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GOVERNMENT FISCAL EFFORTS VS. LABOUR UNION STRIKES
IT TAKES TWO TO TANGO

Government fiscal efforts vs. labour union strikes
It takes two to tango

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Abstract

This paper analyzes the simultaneous interaction between the government and the labour union in a unionized economy by means of a policy-game model. Our model explains how the economic and political interaction between labour unions (wages and strikes), and the government (unemployment and fiscal policy) gives rise to a long run Cournot-Nash equilibrium. Using Italian quarterly data (1960-2009) on government budget surplus (fiscal effort) and hours not worked (strike), we estimate the policy-game model by a cointegrated Vector Autoregressive system. Specific model constraints allow us to identify the long run cointegration relationships as the players' reaction functions of the theoretical model. We find that a rise in unemployment has a negative effect on the equilibrium level of effort and strike, while a rise in wages has a positive effect on effort but negative effect on strike. The speed of long run adjustment and phase diagram representation explain the transition to equilibrium and provide some insights about the efficacy of fiscal and strike policies.

JEL classification: E62, J51, C72, C54, C32.
Keywords: Fiscal efforts, strikes, policy-game, VEC, speed of adjustment.

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1 Introduction

Unions and governments have overlapping economic aims but different political instruments. Unions may use strikes to maximize support from workers while governments can use fiscal policies to gain the support of their electorate. The economic and political interaction of the strategies adopted by these two actors is particularly important in understanding the economic and political performance of unionized economies, where a government's partisanship and fiscal policy greatly affect union behaviour and strikes: it takes two to tango.

Several stylized facts have emerged on strikes and fiscal policies. Strike activity has a very long history in Western countries. Over time, strikes appear cyclically and occur in waves. For example, during the 1970s and 1980s OECD countries experienced a long strike wave, while the last few decades has seen a sharp decline in strikes. Since the 1980s, the motivation for strikes has been changing: economic strikes have been declining while political strikes have been rising.[1] In any case, strikes are always driven by both political and economic forces.

Public debt problems have been the main policy issue in Western countries since World War II. Specifically since the 1970s, OECD countries have experienced large and persistent public deficits that, in turn, have increased the public debt-to-GDP ratio. Recently, several OECD countries have adopted a 'fiscal straitjacket' and implemented fiscal adjustment programs to reduce the government debt-to-GDP ratio and/or the budget deficit-to-GDP ratio.[2] For example, in the European Union, the Maastricht Treaty and the Stability and Growth Pact have imposed institutional constraints on national fiscal policies and, more recently, the Fiscal Compact has imposed severe fiscal consolidation.

In several OECD countries, especially in continental Europe, unions can influence the effects and the transmission mechanism of fiscal policies. However, the interaction between fiscal policy,

[1] There are various definition of the term political strike and several measures of strikes. Hamann et al. (2012), following Hyman (1989) and Walsh (1983), defined 'general strike' (or 'protest strike') as a temporary, national stoppage of work by workers from many industries, directed against the executive or legislative arms of government, to enforce a demand or give voice to a grievance. Using this definition, they distinguished and collected data on political and economic strikes for 16 Western European countries between 1980 and 2006. Lindvall (2013), on the basis of theories of organizational power resources, explains why political strikes are rare in countries with strong union movements. According to his reckoning, between 1980 and 2008, there were only 10 political strikes in Italy.

[2] Mierau et al. (2007), using a panel discrete choice model for 20 OECD countries for the period 1970-2003, found that fiscal adjustments are affected by economic and political variables (such as upcoming elections or broad policy reform). For advanced countries, Lavigne (2011) found that fiscal rules contribute to avoiding situations of fiscal distress. Heylen et al. (2013) found new evidence on the role of public sector efficiency for the success of fiscal consolidation.

unemployment, strikes and wages is still a puzzle. With the notable exceptions of Ardagna (2001, 2007), Forni et al. (2009), and Pappa (2009), most of the theoretical contributions analyze the impact of fiscal policy shocks in macroeconomic models with perfectly competitive labour markets and without considering strategic relationships between agents. On the other hand, a few studies do attempt to explain this puzzle through the lens of macroeconomic policy-game models where labour unions are powerful players. Macroeconomic policy-game models are typically based on a sequential set of player decisions, in which the union moves first and sets wages unilaterally, then the government selects public expenditure and, finally, firms make their hiring decisions (Azam & Salmon 2004, Vernby 2007). Since these empirical tests of policy-game models are based on cross section data, they cannot disentangle the short and long run movements in the macroeconomic variables.

To fill this research gap, we propose a novel policy-game model with simultaneous interaction between the government and the labour union playing fiscal efforts and strikes. Our model explains how a labour union, mainly concerned with wages, and a government, mainly concerned with unemployment, may jointly determine the optimal level of their control variables: strikes and fiscal efforts. We model strike as *strategic substitute* from government perspective and effort as *strategic complement* from labour union perspective. The two players are able to reach the long run equilibrium only if their reaction functions are both inelastic or at least one of the two reaction functions is very inelastic. We interpret the players' reaction functions as the long-term economic relationships and the Cournot-Nash equilibrium of the game as the steady state equilibrium. By means of a cointegrated Vector Autoregressive (VAR) model, we estimate our policy-game model using Italian quarterly data on the period 1960-2009 and check whether the implied Cournot-Nash equilibrium entails a set of identifying cointegration restrictions that are supported by the data. In particular, our over-identifying restrictions on the long run cointegration coefficients and the adjustment coefficients of the cointegrated VAR model are not rejected when compared with the data. In addition, we analyze the structure of dynamic adjustment towards the equilibrium, using the concept of 'speed of long run adjustment' introduced in Fanelli & Paruolo (2010).

The Italian economy is an ideal setting for investigating the economic and political interaction between governments and unions. Issues involving the interactions of fiscal policy, unemployment, strikes and wage setting are emblematic of Italian history and the post World War II configuration of Italian institutions. In Italy, the importance of labour unions both in industrial relationships and in economic and social policy issues is a well-known historical fact. Despite a decline in union density and the technological changes occurring in recent years, labour unions still play an important role in the performance of the labour market.[3] In addition, since labour market institutions have not changed during recent years, labour unions can still affect the political and social climate.[4] In the empirical analysis, where we also take into account the short run movements, we have to use nominal wages along with the inflation rate to account for some specific institutional features at work in the Italian economy on a large portion of the chosen estimation sample.[5]

Overall, our empirical results show that the predicted Cournot-Nash equilibrium is supported by the data. Fiscal efforts and strikes are jointly determined, in the long run, as implied by our strategic policy-game. The estimated policy reaction functions form a system of simultaneous cointegration relationships and the magnitude and sign of estimated structural parameters lines up with the predictions of the theory. This evidence suggests that in Italy the government and the labour union have been both powerful economic players, each capable of affecting the choice of the other player. In addition, the estimated structure of adjustment to equilibrium reveals that: the labour union uses strike policy more actively than the government uses fiscal policy; the efficacy of fiscal policy is comparatively stronger than strike policy, since the detected capability of the government to reach its goal is faster than the labour union.

We derive some important lessons from our model and empirical analysis. First, according to our results, crucial issues such as long term debt sustainability can be fully understood only considering the historical role and strength that labour unions exert in the economic/political context, and the behaviours they follow to interact with the government. Second, focusing on the specific case of Italy, our results show that in the long run equilibrium, shocks in unemployment

[3] In the post-war period, the evolution of the Italian union density of employed workers displays a long cycle of about 30 years, with two peaks (about 50%), one in 1950 and one in 1976. In 1960 and in 2009, the Italian union density was about 25% and 34%, respectively. For more details, see Checchi & Corneo (2000) and Franzosi (2006).

