and an infinite plan horizon. The discount factor is $\delta = \frac{1}{1+i}$, where i is the risk-free interest rate.[5]

In this setting, a previously inactive firm will only enter the market if the hiring costs are recovered. Hence the entry (hiring) trigger price, $P_{entry,j}$, exceeds the wage, w_j, by $\frac{i}{1+i}H_j$. Conversely, a previously active firm will exit the market if losses exceed the interest firing costs. Hence, the exit (contracting) trigger price, $P_{exit,j}$, is below w_j by $\frac{i}{1+i}F_j$.[6]

The decision to enter the market is akin to the hiring decision, and the decision to exit is akin to the firing decision. This simplification does not restrict the application of the model as we can consider a firm divided into single production units, with every unit represented individually (Belke – Göcke 1999) or view the firms as potential units of labour with the set of all potential units of labour representing all the jobs that can potentially be created in the economy (Lang – Peretti 2009). Thus, the employment demand function of firm j, may be represented by the non-ideal relay hysteresis operator (also known as hysteron):

$$n_{j,t} = \mathcal{R}_{P_{exit,j},P_{entry,j}}\left(t_0,\ n_{j,t_0}\right)[P_t] = \begin{cases} 1,\ if\ n_{j,t-1} = 0\ and\ P_t \geq w_j + \dfrac{i}{i+1}H_j \\ \quad or\ n_{j,t-1} = 1\ and\ P_t > w_j\ - \dfrac{i}{i+1}F_j \\ 0,\ if\ n_{j,t-1} = 0\ and\ P_t < w_j + \dfrac{i}{i+1}H_j \\ \quad or\ n_{j,t-1} = 1\ and\ P_t \leq w_j - \dfrac{i}{i+1}F_j \end{cases} \tag{1}$$

[4]We are assuming that all firms face a common demand schedule $(P_{j,t} = P_t)$ and that the wage is constant over time, but not necessarily across firms $(w_{j,t} = w_j)$. Although firms pay different wages possibly due to its different cost structures, they sell at the same price as we assume perfect competition on the goods market. Purely for simplicity reasons, we consider that wages do not vary with changes in the price level. This allows the hysteresis loop, displayed in Fig. 1, to remain fixed when the price varies back and forth.

[5]See Göcke (2002) and Mota et al. (2012) for a complete description of the model.

[6]Note that assuming a planning horizon of just one period, an inactive firm will enter the market only when both components of costs (H_j, w_j) are covered. Conversely, an active firm will exit the market only when the revenue falls below $w_j - F_j$. In a multi-period optimization with an infinite horizon and perfect foresight about market price, P_t *has* to cover only the interest costs of market enter in addition to the wage, since the firm will be able to generate positive profits on an infinite horizon. Therefore, the inaction band in narrower in the dynamic model (with perfect foresight) than in the static model (Göcke 2002).

where $n_{j,t}$ denotes the employment of firm j in period t, $P_{exit,j} = w_j - \frac{i}{i+1}F_j$ and $P_{entry,j} = w_j + \frac{i}{i+1}H_j$ $(P_{exit,j}<P_{entry,j})$ are the threshold values for exit and entry, P_t $(t \geq t_0)$ is the price level, and n_{j,t_0} is the initial state that can take the values of 1 or 0. The values of the operator are defined for $n_{j,t_0} = 0$ if $P_{t_0}<P_{exit,j}$, for $n_{j,t_0} = 1$ if $P_{t_0}>P_{entry,j}$, and both for $n_{j,t_0} = 0$ and $n_{j,t_0} = 1$ if $P_{entry,j}<P_{t_0}<P_{exit,j}$.

The first branch of Equation (1) refers to a situation where firm *j* enters or stays active while the second one specifies the situation where firm *j* stays inactive or exits. Since $P_{entry,j}$ is greater than $P_{exit,j}$ the difference between these two trigger points, $\frac{i}{i+1}(H_j + F_j)$, creates an employment band of inaction (Bertola 1990; Dixit 1992 and Belke – Göcke 2001). Each firm requires an aggregate positive demand shock $P_t>P_{entry,j}$ to enter (hire its workforce), and an aggregate negative demand shock $P_t<P_{exit,j}$ to exit (fire). Demand shocks within the range $P_{exit,j}<P_t<P_{entry,j}$ do not cause any change in employment.

Figure 1 offers a descriptive definition of the relay operator.

Consider a continuous, piecewise-monotone aggregate exogenous demand function P_t for the relay, with $\mathcal{R}_{P_{exit,j},P_{entry,j}}(P_{t_0})$ either equal to 0 or 1. The firm *j* observes the dynamics of the aggregate demand forcing variable, P_t. If P_t monotonically increases, the ascending branch *abcde* (up switching) is followed by the level of employment, $\mathcal{R}_{P_{exit,j},P_{entry,j}}(P_t)$, while if the aggregate demand monotonically decreases, the descending branch *edfba* (down switching) is followed. Thus, the branch *abcde* corresponds to the employment demand function of a previous inactive firm, $\mathcal{R}_{P_{exit,j},P_{entry,j}}(P_{t_0}) = 0$, and the branch *edfba* to the employment demand function of a previous active firm, $\mathcal{R}_{P_{exit,j},P_{entry,j}}(P_{t_0}) = 1$.

This result matches to the observation that employment adjustments are made relatively infrequently and in large amounts, rather than responding more or less continuously to small changes of firms' product demand (e.g., Varejão – Portugal 2007; Mota et al. 2012). Moreover, P_t is not sufficient to determine the firm's state of employment. The whole history of P_t $\{P_\tau,\ \tau \in (0,\ \tau)\} \subset \mathbb{R}$, must be taken into account. Therefore, there is no single-valued mapping from $\mathbb{R}$ into $\mathbb{R}$ that associates each value of $n_{j,t}$, with the current level of P_t. Instead, the system is characterised by path dependence and 'multibranch non-linearity'.