[4] The most important pro-labour legislative act, in Italy, was the Workers' charter of rights, enacted in 1970. The Italian constitutional law has increased work council powers and protects union activity. Notably, labour courts have extended the national wage agreement with unions, to cover all workers.

[5] This modelling choice is consistent with the 'philosophy' behind our empirical approach that hinges on the idea that it is sometimes necessary to adapt the baseline specification to account for possible institutional mechanisms and features at work in the economy which the theoretical model may fail to consider before being taken to the data.

have stronger effects than shocks in wages and strikes are affected by these shocks more than the government budget surplus. Third, since the Maastricht Treaty and the Stability and Growth Pact effectiveness imply a higher government's effort for Italy, our model predicts that this equilibrium's sustainability depends on both an increase in wages and a decrease in unemployment. The predicted effect on the level of strikes is ambiguous.

The remainder of the paper is organized as follows. In Section 2, we briefly review the relevant literature and emphasize our contribution. In Section 3, we introduce the policy-game model and discuss its main implications. In Section 4, we use the vector error correction (VEC) methodology to investigate the proposed policy-game empirically. Specifically, in Sub-section 4.1 we focus on the long run Cournot-Nash equilibrium, in Sub-section 4.2 we analyze the structure of dynamic adjustment and in Sub-section 4.3 we provide an interpretation by means of phase diagrams. Section 5 concludes the paper.

2 Contribution to the literature

Workers may try to influence government policy through strikes against governments. Azam & Salmon (2004) apply an imperfect information framework in a policy-game between a union and government where the government cannot credibly commit to a given level of employment-generating public expenditure, and the union may use strikes to force the government to increase the same public expenditures. Following a similar approach, Vernby (2007) develops a policy-game where a union has the power to call strikes in order to entice the government to increase its job creation efforts. Contrary to Azam & Salmon (2004), he focuses on how the incentive for the government to pursue an accommodationist policy depends on the type of electoral system.[6]

Recently, Franzosi (2006) has argued that a government's partisanship and fiscal policy affect union behaviour and strikes. Fiscal policies aimed at mitigating unemployment, stimulating the economy and the stabilization of business cycles are common across countries and over time.[7] Data for OECD countries reveal that: (i) adjustments on the spending side rather than on the tax side are less likely to create recessions (Alesina & Ardagna 2009); (ii) expansionary fiscal

[6] Lee & Roemer (2005) studied a policy-game model where trade unions interact with endogenously formed partisan political parties, to explain changing political preferences for and against the unionised labour market regime.

[7] The efficacy of fiscal policy is, in general, a controversial issue. Corsetti et al. (2012) have recently addressed this issue.

contractions are effective under certain limited hypothesis (Giavazzi & Pagano 1990); (iii) fiscal contraction implemented through cuts in government spending has a more expansionary effect than reducing taxes (Ardagna 2004); (iv) credible fiscal consolidation has a contractionary effect although the effect may be expansionary if fiscal stress occurs (Perotti 1999).

The overall public budget (government budget surplus) denotes the fiscal effort required to achieve government targets and maintain fiscal sustainability. Schneider & Zapal (2006) apply the growth accounting technique proposed by Von Hagen et al. (2002) and used by Hughes Hallett et al. (2003) to capture the restrictiveness or expansiveness of fiscal policy. They define *net fiscal effort* as the part of the change in the budget not due to growth of the economy, a change in monetary policy conditions, or a change in the level of public debt. In our contribution, the government can not arbitrarily use fiscal effort to minimize unemployment and maximize its support from the electorate, therefore the strategic interaction between the union and the government is crucial to the effectiveness of fiscal efforts. By expanding the approaches developed by Azam & Salmon (2004), Vernby (2007) and Schneider & Zapal (2006) to a broader framework, our study contributes to the existing literature in several respects. First, we develop a novel policy-game model to analyze the simultaneous strategic interaction between the government and the labour union such that we can use their reaction functions to characterize the long-term economic relationships and the steady state equilibrium of fiscal efforts and strikes. Second, we estimate our policy-game model using Italian quarterly data and the error-correction time series methodology by means of parameter restrictions identified in the policy-game model.[8] Third, by combining our estimates of speed of long run adjustment' with a phase diagram representation of our estimated policy-game model, our findings shed light on the adjustment features and the effectiveness of the players. To our knowledge, these aspects have not been explored by other authors in a coherent framework so far.

3 Model

In this section, we set a policy-game model to analyze the interaction between two players: the government (g) and the labour union (l). The government and the labour union are modelled as unitary players, hence we do not discuss their politics. In particular, policy makers and union

[8] The long run relationships isolated in the vector autoregressive model are static cointegrating relationships (Stern 2000). We interpret those relationships as the players' reaction functions of our policy-game model.

leaders implement the optimal policy of the median voter without any agency problem between policy makers and electors, and between union leaders and workers, respectively.[9]

We assume that both players' objective functions are separable into the part involving the government and the labour union's interaction and the part involving other players (e.g. the organization of employers) or other variables (e.g. the inflation rate). In principle, the organization of employers can affect the interplay between g and l, but we maintain that this effect is only marginal, in line with our partial equilibrium approach. Using this orthogonality assumption, we check empirical validity in Sub-section 4.1, we are able to consider only the former part in our objective functions. Starting from the objective function of each player, we obtain their reaction functions. Then, we calculate the Cournot-Nash equilibrium of the game and its properties.

We assume that the player's objective functions are defined on the government's effort (e), the labour union's strikes (s), unemployment (u) and wages (w). In particular, the effect of w on the government's objective function (G) and the effect of u on the labour union's objective function (L) are only indirect: $G(e; s(w), u)$ and $L(s; e(u), w)$. Indeed, a wage curve may link w and u, and a Phillips curve-type relationship may link inflation (π) to unemployment.[10] Contrary to a wage bargaining approach, where the effect of wages on the labour union's objective function is clearly positive, the economic and political interaction we model does not consider employers or government as employer. We consider wages have a negative effect in the separable part of the labour union's objective function, since wages are the opportunity cost of strikes. Hicks (1932) pointed out that strikes are costly for all agents participating in industrial relationships. Thus, if agents were rational and well-informed, there would be no reason to strike.

When the government and the labour union interact, the government focuses its effort on maximizing support from its electorate which depends on the unemployment rate, the fundamental variable on which society evaluates macroeconomic outcomes (Persson & Tabellini 2000). Thus, the government's objective function, G, depends, for any level of labour union's

[9] By this assumption, we can aggregate heterogeneous individual preferences into a unique government and union's objective function (Booth 1984).

[10] In the 1970s and 1980s several authors investigated the interaction between monetary policy and wage setting in terms of policy-games. Gylfason & Lindbeck (1994) analyzed first the non-neutrality of money through a policy-game between the central bank and the labour union.

strikes and unemployment, on its effort e. In particular, G is specified in the form

$$G = vu^{-\tau}s^{-\sigma_g}e - e^{1+\eta_g} \tag{1}$$

The first part of Eq. (1) captures the utility function of the median voter, the parameters $-\tau < 0$ and $\sigma_g > 0$ are the median elector's elasticities of, respectively, unemployment and strikes. The parameter $\eta_g > 0$ in the second part of Eq. (1) measures the cost of effort for the government. Finally, $v > 0$ is a parameter measuring the cost-benefit ratio of G. Observe that the median elector has higher probability of being unemployed with a higher u and a higher s generates a loss to the economy, so we assume electors perceive a lower value for government's effort e whenever u and s increase.