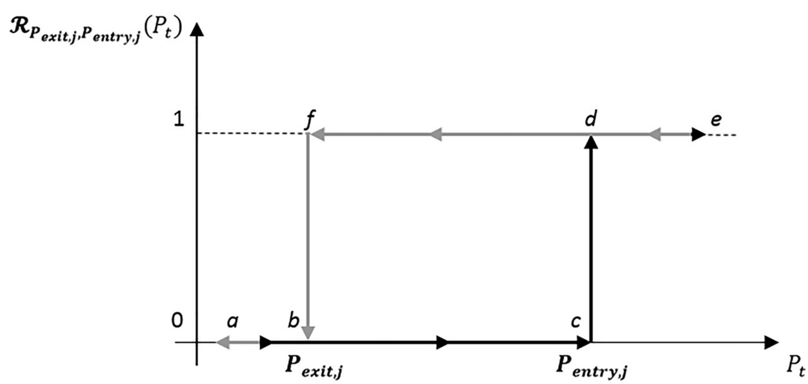

Fig. 1. Non-ideal relay operator

To illustrate the effect of uncertainty, we consider that firms now expect that some shocks will arrive in the price level, which generates revenue uncertainty. As our objective is the aggregation up to the macro level, in line with Belke – Göcke (1999), we model uncertainty in a simple way by assuming a nonrecurring single stochastic change in the output price, which can be either positive, $+\varepsilon$, or negative, $-\varepsilon$. We consider that both realizations of the shock have the same probability of 0.5. In this case, $P_{t+1} = P_t \pm \varepsilon \Rightarrow E(P_{t+1}) = P_t$, and from the period $t+2$ onwards the firm will decide under certainty again.

With uncertainty, a previously inactive/active firm has three possible strategies: *i*) stay inactive/active; *ii*) enter/exit the market; and *iii*) wait and make a decision after the realization of the stochastic shock. If the firm has the possibility of delaying its entry decision, it faces a trade-off: waiting can have a positive value since it brings more information about the evolution of the price level, but it also has the cost of foregoing the profits earned, if entry had occurred. Thus, uncertainty introduces an additional cost of entering (opportunity cost) that is the value of the option to wait.

In this case, the employment demand function of the individual firm can be described as a non-linear hysteretic transformation of a stochastic input, P_t:[7]

$$n_{j,t} = \mathcal{R}_{P^U_{exit,j}, P^U_{entry,j}}\left(t_0,\ n_{j,t_0}\right)[P_t]$$

$$= \begin{cases} 1,\ if\ n_{j,t-1} = 0\ and\ P_t \geq w_j + \dfrac{i}{i+1}H_j + \dfrac{1}{1+2i}\varepsilon\ [entry] \\ or\ n_{j,t-1} = 1\ and\ P_t > w_j - \dfrac{i}{i+1}F_j\ [stay\ active] \\ or\ n_{j,t-1} = 1\ and\ w_j - \dfrac{i}{i+1}F_j - \dfrac{1}{1+2i}\varepsilon < P_t \leq w_j - \dfrac{i}{i+1}F_j\ [wait\ in\ activity] \\ 0,\ if\ n_{j,t-1} = 0\ and\ P_t < w_j + \dfrac{i}{i+1}H_j\ [stay\ inactive] \\ or\ n_{j,t-1} = 0\ and\ w_j + \dfrac{i}{i+1}H_j \leq P_t < w_j + \dfrac{i}{i+1}H_j + \dfrac{1}{1+2i}\varepsilon\ [wait\ in\ inactivity] \\ or\ n_{j,t-1} = 1\ and\ P_t \leq w_j - \dfrac{i}{i+1}F_j - \dfrac{1}{1+2i}\varepsilon\ [exit] \end{cases} \quad (2)$$

Combining both triggers under uncertainty, the width of the band of inaction, *BI*, is determined by the interest costs of hiring and firing, and by uncertainty:

$$BI = P^U_{entry,j} - P^U_{exit,j} = P_{entry,j} - P_{exit,j} + \frac{2\varepsilon}{1+2i} = \frac{i}{i+1}\left(H_j + F_j\right) + \frac{2\varepsilon}{1+2i} \quad (3)$$

where $P^U_{entry,j}$ and $P^U_{exit,j}$. are the entry and the exit triggers under uncertainty respectively. Thus, uncertainty widens the employment band of inaction. The option value of waiting effect raises the optimal entry threshold, increasing the probability of a firm to stay inactive even if the current product demand increases; similarly on the opposite sense, the waiting effect lowers the

[7] See Belke – Göcke (1999) for more detail.

optimal exit threshold, increasing the probability of a firm staying active when product demand decreases. Therefore, hysteresis effects are amplified.

The width of the employment band of inaction, *BI*, described in equation (3) depends positively on the fixed adjustment costs, $\frac{\partial BI}{\partial (H_j+F_j)} = \frac{i}{i+1}>0$ (with $i>0$), and on the degree of uncertainty, $\frac{\partial BI}{\partial \varepsilon} = \frac{2}{1+2i}>0$. However, the effect of interest rates change on the band of inaction depends on how the level of uncertainty compares with the magnitude of the fixed hiring and firing costs.

Furthermore, the lower the interest rate the higher the importance of uncertainty for the width of the band of inaction, and the lower the importance of the fixed adjustment costs: when $i = 0$, $BI = 2\varepsilon$; when $i \to \infty$, $BI \to (H_j + F_j)$.

In fact, in a low interest rate environment, as it is the present situation in many advanced economics, fixed employment adjustment costs are not as relevant as uncertainty to generate the hysteresis effects. Indeed, hysteresis can be quite strong even for small values of the fixed hiring and firing costs (Dixit 1989).

2.2. Hysteresis at the aggregate level

We now consider an aggregation approach based on the Preisach model of hysteresis.[8]

The aggregate economy is represented as a set of the potential number of active heterogeneous J firms (or units of labour), $J \in T$, each one acting according to Equation (2), whereby entry and exit trigger prices are assumed to be firm specific. The set T (named the Preisach triangle) is a two-dimensional half-plan:

$$T = \left\{ \left(P^U_{exit,j},\ P^U_{entry,j} \right):\ P^U_{entry,j} \geq P^U_{exit,j}\ and\ \ P^U_{exit,j} \geq P^U_{exit,min}\ and\ P^U_{entry,j} \leq P^U_{entry,max} \right\}$$

where $P^U_{exit,min}$ is the exiting threshold for the less demanding firm, and $P^U_{entry,max}$ is the entering threshold of the most demanding firm. Given that the level of employment of every active firm is one, the aggregate employment at time t, N_t, is fully described by sum of the active firms in the market:

$$N_t = N_t[t_0,\ N_{t_0}] = \iint_T u\left(P^U_{exit,j},\ P^U_{entry,j}\right)\mathcal{R}_{P^U_{exit,j},P^U_{entry,j}}\left(t_0,\ n_{j,t_0}\right)[P_t]dP^U_{exit,j}dP^U_{entry,j} \tag{4}$$

where $u(P^U_{exit,j},\ P^U_{entry,j})$ is the weight (density) function of the individual firms in T (also known as the Preisach Function), such that the pairs $(P^U_{exit,j},\ P^U_{entry,j})$ are distributed with some integral density:

$$\iint_T u\left(P^U_{exit,j},\ P^U_{entry,j}\right)dP^U_{exit,j}dP^U_{entry,j} = 1$$

[8]The Preisach model is a procedure for aggregating non-ideal relays of the type described by Equation (2) developed in general terms by Krasnosel'skii – Pokrovskii (1989) and Mayergoyz (1986), and introduced to economics by Amable et al. (1993) and Cross (1994). For a complete explanation of the Preisach model of hysteresis, see Mayergoyz (2003) and Mota –Vasconcelos (2012).

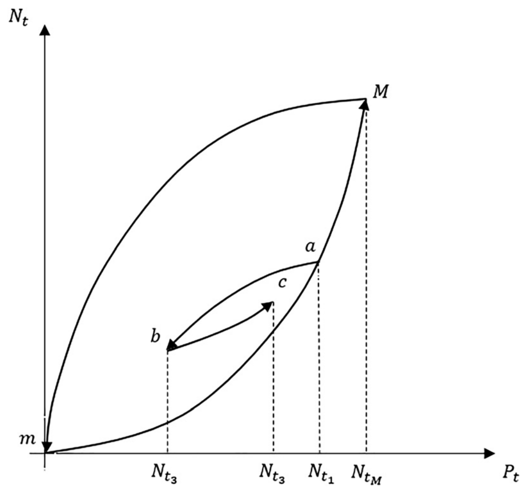

Fig. 2. Preisach hysteresis loop
Source: Mota – Vasconcelos 2012 (p. 99).

and $\mathcal{R}_{P^U_{exit,j},P^U_{entry,j}}(t_0,\ n_{j,t_0})[P_t]$ represents the employment demand of individual firms described by Equation (2).[9]

The main result is that for the cycles of variation in aggregate demand there is a continuous macroeconomic hysteresis loop for aggregate employment as displayed in Fig. 2.

The upward branch captures the aggregate employment change by increasing aggregate demand. The maximum of the upward branch (point M– positive saturation) results from the price increase from 0 to P_{t_m}. The aggregate employment changes as a result of a subsequent price decrease from P_{t_m} to 0 are captured by the downward branch going down from point M to point m.[10]

Differently from the employment dynamics at the firm level,[11] at the aggregate level every reversal of the direction of P_t leads to a structural break in the employment-aggregate demand relationship represented by a continuous transition between different curves (branches).

Let us consider a hypothetical price cycle $P_{t_1} \rightarrow P_{t_2} \rightarrow P_{t_3}$. When the price level increases from 0 to P_{t_1}, the aggregate employment N_t increases along the limiting upward branch up to point a. After a reversal of the path of price level to P_{t_2}, there is an initial weak response of employment

[9]Note that the distance of the relays, $\mathcal{R}_{P^U_{exit,j},P^U_{entry,j}}$, from the origin in T is determined by the variable cost, w_j, and the orthogonal distance of the relays from the 45º-line is a positive function of the non-convex employment adjustment costs, and uncertainty.

[10]Note that the branches of the hysteresis loop are quadratic functions if a uniform Preisach function, $u(P_{exit,j},\ P_{entry,j})$, is considered.

[11]At the firm level there are only two branches, and the transition between those branches only occurs when P_t increases above $P^U_{entry,j}$ or decreases below $P^U_{exit,j}$.

that will evolve into a strong one, once the entry or exit thresholds of many firms are passed. N_t decreases along an inner downward branch up to point *b*. If the price level increases again to P_{t_3}, the aggregate employment increases along an inner upward branch up to point *c*. Thus, whenever direction of the aggregate demand changes, a continuous branch-to-branch transition occurs, implying that transitory changes in P_t can lead to permanent variations in N_t.

3. THE DYNAMICS OF EMPLOYMENT PROTECTION LEGISLATION AND UNCERTAINTY

Portuguese labour law, traditionally based on legal provisions and on collective agreements between the employers' associations and trade unions, was until recently placed among the most rigid across the OECD countries. This is particularly the case of the protection of regular employment.[12]

In the time span of our data set, and especially in the aftermath of the recent financial crisis, successive labour market reforms were implemented.[13] Firstly, a new Labour Code came out in August 2003. The outcome was a significant fall in collective bargaining. It also introduced more working time flexibility, and loosened the rules for the use of fixed-term contracts and temporary employment agencies.

After the financial crisis, a first major reform of the Labour Code was implemented in 2009. Concerning employment protection, the main changes were: *i*) the simplification of the administrative procedures associated to individual and collective dismissals, including deadlines, steps involved and consequences; *ii*) the reduction of the notice period for the short-duration workers; *iii*) the decrease of the compensation paid to workers and the right to reinstatement whenever the dismissal is judged irregular for processual reasons; and *iv*) the decrease of the period that workers have to denounce the dismissal from one year to 60 days.

Other major reforms were implemented in the context of the conditionality measures associated to the financial assistant programme signed with the *Troika* in 2011. The reforms covered four areas: *i*) employment protection; *ii*) working time arrangements; *iii*) wage setting and collective bargaining; and *iv*) unemployment benefits.

Regarding employment protection legislation of regular employment, the main revisions of the Labour Code introduced in 14 October 2011 reduce the severance pay of the non-fixed term contracts from 30 to 20 days salary for each year of service, with an upper limit equal to the minimum of 12 months or 240 times the minimum wage for new contracts, and creates an employer fund to finance these payments. The revised Code reduced further severance payments to 12 days per year of service in the case of collective dismissals, and created a transitory regime for reducing the severance pay in the case of individual dismissals. The revision of the Labour Code also turned the definition of fair dismissals easier. About temporary contracts, an extraordinary regime of two additional renewals (which may not exceed 18 months) for fixed-term employment contracts that reach their maximum duration by 30 June 2013 was introduced.

[12] We are relying in the Employment Protection Legislation for Regular Contracts Indicator (version 2) built by OECD.