The derivative of G with respect to the control variable of the player g is given by

$$G_e = vu^{-\tau}s^{-\sigma_g} - (1+\eta_g)e^{\eta_g} \tag{2}$$

where the term $vu^{-\tau}s^{-\sigma_g}$ is the constant marginal benefit of e in terms of support from electors, and $(1+\eta_g)e^{\eta_g}$ is the increasing marginal cost of e. Note that, to capture the idea of a trade-off between costs and benefits of the government's effort, the median elector's elasticity of effort is fixed to 1 in Eq. (1). By this assumption, G_e has an inverted-U shape, that is the government's control variable e has a positive and then a negative effect on G:

$$G_{e=0} = vu^{-\tau}s^{-\sigma_g} > 0 \qquad G_{e\to+\infty} = -\infty < 0 \tag{3}$$

In the strategic interaction between g and l, the labour union uses strikes to maximize support from workers who are mainly influenced by wages (Booth 1995). Therefore, for any given government effort and wages, the labour union's objective function depends on strikes s. Specifically, the objective function L is specified in the form

$$L = rw^{-\rho}e^{\eta_l}s - s^{1+\sigma_l} \tag{4}$$

The first part of Eq. (4) captures the utility function of the median worker, and the parameters $-\rho < 0$ and $\eta_l > 0$ reflect the median worker's elasticities of wages and effort, respectively.

The parameter $\sigma_l > 0$ in the second part of Eq. (4) measures the cost of strikes for the labour union. Finally, $r > 0$ is a parameter measuring the cost-benefit ratio of L. As already noted, our model considers wages only as the opportunity cost of strikes, hence wages have a negative effect. Moreover, starting from the idea that union leaders are motivated by personal advancement (Ross 1953), and that their support from workers increases when the union is able to induce a higher government effort, we assume that the positive effect of s is increasing in effort.

The derivative of L with respect to the control variable of the player l is given by

$$L_s = rw^{-\rho}e^{\eta_l} - (1+\sigma_l)s^{\sigma_l} \tag{5}$$

where the term $rw^{-\rho}e^{\eta_l}$ captures the constant marginal benefit of s in terms of support from workers, and $(1+\sigma_l)s^{\sigma_l}$ is the increasing marginal cost of s.[11] By analogy with the government trade-off between costs and benefits, the median worker's elasticity of strikes is fixed to 1 in Eq. (4). By this assumption, L_s has an inverted-U shape, that is the labour union's control variable s has a positive and then a negative effect on L:

$$L_{s=0} = rw^{-\rho}e^{\eta_l} > 0 \qquad L_{s\to+\infty} = -\infty < 0 \tag{6}$$

In Sub-section 3.1 we derive the reaction functions of the two players and in Sub-section 3.2 we discuss the implied Cournot-Nash equilibrium.

3.1 Reaction functions

In our symmetric policy-game, both players g and l maximize their objective functions by choosing their respective control variable, e and s, simultaneously. Given the strategic interaction between the two players, the optimal strategies arise from their reaction functions. The government's reaction function is obtained by maximizing its objective function. From the First Order Condition of this problem ($G_e = 0$ in Eq. (2)), we obtain the government's reaction function

[11] Strikes have also a positive effect on the median workers utility because strikes are intended as effective ways of participation in the socio-economic political process.

that we express in natural logs:

$$\ln e^C = \frac{1}{\eta_g} \ln\left(\frac{v}{1+\eta_g}\right) - \frac{\tau}{\eta_g} \ln u - \frac{\sigma_g}{\eta_g} \ln s \tag{7}$$

Since $-\frac{\sigma_g}{\eta_g} < 0$, the government's reaction function has a negative slope. Therefore, strikes are *strategic substitute* from government perspective, meaning that a more 'aggressive' labour union lowers the marginal benefit of the government's effort. To simplify notation for future use in the estimated system of simultaneous cointegrating equations, we rewrite Eq. (7) in the form

$$\ln e^C + \beta_g^0 + \beta_g^u \ln u + \beta_g^s \ln s = 0 \tag{8}$$

where $\beta_g^0 = \frac{-1}{\eta_g} \ln\left(\frac{v}{1+\eta_g}\right)$, $\beta_g^u = \frac{\tau}{\eta_g} > 0$ and $\beta_g^s = \frac{\sigma_g}{\eta_g} > 0$.

The labour union's reaction function is calculated by maximizing its objective function. By imposing $L_s = 0$ in Eq. (5) and taking natural logs, we obtain the labour union's reaction function

$$\ln s^C = \frac{1}{\sigma_l} \ln\left(\frac{r}{1+\sigma_l}\right) - \frac{\rho}{\sigma_l} \ln w + \frac{\eta_l}{\sigma_l} \ln e \tag{9}$$

Since $\frac{\eta_l}{\sigma_l} > 0$, the labour union's reaction function has a positive slope. From labour union perspective effort is *strategic complement*, meaning that a more aggressive government raises the marginal benefit of strike. As above, we rewrite Eq. (9) in the form

$$\ln s^C + \beta_l^0 + \beta_l^w \ln w + \beta_l^e \ln e = 0 \tag{10}$$

where $\beta_l^0 = \frac{-1}{\sigma_l} \ln\left(\frac{r}{1+\sigma_l}\right)$, $\beta_l^w = \frac{\rho}{\sigma_l} > 0$ and $\beta_l^e = -\frac{\eta_l}{\sigma_l} < 0$.

3.2 Cournot-Nash equilibrium

Assuming an interior solution, the Cournot equilibrium associated with the game between g and l is obtained from Eq. (8) and Eq. (10), i.e.

$$\ln e^* = \frac{\beta_g^s \beta_l^0 - \beta_g^0}{1 - \beta_g^s \beta_l^e} - \frac{\beta_g^u}{1 - \beta_g^s \beta_l^e} \ln u + \frac{\beta_l^w \beta_g^s}{1 - \beta_g^s \beta_l^e} \ln w \tag{11}$$

$$\ln s^* = \frac{\beta_g^0 \beta_l^e - \beta_l^0}{1 - \beta_g^s \beta_l^e} + \frac{\beta_g^u \beta_l^e}{1 - \beta_g^s \beta_l^e} \ln u - \frac{\beta_l^w}{1 - \beta_g^s \beta_l^e} \ln w \tag{12}$$

This Cournot equilibrium is stable only if

$$\left|\frac{\partial \ln e^C}{\partial \ln s}\right| < \left|\frac{1}{\frac{\partial \ln s^C}{\partial \ln e}}\right| \tag{13}$$

and this inequality holds, looking to Eq. (8) and Eq. (10), only if

$$|\beta_g^s| < \left|\frac{1}{\beta_l^e}\right| \tag{14}$$

Since β_g^s and β_l^e are, respectively, the elasticity of the government's reaction function with respect to strike ($E_{e^C,s}$) and the elasticity of the labour union's reaction function with respect to effort ($E_{s^C,e}$), Eq. (14) is equivalent to the condition

$$|E_{e^C,s}| \cdot |E_{s^C,e}| < 1 \tag{15}$$

This implies that the players's reaction functions need to be sufficiently inelastic for the equilibrium to be stable.

Moreover, in our setup, at equilibrium, the effect of an increase in unemployment on the level of control variables (effort and strike) is negative, but the effect of a rise in wages on the level of effort and strike is respectively positive and negative. More formally:

$$E_{e^*,u} = u\frac{\partial \ln e^*}{\partial u} = \frac{-\beta_g^u}{1-\beta_g^s\beta_l^e} < 0 \tag{16}$$

$$E_{s^*,u} = u\frac{\partial \ln s^*}{\partial u} = \frac{\beta_g^u\beta_l^e}{1-\beta_g^s\beta_l^e} < 0 \tag{17}$$

$$E_{e^*,w} = w\frac{\partial \ln e^*}{\partial w} = \frac{\beta_l^w\beta_g^s}{1-\beta_g^s\beta_l^e} > 0 \tag{18}$$

$$E_{s^*,w} = w\frac{\partial \ln s^*}{\partial w} = \frac{-\beta_l^w}{1-\beta_g^s\beta_l^e} < 0 \tag{19}$$

The aforementioned equilibrium properties give rise to a set of testable empirical implications that we address in detail in the next section.

4 Empirical analysis: the case of Italy

In this section, we take our policy-game to the Italian quarterly data, using cointegration analysis. In Sub-section 4.1 we investigate, in particular, whether the reaction functions in Eq. (8) and Eq. (10) can be estimated as a system of static simultaneous cointegrating equations. We then focus on the dynamics of adjustment in Sub-section 4.2, with the idea of inferring from the data which of the two players of our strategic interaction game drives the process of convergence towards the equilibrium and which adjusts faster. Finally, we provide an interpretation of our results in terms of phase diagrams in Sub-section 4.3.

The Italian economy, for its history and institutional background, is well-suited to investigating the equilibrium reaction functions in Eq. (8) and Eq. (10) (we postpone in Appendix A a thorough discussion). Since the time series that proxy the variables of our theoretical model are nonstationary, we use a cointegrated VAR model and Johansen's methodology (Johansen 1995, Juselius 2006). This methodology allows us to meet two requirements. On the one hand, we can check whether the data support the existence of at least two cointegrating relationships consistent with the Cournot-Nash equilibrium predicted by our theoretical model. On the other hand, conditional on the identified long run structural equilibrium relationships, we use the VEC counterpart of the cointegrated VAR system and 'let the data speak' about the dynamic structure of adjustment towards equilibrium.

We consider quarterly observations relative to the period 1960.Q1-2009.Q4, and proxy the variables of our theoretical model as follows (detailed descriptions and data sources may be found in Appendix B): $\ln e$ is proxied by $effort_t = \ln\left(1 + \frac{S_t}{GDP_t}\right)$, where $S_t = -\Delta B_t$ is minus the public deficit, B_t is the nominal stock of debt and GDP_t is the nominal Gross Domestic Product; $\ln s$ is proxied by $strike_t = \ln\left(1 + \frac{H_t}{POP_t}\right)$, where H_t is the amount of hours not worked due to labour disputes arising from the labour contract and POP_t is the active population aged 15-64; $\ln u$ is proxied by $un_t = \ln\left(1 + \frac{U_t}{LF_t}\right)$, where $\frac{U_t}{LF_t}$ is the official unemployment rate (LF_t is the labour force and U_t are the unemployed workers); $\ln w$ is proxied by $wage_t = \ln\left(1 + W_t^{06}\right)$, where W_t^{06} is the hourly nominal wage index of the manufacturing sector equal to 100 in 2006.Q1. From the definitions above, it turns out that $effort_t$ can be interpreted as a measure of the budget surplus the government obtains, over the level of GDP, while $strike_t$ is a measure of the amount of hours not worked per capita. The time series of main interest, $effort_t$ and

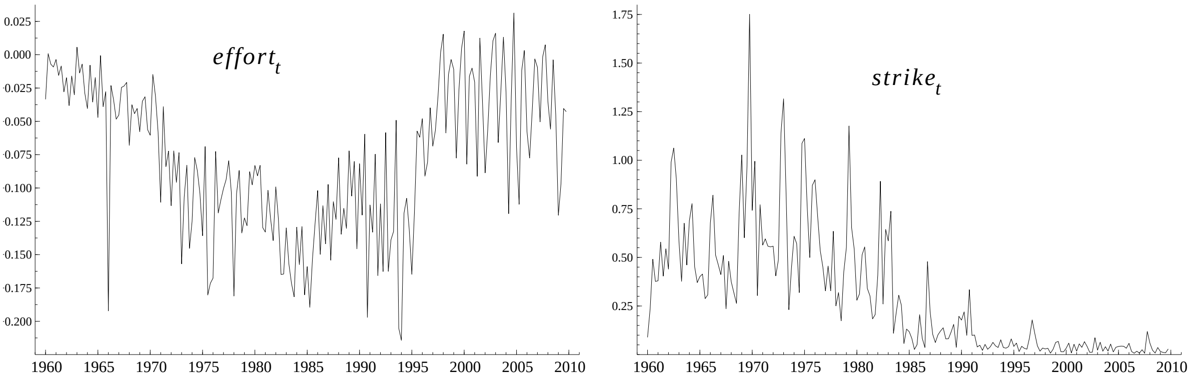

Figure 1: $effort_t$ and $strike_t$ over the period 1960.Q1-2009.Q4

$strike_t$, are plotted in Figure 1.

According to the efficiency-wages theory, the monopoly union model and the Phillips curve framework (Layard & Nickell 1990, Manning 1991, 1993), the outcome of collective bargaining is wage. In the short run, for a given price level, the main object of negotiation between the union and the government is the nominal wage.[12] The choice of using nominal wages in the estimation of our model reflects also the need of taking Italian history and the post-World War II configuration of Italian institutions into account. In Italy, the labour market rigidity both in terms of wages and unemployment can essentially be ascribed to real wage rigidity, rather than downward nominal wage rigidity. Until 1992, the *scala mobile* mechanism (the Italian automatic wage indexation clause) kept the real purchasing power of wages unchanged, since the growth of nominal wages was roughly the same as the inflation rate. To suitably feature the extent of Italian wage rigidity, we use nominal wages, including the inflation rate, π_t, in the system. Using a nominal wage index, we expect that inflation plays a key role in explaining unemployment. As a matter of the fact, inflation has always played an important role in Italian policy practice and economic history. Although the literature on the wage curve or wage-setting in Italy is quite limited, the existing empirical evidence on the relationship between inflation, wages, unemployment and labour productivity is now clear (Chiarini & Piselli 2003). We are aware that using nominal wages without any other 'nominal' variable in levels in the system might come at some costs on the econometric side. Indeed, nominal wages might be better described as I(2) processes, while all the other variables of the system are I(1). In this paper we work under the maintained assumption that the variable $wage_t$ can be approximated as I(1)

[12]In Italian income policy, salary has been considered an 'independent variable' for many years (Sraffa 1960).

process (persistent, almost-I(2)).[13]

The five variables of our model are collected in the vector X_t=(effort_t, strike_t, un_t, $wage_t$, π_t)′ and modeled as a VAR system. After a data-oriented specification search summarized in Appendix C, we opted for a VAR model with four lags, a constant and three deterministic seasonal dummies. The deterministic seasonal dummies were included to account for residual seasonal patterns in the system. In principle, many episodes and institutional changes might have impacted the dynamics of the variables included in X_t, hence we could potentially enrich our VAR specification with a relatively large set of intervention (impulse/step) dummies in D_t associated with several historical episodes.[14] However, our preliminary analyses showed that the VAR-based results on the long run Cournot-Nash equilibrium we discuss below are substantially invariant to the inclusion of many intervention dummies.[15]

The reference VAR model is given by

$$X_t = \sum_{i=1}^{4} A_i X_{t-i} + \mu + \Phi D_t + \varepsilon_t \quad t = 1, ..., T \tag{20}$$

where A_i is a 5×5 matrix of parameters, $i = 1, 2, 3, 4$, μ is a 5×1 vector of constants, D_t is a 3×1 vector containing three centered deterministic seasonal dummies with associated coefficients in the 5×3 matrix Φ and ε_t is a 5-dimensional white noise process with covariance matrix Σ_ε.