[13] See Ramalho (2013), and Távora – González (2014) for a comprehensive analysis of labour markets reforms in Portugal in the last two decades, with particular incidence in the period after the 2008/2009 financial crisis.

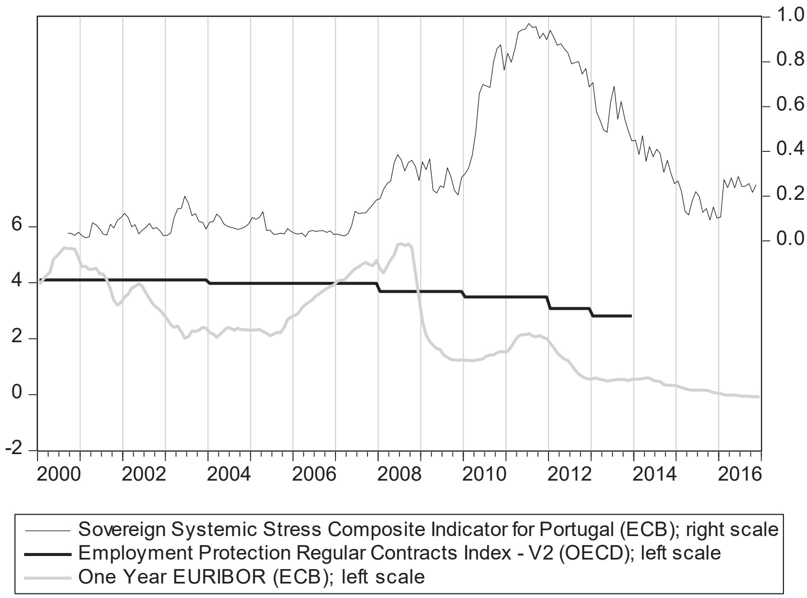

Fig. 3. Dynamics of employment protection legislation and volatility

The 5th Amendment to Labour Code approved in 2013 reduced the severance payments even more for new hires.

The labour market reforms are reflected in the dynamics of the employment protection legislation index for regular contracts built by OECD (EPRC V2) and displayed in Fig. 3. There is a decrease of this index in 2004 reflecting the reforms introduced by the Labour code of 2003. After the crisis, measures towards the relaxation of the protection against individual dismissals and the reduction of severance pay are reflected in the decrease of the index of employment protection for regular contracts in four steps – the first in 2008, the second in 2010, the third in 2012, and the last one in 2013 (see Fig. 3).

Nonetheless, at the same time uncertainty increased substantially. In Fig. 3, we display, together with the employment protection index,[14] the Sovereign Systemic Stress Composite Indicator for Portugal (CISS), which is an indicator of the contemporaneous instability or "stress" in the financial system.[15] The CISS indicator increased markedly after August 2007, and especially after the failure of Lehman Brothers in 2008.

[14]The index of employment protection of regular contracts is the weighted sum of sub-indicators concerning the regulations for individual dismissals and additional provisions for collective dismissals. The indicators of employment protection take values between 0 and 6. Higher values indicate more rigid regulation.

[15]The Sovereign Systemic Stress Composite Indicator comprises five segments of the financial system: *i*) the bank sector; *ii*) the non-bank financial institutions sector; *iii*) money markets; *iv*) securities markets; and *v*) foreign exchange markets. The current level of stress in each of these segments is measured on the basis of three indicators capturing agents' uncertainty, investor disagreement and information asymmetries. Higher values indicate more stress (see, for more detail, Holló et al. 2012).

The recent contrasting dynamics of employment protection legislation and uncertainty were observed in a context of very low interest rates. In fact, the ECB was initiated in October 2008 as a sequence of cuts in the interest rate of the main refinancing operations. In the period of eight months the ECB key interest rate decreased from 4.25% to 1.00% in May 2019. After an increase in the ECB key interest rates in two steps in 2011 to 1.5%, since January 2012 the key interest rate started to decrease again reaching zero in March 2016.

As mentioned before, the theory predicts that increasing uncertainty and the reduction of non-convex employment adjustment costs have opposite effects on the employment band of inaction (with the importance of uncertainty increasing with the decline of interest rates) and consequently on the ability of employment to adjust. Which effect predominates is ultimately an empirical question.

4. EMPIRICAL STRATEGY AND DATA

4.1. Empirical implementation

In the empirical work, we apply the linear play model of hysteresis[16] that can be viewed as a piecewise-linear approximation of the Preisach hysteresis loop, where the slope of the linear function changes at extrema (Fig. 4).[17]

Let us say that the linear play operator $\mathcal{P}$ is characterised by slightly sloping reversible inner branches of the same length (the play segment)[18] and upward more inclined linear limiting branches (the spurt segments) that form counter-clockwise oriented loops as shown in Fig. 4.

Starting in a spurt line, the slope of a linear section changes when there is a reversion in the direction of P_t. The system enters in a play line. And only when P_t traverses the *play interval*, the system changes again to a spurt line where a strong reaction of employment to aggregate demand variations occurs.

There are similarities between concepts of employment band of inaction at the firm level and the play interval, $PLAY$, that is its counterpart at the aggregate level.

In this model the memory effect is captured by the difference in slopes between two adjacent lines (the play line and the spurt lines – see Fig. 4). If β_1 denotes the slope of the flatter line – the play, then $(\beta_1 + \beta_2)$ is the slope of the steeper one - the spurt, and β_2 is the memory or remanence parameter (Göcke 2001).

[16]A different approach to compute the hysteresis variable as a function of the non-dominated sequence of extremums of the input variable is to calculate the area of the active firms in the Preisach triangle for every time t (Piscitelli et al. 2000; Cross et al. 2005; Lang – Peretti 2009; Mota – Vasconcelos 2012). The test of hysteresis based on this method has more power than the one we use in this paper in identifying hysteresis in the data against other non-linear alternatives (Hallett – Piscitelli 2002): However, it does not provide a quantitative measure of the hysteresis effects, like the one we obtain with the play model – the band of inaction, that can be put together with the change in the proxies of labour market and uncertainty to explain aggregate employment dynamics, which is the purpose of this contribution.

[17]See Kranosel'skii – Pokrovskii (1989) and Visitin (1994) for a general description of the model.

[18]The term is used due to its analogy to play in mechanics.

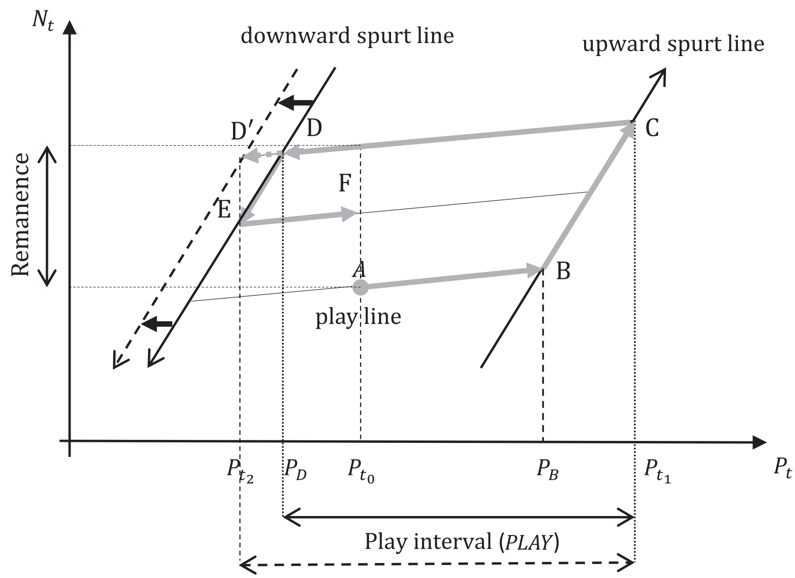

Fig. 4. Play hysteresis loop

$$\frac{dN_t}{dP_t} = \beta_1 + D\beta_2, \quad with\ D = \begin{cases} 0, & on\ the\ play\ lines \\ 1, & on\ the\ spurt\ lines \end{cases} \tag{5}$$

As the slope of the limiting branches is fixed, the play operator is characterised by a single parameter – its input threshold value or the magnitude of the play segment. The value of this parameter increases with the magnitude of employment non-convex adjustment costs and uncertainty. The initial value of the operator state, the pair $(\mathcal{P}_{t_0},\ P_{t_0})$, together with the future values of the input, P_t, determines the value of the employment.

This model has two testable implications. Firstly, after the reversal of the direction of the price level we expect to observe a weak reaction of the employment to changes in P_t. Secondly, a switch to a strong reaction of aggregate employment to changes in price occurs for large changes in P_t.

The linearized play dynamics is illustrated in Fig. 4. Assume $P_t = P_{t_0}$ (the system starts at point A). An increase in the price level up to P_{t_1} causes, initially, a weak response of the aggregate employment (along a *play line*) until a threshold value P_B is surpassed (the system is at point B). This is due to the existence of non-convex costs of employment adjustment and uncertainty. When the price change becomes sufficiently large (*i.e.*, when the threshold value P_B is surpassed), the employment responds strongly, increasing along an *upward spurt line* (the level of employment follows the sequence ABC). If the price starts to decrease to P_{t_2}, employment initially decreases weakly until a threshold at P_D is reached (the system is at point D). After this threshold value is surpassed, employment starts to decrease strongly along the *downward spurt line* (the level of employment follows the sequence CDE). A further reversion of the aggregate demand to P_{t_0} leads again to a weak employment reaction along a *play line*, which is vertically shifted downward (the level of employment follows the sequence EF).

The transitory positive shock leaves a permanent effect on the level of aggregate employment (remanence). Thus, to restore the original state of equilibrium it is not enough to revert the input variable to the original value.

To illustrate the effect of uncertainty, consider that when aggregate demand starts to decrease from P_{t_1} there is an increase in uncertainty.[19] In this case, the downward spurt line is displaced to the left, and a reduction of aggregate demand to P_{t_2} has only a weak impact on the level of employment due to the increase of the play interval. The system ends up at point D′.[20]

The linear play model is implemented empirically via a linear switching employment equation with an unknown splitting factor – the *PLAY*– to capture the non-linear play hysteresis effects.

We describe the change in aggregate employment, N_t, induced by a change in the price, P_t, as divided between a weak reaction along a *play line* and a strong reaction along a *spurt line*, when P_t changes sufficiently, and we estimate the following equation:[21]

$$N_t = \beta_0 + \beta_1 Y_t + \beta_2 SPURT_t + \beta_3 W_t + \beta_4 t + \varepsilon_t \tag{6}$$

where $SPURT_t$ is a hysteresis transformed input variable results from the P_t series with all small changes ($\Delta P_t < PLAY_t$) filtered out. In this framework β_1 gives the reaction of aggregate employment, N_t, along the *play line*, while β_2 is the difference of the reaction of N_t along the *spurt line* and the *play line* caused by price changes.

In the estimation we use real production in industry, Y_t, as a proxy for the aggregate demand represented in the theoretical model by P_t. We also include in the equation as non-hysteretic regressors, the real wage, W_t, and a time trend, t, due to the secular decline of employment in industry caused by technological change (all the variables are in logarithms).[22]

The strategy is to test whether the non-linear model, which includes hysteresis, provides better results than the linear one, by looking to the significance of the transformed real production variable. The presence of hysteresis is corroborated if β_2 is significantly greater than zero.

Following the algorithm described in Belke – Göcke (2001) and Mota et al. (2015), a MATLAB program to generate the hysteresis transformed real production variable, $SPURT_t$, was developed and implemented, which in turn requires the estimation of the width of the *PLAY* interval – the employment band of inaction at the macro level. The innovation here is that the program allows for different splitting factors (different *PLAY* values) caused by the application of major reforms towards the increase of the flexibility of the Portuguese labour market.[23]

[19]This can be the result of an exogenous shock or endogenously caused by the decrease of demand. In fact, a lack of aggregate demand and increasing unemployment can be viewed as the result of the malfunctioning of the economy, and thus, affects business confidence.

[20]A similar effect is caused by an increase of the flexibility of adjusting the number of hours of work per employee (Mota et al. 2012).

[21]The details of the empirical implementation of the play model can be found in Belke – Göcke (2001), Mota et al. (2012) and Mota – Vasconcelos (2015).

[22]ε_t is a random disturbance term.

[23]The results can be requested from the authors directly.