System (20) was estimated on the period 1960.Q1-2009.Q4 (T = 196, excluding the four initial lags). The upper panel of Table 1 reports some residuals diagnostic tests on the estimated model. The diagnostic checks suggest that the specified model captures the dynamics of the five variables fairly well; even though the VAR disturbances are not Gaussian, the residuals

[13]We conducted the Local Whittle estimation on the individual time series $\Delta wage_t$, see Phillips & Shimotsu (2004), obtaining an estimated degree of integration equal to 0.76. Although this finding points towards long-memory properties in $\Delta wage_t$, it also confirms our modelling choice of treating $\Delta wage_t$ ($wage_t$) as a borderline case between I(0) (I(1)) and I(1) (I(2)). We will elaborate more on this in Appendices C and D.

[14]For instance, in 1975.Q1 the labour union requested the general agreement on wage indexation (Contingency allowance or scala mobile); on 13 March 1979 Italy entered in the European Monetary System and signed an agreement for the maintenance of a fixed exchange parity with respect to the ECU; in 1981.Q3 the separation of the Treasury from the banking system occurred; on the 14 February 1984 the Craxi government decreased the amount of the Contingency allowance by 4 percentage points, and the Contingency allowance was finally abolished on 31 July 1992 by the Amato government; on the 23 July 1993 the Ciampi government adopted the consultation model based on participation in political decisions of trade unions, employers' organizations and the government; on the 1 November 1993 the Treaty on European Union came into force in Italy, bringing to the creation of the European Central Bank and the European System of Central Banks on the 1 January 1999.

[15]Among the many robustness checks we performed, we took also into account the government's ideology (left vs. right), the electoral system (majoritarian vs. proportional system), the election date and union membership. Since these political variables do not result significant, the variables considered in our model represent the relevant political-economic environment (Castañeda 1995). Results are available upon request from the authors.

Table 1: Diagnostic tests on the estimated VAR system in Eq. (20)

Equations:	$effort_t$	$strike_t$	un_t	$wage_t$	π_t
LM-AR 1-5 test:	0.33 [0.90]	0.52 [0.76]	2.22 [0.55]	1.46 [0.21]	1.49 [0.19]
LM-Normality test:	22.30 [0.00]	50.36 [0.00]	12.12 [0.00]	10.72 [0.00]	41.91 [0.00]
System: LM-AR 1-5 vector test: 1.07 [0.30]					
System: LM-Normality vector test: 135.00 [0.00]					

Largest eigenvalues of estimated companion matrix		
Real	Imag.	Modulus
0.9987	0.0000	0.9987
0.9628	0.0335	0.9634
0.9628	-0.0335	0.9634
0.0134	0.8532	0.8533
0.0134	-0.8532	0.8533

The estimation sample is 1960.Q1-2009.Q4, including initial lags.
UPPER PANEL: LM-AR 1-5 is a Lagrange multiplier test for the null of absence of autocorrelation in the VAR disturbances against the alternative of autocorrelations up to lag order 5. LM-Normality is a Lagrange multiplier test for the null of normally distributed disturbances against the alternative of a non Gaussian distribution. P-values are reported in squared brackets.
LOWER PANEL: largest estimated roots (eigenvalues) of VAR companion matrix.

obtained from the estimated system are consistent with the occurrence of serially uncorrelated disturbances. Therefore, the choice of the variables included in our policy-game model seems to be supported by data. More details on the specification analysis of the VAR may be found in Appendix C.

To obtain indications about the persistence of the modeled time series and the data adequacy of our model, the lower panel of Table 1 reports the largest estimated roots (eigenvalues) of the VAR companion matrix. The estimated eigenvalues suggest that the system is likely to be driven by a minimum of one up to a maximum of three common stochastic trends (unit roots) and such evidence is consistent with the implications of our structural reaction functions. Indeed, under the null that the strategic interaction model summarized by Eq. (8) and Eq. (10) holds true, we would expect to find not more than three unit roots in the VAR system for $X_t = (effort_t, strike_t, un_t, wage_t, \pi_t)'$.

4.1 Equilibrium

When the VAR system (20) is driven by unit roots and the variables are cointegrated, it is useful to consider its VEC counterpart (Johansen 1995):

$$\Delta X_t = \alpha(\beta', \mu_c)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} + \sum_{j=1}^{3} \Gamma_i \Delta X_{t-i} + \mu_u + \Phi D_t + \varepsilon_t \quad t = 1, ..., T \tag{21}$$

where $\Delta X_t = X_t - X_{t-1}$, Γ_j are 5×5 matrices which depend on the original VAR parameters, and α and β are matrices of dimension $5 \times r$ of full column rank $r < 5$. Under a set of suitable identifying restrictions on β of the type $\beta = \beta_I$, the r-dimensional vector $\beta_I' X_{t-1}$ captures the steady state relationships embedded in the system, while the coefficients in the matrix α capture the short run (next-period) adjustment of the variables in ΔX_t to the equilibrium. Our strategic interaction game predicts that there should be at least two cointegrating relationships between the variables in X_t consistent with the structural equilibrium reaction functions derived in Sub-section 3.1.

The departure of the error terms from the Gaussian distribution documented in Table 1 does not preclude the use of Johansen's maximum likelihood (ML) sequential cointegration rank test for the determination of r, and the estimation of the parameters β=β_I and α, Γ_1, Γ_2, Γ_3, μ, Φ and Σ_ε, see Gonzalo (1994).

Table 2: LR trace cointegration rank test

$H_0 : r \leq j$	Trace	asym. p-value	iid-boot. p-value	wild-boot. p-value
$j = 0$	112.500	0.000	0.000	0.000
$j = 1$	64.884	0.000	0.000	0.008
$j = 2$	38.695	0.003	0.002	0.008
$j = 3$	14.558	0.068	0.163	0.158
$j = 4$	0.071	0.790	0.850	0.805

The estimation sample is 1960.Q1-2009.Q4, including initial lags. The cointegration rank test is conducted in the context of the VAR system in Eq. (20) considering the case of unrestricted constant μ. 'asym. p-value' denotes p-values computed from the asymptotic approximation of the test; 'iid-boot. p-value' and 'wild-boot. p-value' denotes p-values computed using the iid and wild bootstrap procedures discussed in Cavaliere et al. (2012).

In Table 2 we summarize the results of the LR Trace test (Johansen 1995) to determine the cointegration rank, r. The test is carried out by considering an unrestricted specification for the constant, and treating the system as integrated at most of order one (I(1)). In addition to reporting the p-values associated with the sequential LR Trace test using the asymptotic critical values, we also compute the non-parametric iid- and wild-bootstrap counterparts of the p-values, discussed in Cavaliere et al. (2012). When the tendency to over-reject the test in finite samples is corrected with the bootstrap, $r = 3$ cointegrating relationships are accepted at the 5% level of significance. The wild-bootstrap version of the cointegration rank test is robust to various forms of heteroskedasticity that might occur in the data, see Cavaliere et al. (2012). This is particularly important in light of the diagnostic analysis summarized in Appendix C, where it is shown that our data might possibly be affected by conditional heteroskedasticity. We further observe that with r=4, it would be difficult to identify two 'additional' equilibria other the two predicted by our strategic policy model. We thus condition our subsequent empirical analysis on the choice $r = 3$. With $r = 3$, the quantity $\beta' X_{t-1}$ in Eq. (21) is a 3-dimensional vector and the parameters in β need to be identified, i.e. β must fulfill the restriction $\beta = \beta_I$, where β_I matches the conditions discussed in Johansen (1995). This entails identifying an 'extra' long run relationship other than the equilibrium reaction functions implied by Eq. (8) and Eq. (10). In addition, $\mu_c = (\beta_g^0, \beta_l^0, \beta_\pi^0)'$ is the portion of the constant we force to enter the cointegration relationships.

The first column of the matrix β_I, $\beta_{I,1}$, identifies the beta coefficients of the long run government's reaction function, i.e. the quantity $v_{e,t-1} = \beta'_{I,1} X_{t-1} + \beta_g^0 = \mathit{effort}_{t-1} + \beta_g^0 + \beta_g^u un_{t-1} + \beta_g^s strike_{t-1}$ captures the deviation of the observed effort, effort_{t-1}, from its long run equilibrium level as implied by Eq. (8). The second column of the matrix β_I, $\beta_{I,2}$, identifies the beta coefficients of the long run labour union's reaction function, i.e. $v_{s,t-1} = \beta'_{I,2} X_{t-1} + \beta_l^0 = strike_{t-1} + \beta_l^0 + \beta_l^w wage_{t-1} + \beta_l^e \mathit{effort}_{t-1}$ captures the deviation of the observed strike, $strike_{t-1}$, from its long run equilibrium level as implied by Eq. (10). Finally, the third column of the matrix β_I, $\beta_{I,3}$, is left just-identified and is given by $v_{\pi,t-1} = \beta'_{I,3} X_{t-1} + \beta_\pi^0 = \pi_{t-1} + \beta_\pi^0 + \beta_\pi^u un_{t-1} + \beta_\pi^w wage_{t-1}$; this relationship features the inflation rate, the unemployment rate and the wage index and it will be discussed in detail below. Overall, the simultaneous system of equations given by

$$(\beta'_I, \mu_c) \begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} = v_{t-1} \tag{22}$$

where $v_{t-1} = (v_{e,t-1}, v_{s,t-1}, v_{\pi,t-1})'$, is exactly identified if a no additional restriction is placed on β_I.

The estimated identified long run relationships are given by

$$(\hat{\beta}'_I, \hat{\mu}_c)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} = \begin{cases} \hat{\beta}'_{I,1}X_{t-1} + \hat{\beta}^0_g \\ \hat{\beta}'_{I,2}X_{t-1} + \hat{\beta}^0_l \\ \hat{\beta}'_{I,3}X_{t-1} + \hat{\beta}^0_\pi \end{cases} = \begin{cases} \mathit{effort}_{t-1} + \underset{(0.045)}{0.183}\mathit{strike}_{t-1} + \underset{(0.529)}{2.180}un_{t-1} - 0.117 \\ \mathit{strike}_{t-1} - \underset{(0.731)}{2.260}\mathit{effort}_{t-1} + \underset{(0.118)}{0.972}wage_{t-1} - 0.396 \\ \pi_{t-1} + \underset{(0.089)}{0.089}un_{t-1} + \underset{(0.009)}{0.027}wage_{t-1} - 0.016 \end{cases} \tag{23}$$

and are also reported in the left panel of Table 3, along with the adjustment coefficients α. The estimation of α and β_I was carried out by ML. The LR test reported in the bottom part of the left panel of Table 3 is a joint test for the restrictions on β_I and α matrix and can be regarded as a statistical test for the overall specification. In particular, the estimated magnitude and sign of the parameters of the long run relationships support the structure of our policy-game model.

The first two long run relationships are the estimated government and labour union reaction functions. Before discussing their estimated coefficients, it is worth returning on our orthogonality assumption through which the organization of employers has been marginalized out from the policy-game. Although the proxy we have used for strikes is a measure of 'general strikes', the results in the left panel of Table 3 suggest that the possible effects of the strikes directed against the organization of employers are conveyed in the cointegration residual, $\hat{v}_{s,t-1} = \mathit{strike}_{t-1} + \hat{\beta}^0_l + \hat{\beta}^w_l wage_{t-1} + \hat{\beta}^e_l \mathit{effort}_{t-1}$, which captures the transitory part of strike_t not explained by our theoretical model. It follows that the long run properties of the time series we have used for $\ln s$ are well captured by our strategic interaction model, while all other factors that influence its dynamics have only transitory effects. This evidence indirectly supports one of the crucial assumptions of our model.

The $\hat{\beta}_I$ coefficients in the left panel of Table 3 capture the slopes of the reaction functions: for an increase in strike (amount of hours not worked) of 1 hour per quarter per capita, the best responsive effort (government budget surplus) decreases by 0.183% in terms of GDP; for an increase in effort of 1% in terms of GDP the best responsive strike increases by 2.260 hours

Table 3: Estimated cointegration relationships and adjustment coefficients

Estimated β_I for fixed cointegration rank $r = 3$

$$\begin{pmatrix} \hat{\beta}_I \\ \hat{\mu}_c' \end{pmatrix} = \begin{pmatrix} 1 & \underset{(0.731)}{-2.260} & 0 \\ \underset{(0.045)}{0.183} & 1 & 0 \\ \underset{(0.529)}{2.180} & 0 & \underset{(0.089)}{0.089} \\ 0 & \underset{(0.118)}{0.972} & \underset{(0.009)}{0.027} \\ 0 & 0 & 1 \\ -0.117 & -0.396 & -0.016 \end{pmatrix}$$

Additional restriction on β_I

$$\begin{pmatrix} \hat{\beta}_I \\ \hat{\mu}_c' \end{pmatrix} = \begin{pmatrix} 1 & \underset{(0.970)}{-4.830} & 0 \\ \underset{(0.039)}{0.178} & 1 & 0 \\ \underset{(0.460)}{2.118} & 0 & \underset{(0.075)}{0.344} \\ 0 & \underset{(0.169)}{0.892} & 0 \\ 0 & 0 & 1 \\ -0.118 & -0.442 & -0.031 \end{pmatrix}$$

Estimated adjustment coefficients α for $r = 3$

	$v_{e,t-1}$	$v_{s,t-1}$	$v_{\pi,t-1}$		$v_{e,t-1}$	$v_{s,t-1}$	$v_{\pi,t-1}$
$\Delta effort_t$	0	0	0	$\Delta effort_t$	0	0	0
$\Delta strike_t$	-0.822 (0.347)	-0.502 (0.093)	3.414 (1.898)	$\Delta strike_t$	-1.511 (0.350)	-0.374 (0.070)	4.221 (1.711)
Δun_t	-0.016 (0.004)	0	0	Δun_t	-0.016 (0.004)	0	0
$\Delta wage_t$	0	0	0.088 (0.020)	$\Delta wage_t$	0	0	0.070 (0.018)
$\Delta \pi_t$	-0.030 (0.012)	0.011 (0.003)	-0.203 (0.067)	$\Delta \pi_t$	-0.014 (0.012)	0.009 (0.003)	-0.167 (0.061)
LR test of restrictions $\chi^2(7) = 4.791$ [0.686]				LR test of restrictions $\chi^2(8) = 10.604$ [0.225]			

The estimation sample is 1960.Q1-2009.Q4, including initial lags. The only difference between the left and right panel is that the right panel incorporates the restriction $\beta_\pi^w = 0$ in the third cointegration vector. UPPER PANEL: estimated cointegration relationships. LOWER PANEL: estimated adjustment coefficients. The LR test is a likelihood ratio test for the zero restrictions in the α matrix. Standard errors in parentheses; p-values in squared brackets.

per quarter per capita.