In line with the changes of the employment protection indicator displayed in Fig. 1, which results from the implementation of labour reforms, the algorithm allows for structural breaks in the splitting factor of the employment equation in 2008:01; 2010:01 and 2012:01. This originates four possibly different switching parameters. The algorithm estimates the R^2 of the employment equation associated to each combination of those four play values. Finally, the program selects the combination that maximises the R^2 of the employment equation.[24]

4.2. Data

In the estimation we use industrial monthly data from the EUROSTAT – General Statistics, Industry Commerce and Services for Portugal. Aggregate employment, N_t, is measured by the index of the number of employees in industry. We use the volume of production in industry adjusted by the number of working days, Y_t as the proxy of aggregate demand. Real wages, W_t, are measured by the index of gross wages in industry deflated by the general consumer price index. All series were seasonally adjusted. The data covers the period from January 2000 to October 2016.

5. ESTIMATION RESULTS

We start by analysing the stationarity of the series by applying the augmented Dickey-Fuller units root test to the series in levels and to their first differences (Table 1). For all the variables in levels the augmented Dickey-Fuller test statistic is larger than the 5% critical value (–2.875) indicating that we do not reject the hypothesis of the existence of a unit root. For the first difference of the series, we reject the hypothesis of the existence of a unit root (in this case, the test statistic is smaller than the 5% critical value for all the variables). Thus, the variables included in the regression are integrated of order one, I(1).

To verify the existence of a true equilibrium relationship between the variables, we test for cointegration using the Johansen Test Procedure.[25] Based on this test, we do not reject the hypothesis of a single cointegrating vector relating the variables. In the two models considered

Table 1. Augmented Dickey-Fuller test statistics

Variable	Level	1st Difference
N_t	–2.242	–3.989
Y_t	–1.070	–10.035
W_t	–2.006	–3.686
$SPURT_t$	–1.020	–8.320

Note: 5% critical value: –2.875.

[24]Further details, particularly about the construction of the spurt variable from a given play series can be found in Belke – Göcke (2001), Mota et al. (2012) and Mota – Vasconcelos (2015).

[25]We apply the Trace Test performed with four lags in the VAR representation and with an intercept and time trend in the cointegrating equation. We report the results of testing the null hypothesis of no cointegration ($r = 0$) against the existence of at least one cointegrating vector (r).

(the standard employment equation and the switching employment equation), the trace test statistic is greater than the 5% critical value (Table 2).

However, because the series are non-stationary, to obtain asymptotically unbiased estimates of the parameters, we estimate the cointegrating regression (Equation (6)) using Fully Modified Least Squares (FM-OLS), which is an asymptotically efficient estimator of long-run economic relationships and leads to conventional chi-squared criteria for inferential purposes with respect to the coefficients (fully modified Wald tests).

The method modifies least squares with semiparametric corrections that account for serial correlation effects and for endogeneity in the regressors that result from the existence of the cointegrating relationships (Phillips – Hansen 1990; Phillips 1995).

Through the process of four-dimensional grid search described above, the estimated values obtained for the play are 0.12 for the period until 2007:12, 0.04 for the period between 2008:01 and 2009:12, 0.2 for the period between 2010:01 and 2011:12, and 0.20 for the period after 2012:01 (Fig. 5b and Table 2).

Table 2. Employment switching equation estimation results

Dependent variable: logarithm of aggregate employment in industry (N_t)		
Variables	**Estimates**	
	FM-OLS	***GMM***
$PLAY_t$	– Until December 2007: 0.12 – From January 2008 to December 2009: 0.04 – From January 2010 to December 2011: 0.20 – After January 2012: 0.07	
C	4.751*** (6.886)	4.314*** (7.890)
Y_t	0.133 (1.415)	0.155 (1.413)
$SPURT_t$	0.747*** (5.092)	0.657*** (4.419)
W_t	-0.119 (-0.869)	-0.047 (-0.395)
t	-0.002*** (-12.456)	-0.002*** (-9.1174)
R^2	0.964	0.965
Trace test stat	82.786 (Critical value: 63.876)	

Note: t-statistics are in parentheses.
***, **, * significant at 1, 5, and 10%, respectively.

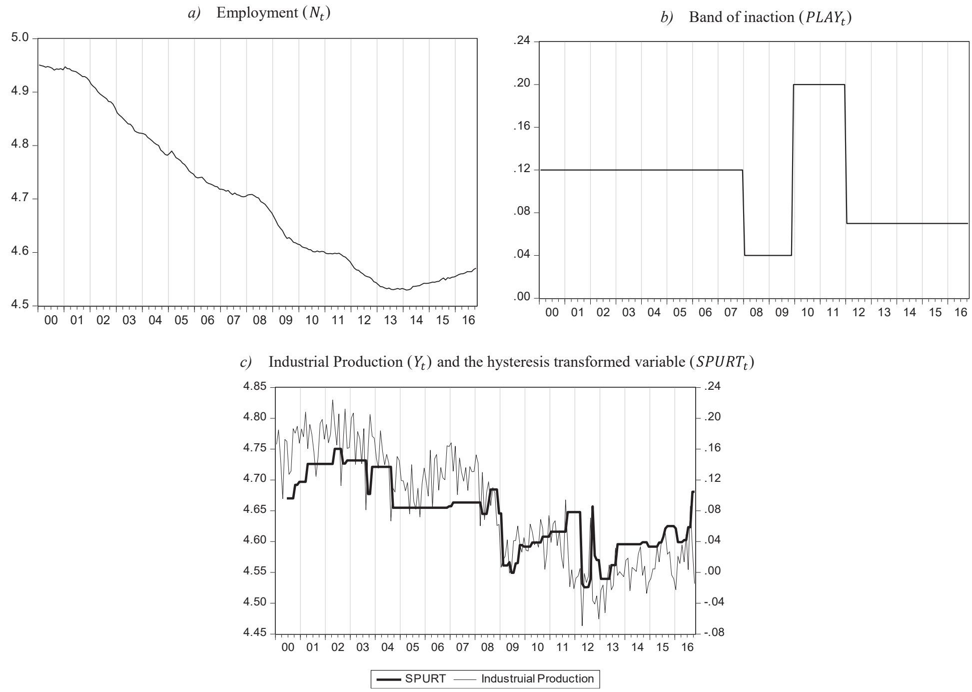

Fig. 5. Original series, the spurt and the play variables

These results are consistent with the presence of an employment band of inaction that depends positively on the magnitude of employment adjustment costs, but which is also found to be wider when uncertainty is high. Thus, the measures towards the deregulation of the labour market applied after the crises decreased the employment band of inaction except in the period where uncertainty is very high. In this case the effect of uncertainty may have offset the effect of the reduction of employment adjustment costs.