The third estimated cointegration vector in Eq. (23) and the left panel of Table 3, needs some explanations because, as already explained, we have used nominal wages along with the inflation rate to account for the specific institutional features at work in the Italian economy over a large portion of the estimation period. A reasonable concern in this case is how the trending/growing wage variable is supposed to be balanced with the inflation rate and unemployment in this just-identified cointegration vector.[16] We have re-estimated the three cointegration vectors by imposing the additional constraint $\beta_\pi^w = 0$ in the third cointegration vector, namely we have suppressed the nominal wage variable. The results are reported in the right panel of Table 3. In this case, we obtain a statistically significant inverse relationship between π_t and un_t in the

[16]The estimated coefficient associated with the unemployment rate, β_π^u has a t-ratio equal to 1, hence one might be erroneously tempted to observe that our third cointegration vector actually reflects the stationarity of the inflation rate.

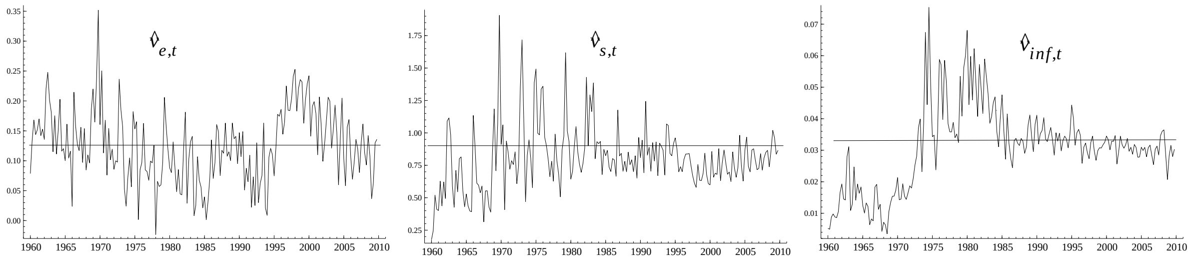

Figure 2: Estimated error correction terms

third cointegration vector, which can be roughly interpreted, with qualifications, as statistical Phillips curve-type relationships. The LR test for the joint set of restrictions on β_I and α does not imply rejection at the 5% level of significance (the p-value is equal to 0.225). As concerns the first two cointegration relationships, the magnitude and sign of the estimated parameters does not change substantially.[17] Recalling that the objective of our analysis is not the estimation of a Phillips curve of the Italian economy but the Cournot-Nash equilibrium implied by the strategic game between the government and the union, we develop our empirical investigation by considering the first two long run equilibria iin Eq. (23) fully consistent with the mechanics of our strategic interaction game. Moreover, the rest of our empirical analysis is carried out by leaving the third cointegration vector unrestricted as in Eq. (23), recalling that it features a meaningful structural interpretation under the additional constraint $\beta_\pi^w = 0$.

Figure 2 plots the cointegration residuals $\hat{v}_{e,t}, \hat{v}_{s,t}$ and $\hat{v}_{\pi,t}$ implied by Eq. (23). The two error correction terms of interest, $\hat{v}_{e,t}$ and $\hat{v}_{s,t}$, are surprisingly stable over the investigated period.

Table 4 summarizes the estimates of the strategic interaction model's elasticities derived in Eq.s (16)-(19). First of all, we observe that by replacing the theoretical parameters with their super-consistent point estimates, the stability condition for the equilibrium is verified with our data. Furthermore, the estimated equilibrium elasticities are in line with the predictions of the theoretical model. At equilibrium, the effect of an increase in unemployment and wages is mainly negative on the level of the control variables of the government and the labour union.

[17]It could be argued that the magnitude of the estimated parameter β_l^e from Table 3 is twice (right panel) as much compared to the case in which the restriction $\beta_\pi^w = 0$ on nominal wages is not imposed (left panel). However, if we impose e.g. the additional restriction $\beta_l^e = -2.3$ (this value is close to the estimate $\hat{\beta}_l^e = -2.260$ obtained in the right panel of Table 3), and re-estimate the cointegration relationships, the LR test for the joint set of restrictions on β_I and α has a p-value equal to 0.208, and the magnitude and sign of all other coefficients remains substantially unchanged. The results are available upon request to the authors.

Table 4: Cournot-Nash equilibrium properties

Estimated stability condition in Eq. (14)	
Theoretical	Estimated
$\lvert\beta_g^s\rvert < \left\lvert\frac{1}{\beta_l^e}\right\rvert$	$\lvert\hat{\beta}_g^s\rvert = 0.183 < \left\lvert\frac{1}{\hat{\beta}_l^e}\right\rvert = 0.442$

ML estimates of the elasticities in Eq.s (16)-(19)	
Theoretical	Estimated
$E_{e^*,u} = \frac{-\beta_g^u}{1-\beta_g^s\beta_l^e}$	$\hat{E}_{e^*,u} = \frac{-\hat{\beta}_g^u}{1-\hat{\beta}_g^s\hat{\beta}_l^e} = \underset{(0.391)}{-1.542}$
$E_{s^*,u} = \frac{\beta_g^u\beta_l^e}{1-\beta_g^s\beta_l^e}$	$\hat{E}_{s^*,u} = \frac{\hat{\beta}_g^u\hat{\beta}_l^e}{1-\hat{\beta}_g^s\hat{\beta}_l^e} = \underset{(0.887)}{-3.485}$
$E_{e^*,w} = \frac{\beta_l^w\beta_g^s}{1-\beta_g^s\beta_l^e}$	$\hat{E}_{e^*,w} = \frac{\hat{\beta}_l^w\hat{\beta}_g^s}{1-\hat{\beta}_g^s\hat{\beta}_l^e} = \underset{(0.027)}{0.126}$
$E_{s^*,w} = \frac{-\beta_l^w}{1-\beta_g^s\beta_l^e}$	$\hat{E}_{s^*,w} = \frac{-\hat{\beta}_l^w}{1-\hat{\beta}_g^s\hat{\beta}_l^e} = \underset{(0.097)}{-0.688}$

The estimation sample is 1960.Q1-2009.Q4, including initial lags. Standard errors in parentheses.

The estimated elasticity (positive but small in magnitude) implies that the long run effort has mildly increased, along with the historical increase in wages. Regarding the magnitude of the elasticities, we note that changes in unemployment have stronger effects than changes in wages, and that strikes are affected more than effort at the long run equilibrium. In order to interpret the effort elasticities, we can assume that (i) an increase in structural (long-term) unemployment corresponds to a leftward shift of the AS curve, and (ii) an increase in long-term wages, associated with an increase in productivity, corresponds to a rightward shift of the AS curve. Regarding (i), the higher the unemployment the lower the GDP. Given the estimated negative elasticity $\hat{E}_{e^*,u}$ and knowing that effort is roughly equal to government budget surplus over GDP, the decrease in GDP has to be less than proportional to the decrease in the surplus. With respect to (ii), the lower the wages the lower the GDP. Given the estimated positive elasticity $\hat{E}_{e^*,w}$, the decrease in GDP has to be less than proportional to the decrease in the surplus. Both these results are in line with the Keynesian fiscal policy implemented in Italy in the last half century. The estimated strike elasticities testify the historical long run decrease in strikes and increase in unemployment and wages.

4.2 Adjustment dynamics

The parameters in the matrix α of the VEC in Eq. (21) are short run adjustment coefficients and capture the next-period (next-quarter in our case) responses of the variables in ΔX_t to lagged disequilibria v_{t-1} (i.e. to lagged deviations of effort and strike from their cointegration levels).