The original aggregate employment series is plotted in Fig. 5a) and the industrial production series, Y_t, along with its transformation according to the model of hysteresis, $SPURT_t$, are displayed in Fig. 5c).

In Table 2 (column 2), we present the results of the estimation of the switching employment equation (6). Table 2 shows that using fully modified Wald tests, the coefficient that captures the reaction along the play, β_1, is not significantly different from zero, while the coefficient that captures the difference of the reaction along the spurt and the play, β_2, is 0.747 (significant at 1%). This means that the reaction along the play is weaker (non-existent in this case) than the reaction along the spurt, implying that employment change requires sufficiently large demand shocks.[26]

[26]The coefficient associated to the real wage is non-significant, while the time trend is negative and significant at 1%, as expected.

In order to check the robustness of the results, and in particular to overcome any simultaneity bias problem that may exist, we also re-estimate the employment switching equation using GMM.[27] Table 2, column 3, shows that the results do not change significantly.

6. CONCLUSION

The theoretical model of hysteresis predicts that in a low interest rate environment, fixed employment adjustment costs are not as relevant as uncertainty in generating hysterical effects. Consequently, hysteresis can be quite strong even for small values of the fixed hiring and firing costs that may result from the measures to increase the flexibility of the labour market. At the same time, we document the presence of a contrasting dynamics of employment protection legislation that is a source of adjustment costs and uncertainty after the emergence of the recent financial crisis, in the context of a general decrease of interest rates.

We have found that the measures towards the deregulation of the labour market reduced the hysteresis effects in the dynamics of aggregate Portuguese employment except in the period where uncertainty increased substantially. Therefore, when interest rates are low, hysteresis can be quite strong even if the government applies measures towards the deregulation of the labour market, due to uncertainty. Besides, uncertainty can even result from attempts to reduce non-convex adjustment costs, or from austerity measures that depress the economy in the short run.

These results have important policy implications. Supporting Blanchard – Summers (2009): “So what are policymakers to do? First and foremost, reduce uncertainty”, this paper offers arguments for the implementation of stabilizing aggregate demand policies. In fact, not only transitory negative aggregate demand shocks may affect employment permanently, but also, strong variations of employment forcing variable increases uncertainty contributing to stronger hysteresis effects.

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REFERENCES

Abraham, K. – Haltiwanger, J. – Snadusky, K. – Spletzer, J. (2016): The Consequences of Long-Term Unemployment: Evidence from Matched Employer-Employee Data. *NBER Working Papers*, No. 22665.

Amable, B. – Henry, J. – Lordon, F. – Tool, R. (1993): Unit-Root in Wage-Price Spiral Is Not Hysteresis in Unemployment. *Journal of Economic Studies*, 20(1–2): 123–135.

[27]We consider four lags of the independent variables as the instruments.

Amable, B. – Henry, J. – Lordon, F. – Topol, R. (1994): Strong Hysteresis versus Zero-Root Dynamics. *Economics Letters*, 44(1–2): 43–47.

Amable, B. – Henry, J. – Lordon, F. – Topol, R. (1995): Hysteresis Revisited: A Methodological Approach. In: Cross, R. (ed.), *The Natural Rate of Unemployment-Reflections on 25 Years of the Hypothesis*. Cambridge University Press, pp. 181–200.

Arestis, P. – Sawyer, M. (2009): Path Dependency and Demand–Supply Interactions in Macroeconomic Analysis. In: Arestis, P. – Sawyer, M. (eds): *Path Dependency and Macroeconomics*. London: Palgrave Macmillan, pp. 37–39.

Ball, L. (2014): Long-Term Damage from the Great Recession in OECD Countries. *NBER Working Papers*, No. 20185.

Bassi, F. – Lang, D. (2016): Investment Hysteresis and Potential Output: A Post-Keynesian-Kaleckian Agent-Based Approach. *Economic Modelling*, 52: 35–49.

Belke, A. – Göcke, M. (1999): A Simple Model of Hysteresis in Employment under Exchange Rate Uncertainty. *Scottish Journal of Political Economy*, 46(3): 260–286.

Belke, A. – Göcke, M. (2001): Exchange Rate Uncertainty and Employment: An Algorithm Describing the 'Play'. *Applied Stochastic Models in Business and Industry*, 17: 181–204.

Belke, A. – Göcke, M. (2003): Monetary Policy (In)-Effectiveness under Uncertainty – Some Normative Implications for European Monetary Policy. *Diskussionsbeitäge aus dem Insitut für Volkswirtschaftslehere – Universität Hohebheim*, No. 23.

Belke, A. – Göcke, M. (2005): Real Options Effects of Employment: Does Exchange Rate Uncertainty Matter for Aggregation. *German Economic Review*, 6(2): 185–203.

Belke, A. – Göcke, M. (2006): Monetary Policy and Investment Decision – A Stylized Treatment of the Uncertainty Trap. *Mimeo*, Universities of Stuttgart-Hohenheim and Giessen.

Bertola, G. (1990): Job Security, Employment and Wages. *European Economic Review*, 34(4): 851–879.

Blanchard, O. – Summers, H. (2009): (Nearly) Nothing to Fear but Fear Itself. *The Economist*, January 29, 2009.

Blanchard, O. – Summers, H. (1986): Hysteresis and the European Unemployment Problem. *NBER Macroeconomics Annual*, 1: 15–90.

Cross, R. (1994): The Macroeconomic Consequences of Discontinuous Adjustment: Selective Memory of Non-Dominated Extrema. *Scottish Journal of Political Economy*, 41(2): 212–221.

Cross, R. (1995): Is the Natural Rate Hypothesis Consistent with Hysteresis? In: *The Natural Rate of Unemployment-Reflections on 25 Years of the Hypothesis*. Cambridge University Press, pp. 181–200.

Cross, R. (2014): Unemployment: Natural Rate Epicycles or Hysteresis? *European Journal of Economics and Economic Policies: Intervention*, 11(2): 136–148.

Cross, R. – Darby, J. – Ireland, J. – Piscitelli, L. (2005): Hysteresis and Unemployment: A Preliminary Investigation. In: Bertotti, G. – Mayergoyz, I. (eds): *The Science of Hysteresis*, vol. 1: Mathematical Modeling and Applications. San Diego, CA: Academic Press, pp. 667–699.

deLong, J. – Summers, L. (2012): Fiscal Policy in a Depressed Economy. *Brooking Papers on Economic Activity*, Spring: 233–297.

deLong, B. – Summers, L. – Ball, L. (2014): *Fiscal Policy and Full Employment*. Speech at Center for Budget and Policy Priorities Event on Full Employment, Policy Futures, April 2.

Dixit, A. (1989): Entry and Exit-Decisions Under Uncertainty. *Journal of Political Economy*, 62(3): 620–38.

Dixit, A. (1991): Analytical Approximations in Models of Hysteresis. *Review of Economic Studies*, 58: 141–51.

Dixit, A. (1992): Investment and Hysteresis. *Journal of Economic Perspectives*, 6(1): 107–132.

Dixit, A. – Pindyck, R. (1994): *Investment Under Uncertainty*. Princeton University Press.

Dosi, G. – Pereira, M. – Roventini, A. – Virgillito, M. (2017): When More Flexibility Yields More Fragility: The Microfoundations of Keynesian Aggregate Unemployment. *Journal of Economic Dynamics and Control*, 81: 162–86.

Folta, T. (2006): Uncertainty, Irreversibility, and the Likelihood of Entry: An Empirical Assessment of the Option to Defer. *Journal of Economic Behavior & Organization*, 61(3): 432–452.

Göcke, M. (2001): A Macroeconomic Model with Hysteresis in Foreign Trade. *Metroeconomica*, 52(4): 449–473.

Göcke, M. (2002): Various Concepts of Hysteresis Applied in Economics. *Journal of Economic Surveys*, 16(2): 167–188.

Göcke, M. – Matulaityte, J. (2015): Modelling Economic Hysteresis Loses Caused by Sunk Costs. *MAGKS Joint Discussion Papers Series in Economics, Philipps-University Marburg, School of Business and Economics*, No. 36.

Hallett, A. – Piscitelli, L. (2002): Testing for Hysteresis Against Non-Linear Alternatives. *Journal of Economic Dynamics and Control*, 27(2): 203–27.

Hamermesh, D. – Pfann, G. (1996): Adjustment Costs in Factor Demand. *Journal of Economic Literature*, 34(2): 1264–1292.

Holló, D. – Kremer, M. – Lo, D. (2012): CISS – A Composite Indicator of Systemic Stress in the Financial System. *ECB Working Papers*, No. 1426.

Jaimovich, N. – Siu, H. (2012): The Trend is the Cycle: Job Polarization and Jobless Recoveries. *NBER Working Papers*, No. 18334.

Krasnosel'skii, M. – Pokrovskii, A. (1989): *Systems with Hysteresis*. Berlin: Springer.

Lang, D. – Peretti, C. (2009): A Strong Hysteretic Model of Okun's Law: Theory and a Preliminary Investigation. *International Review of Applied Economics*, 23(4): 445–462.

Layard, R. – Nickell, S. – Jackman, R. (1991): *Unemployment Macroeconomic Performance and the Labour Market*. New York: Oxford University Press.

Mayergoyz, I. (1986): Mathematical Models of Hysteresis. *IEEE Transactions on Magnetics*, 22(5): 603–608.

Mayergoyz, I. (2003): *Mathematical Models of Hysteresis and Their Applications*. New York: Elsevier.

Mota, P. – Varejão, J. – Vasconcelos, P. (2012): Hysteresis in the Dynamics of Employment. *Metroeconomica*, 63(4): 661–692.

Mota, P. – Varejão, J. – Vasconcelos, P. (2015): A Hysteresis Model-Based Indicator for Employment Adjustment Rigidity. *Empirica*, 42(3): 547–569.

Mota, P. – Vasconcelos, P. (2012): Non-Convex Adjustment Costs, Hysteresis, and the Macrodynamics of Employment. *Journal of Post Keynesian Economics*, 35(1): 93–112.

Mota, P. – Vasconcelos, P. (2015): The Macrodynamics of Employment Under Uncertainty. In: Bourguignon, J. P. – Jeltsch, R. – Pinto, A. A. – Viana, M. (eds): *Dynamics, Games and Science*. Vol. 1 of the CIM Series in Mathematical Sciences, pp. 479–497.

Phelps, E. S. (1972): *Inflation Policy and Unemployment Theory – The Cost-Benefit Approach to Monetary Planning*. Macmillan.

Phillips, P. (1995): Fully Modified Least Squares and Vector Autoregression. *Econometrica*, 65(5): 1023–78.

Phillips, P. – Hansen, B. (1990): Statistical Inference in Instrumental Variables Regression with I (1) Processes. *Review of Economic Studies*, 57(1): 99–125.

Pindyck, R. (1988): Irreversible Investment, Capacity Choice and the Value of the Firm. *American Economic Review*, 78(5): 969–985.

Pindyck, R. (1991): Irreversibility, Uncertainty, and Investment. *Journal of Economic Literature*, 29(3): 110–1148.

Piscitelli, L. – Cross, R. B. – Grinfeld, M. – Lamba, H. (2000): A Test for Strong Hysteresis. *Computational Economics*, 15(1–2): 59–78.

Ramalho, M. (2013): Portuguese Labour Law and Industrial Relations during the Crisis. *ILO Working Papers*, No. 54.

Setterfield, M. (2009): Path Dependency, Hysteresis and Macrodynamics. In: Arestis, P. – Sawyer, M. (eds): *Path Dependency and Macroeconomics.* Palgrave Macmillan, pp. 37–79.

Távora, I. – González, P. (2014): The Reform of Joint Regulation and Labour Market Policy during the Current Crisis: National Report on Portugal. In: Kokiadaki, A. – Lucio, M. M. – Távora, I. (eds): *Joint Regulation and Labour Market Policy in Europe during the Crisis*. Brussels: ETUI, pp. 321–393.

Varejão, J. – Portugal, P. (2007): Employment Dynamics and the Structure of Labor Adjustment Costs. *Journal of Labor Economics*, 25(1): 137–165.

Visitin, A. (1994): *Differential Models of Hysteresis.* Springer.

Yagan, D. (2017): Employment Hysteresis from the Great Recession. *NBER Working Papers*, No. 23844.