The estimated αs reported in the lower panel of Table 3 suggest that the government does not adjust in the short run to any of the identified long run relationships, while the labour union adjusts significantly to the error correction terms associated with the two estimated reaction functions, in addition to the error correction term involving the statistical Phillips curve-type relationship. More precisely, there is no error-correction mechanism at work in the $\Delta effort_t$-equation, meaning that $effort_t$ is 'weakly exogenous' with respect to the identified β_I (Hendry 1995). These results indicate, with some qualifications, that $effort_t$ acts as the stochastic (common) trend driving the sub-system formed by $effort_t$ and $strike_t$, while the labour union acts as the 'buffer' for the adjustment process, in the sense that $strike_t$ is the variable which corrects, quarter-by-quarter, the dynamic path of adjustment such that deviations from the two cointegrating reaction functions do not drift too far apart. It turns out that the labour union's strike policy is influenced by the government's effort not only in the long run, as suggested by Eq. (10) and its estimated counterpart in Eq. (23), but over shorter horizons as well. Note that, strike policy is also affected by the deviations of inflation from its long run equilibrium level (third long run relationship): in negotiating nominal wages, the labour union takes inflation into account.

The detected lack of adjustment of $\Delta effort_t$ to $\hat{v}_{e,t-1}$, $\hat{v}_{s,t-1}$ (and $\hat{v}_{\pi,t-1}$) does not necessarily mean that the government makes no adjustments to the labour union's actions, and neither does the fact that $effort_t$ is weakly exogenous with respect to the cointegration parameters necessarily mean that the variable controlled by the labour union, $strike_t$, is the variable which adjusts faster to the equilibrium. Indeed, since the dynamics of our estimated VEC are relatively rich and involves the parameters in the matrices Γ_1, Γ_2 and Γ_3 other than the parameters in α, it may be the case that the terms $\hat{v}_{e,t-1}$, $\hat{v}_{s,t-1}$ (and possibly $\hat{v}_{\pi,t-1}$) produce their effect on $\Delta effort_t$ (and hence on the variable in level, $effort_t$) over longer horizons (under a *ceteris paribus* condition). In order to fully understand the nature of the adjustment process towards equilibrium underlying our estimated model, it is necessary to disentangle the concepts of 'short run' and and 'long run' adjustment. The short run adjustment depends on the elements of the matrix α, while the long run adjustment depends on all parameters α, Γ_1, Γ_2 and Γ_3, see Fanelli & Paruolo (2010). The distinction between these two concepts is important in our framework because the player with a faster 'reaction time' is not necessarily the player who adjusts faster to the long run equilibrium.

Following Fanelli & Paruolo (2010), we define the speed of long run adjustment of $effort_t$ ($strike_t$) to a unit perturbation in $\hat{v}_{e,t-1}$ ($\hat{v}_{s,t-1}$), as the number of quarters employed by $effort_t$ ($strike_t$) to complete a portion λ ($0 < \lambda < 1$) of the adjustment path towards its long run position; the 'long run position' is the long run impact of $\hat{v}_{e,t-1}$ ($\hat{v}_{s,t-1}$) on $effort_t$ ($strike_t$), i.e. the long run -or total- multiplier. Obviously, if there is no significant long run impact of $\hat{v}_{e,t-1}$ ($\hat{v}_{s,t-1}$) on $effort_t$ ($strike_t$), it does not make sense to measure the speed of adjustment.

Table 5: Estimated speed of long run adjustment (quarters) with 90% confidence intervals

Speed of adjustment of	$effort_t$	$strike_t$
to perturbation to $\hat{\beta}'_{I,1}X_{t-1} + \hat{\beta}^0_g = \hat{v}_{e,t-1}$	2 (1,23)	*
to perturbation to $\hat{\beta}'_{I,2}X_{t-1} + \hat{\beta}^0_l = \hat{v}_{s,t-1}$	*	13 (1,38)

The estimation sample is 1960.Q1-2009.Q4, including initial lags. $\hat{v}_{e,t-1}$ and $\hat{v}_{s,t-1}$ are defined in Eq. (22) of the paper. The reported measures of speed of long run adjustment correspond to the long run λ-lives (obtained with $\lambda = 0.5$) introduced in Fanelli & Paruolo (2010). 90% confidence intervals in parentheses are computed by a non-parametric bootstrap procedure based on M=100 replications. The symbol '*' means that there is no significant long run response of the variable to the perturbation at the 5% level of significance, hence it does not make sense investigating the speed of adjustment.

Table 5 shows the estimated speeds of the long run adjustment stemming from our VEC system, obtained with $\lambda = 0.5$ (half-life), along with 90% confidence intervals. We have computed not only the speed of long run adjustment of $effort_t$ ($strike_t$) to a perturbation in $\hat{v}_{e,t-1}$ ($\hat{v}_{s,t-1}$), but also speeds of 'cross-long run adjustment', i.e. the speeds of long run adjustment of $effort_t$ ($strike_t$) to perturbations in $\hat{v}_{s,t-1}$ ($\hat{v}_{e,t-1}$). Table 5 highlights some interesting facts. First, while we find significant long run adjustment of $effort_t$ ($strike_t$) to perturbations in $\hat{v}_{e,t-1}$ ($\hat{v}_{s,t-1}$) we do not find any significant 'cross-long run adjustment', i.e. both the government and the labour union do not seem to be influenced, in the long run, by the cointegrating relationships characterizing the behaviour of the other player. Although, in the short run we detect a strong adjustment of the labour union's strike to all identified cointegrating relationships and a complete lack of adjustment of the government's effort to any identified cointegration relationship. Second, the comparison of the estimated speeds reveals that the speed of long run adjustment of effort_t to $\hat{v}_{e,t-1}$ is given by 2 quarters (point estimate) and can reach a maximum of 23 quarters according to the upper bound of its 90% confidence set, as opposed to the speed of long run adjustment of $strike_t$ to $\hat{v}_{s,t-1}$, which is given by 13 quarters (point estimate) and can reach up to a maximum of 38 quarters according to the upper bound of its 90% confidence set.

Combining these results with the estimated αs in Table 3, we conclude that, although the player responsible for $strike_t$ has a faster reaction time, the other player has a higher speed of long run adjustment, since effort_t is the variable which adjusts faster to the long run equilibrium. These results highlight that fiscal and strike policies have different effectiveness over long horizons: even though the labour union uses strike policy 'actively', the efficacy of fiscal policy is comparatively stronger because of the detected capability of the government to reach its goals faster than the labour union.

In addition, the estimated structure of adjustment to equilibrium reveals that (i) the labour union uses strike policy more actively than the government uses fiscal policy, (ii), the efficacy of fiscal policy is comparatively stronger than strike policy, since the detected capability of the government to reach its goal is faster than the labour union.

Finally, it is worth observing that the estimated α parameters in Table 3 reveal additional interesting facts. We notice that the acceleration rate, $\Delta\pi_t$, adjusts not only to $\hat{v}_{\pi,t-1}$, as expected, but to both the estimated disequilibria $\hat{v}_{e,t-1}$ and $\hat{v}_{s,t-1}$ as well, suggesting that the strategic interaction between the government and the labour union plays a unique role in explaining Italian inflation dynamics over the last fifty years.

4.3 Phase diagram representation

In this sub-section, using phase diagrams we provide an interpretation for the long run and adjustment features of our estimated strategic interaction game.

Eq.s (24) - (25) below correspond to the equations of the VEC system (21) associated with the government's control variable (effort) and the labour union's control variable (strike), respectively, i.e.

$$\begin{aligned}\Delta effort_t = \ & \alpha_e^g(effort_{t-1} - \ln e_{t-1}^C) + \alpha_e^l(strike_{t-1} - \ln s_{t-1}^C) \\ & + f_e(v_{\pi,t-1}; \Delta X_{t-1}, \Delta X_{t-2}, \Delta X_{t-3}; \Gamma_1, \Gamma_2, \Gamma_3) + \varepsilon_t^{effort}\end{aligned} \tag{24}$$

$$\begin{aligned}\Delta strike_t = \ & \alpha_s^g(effort_{t-1} - \ln e_{t-1}^C) + \alpha_s^l(strike_{t-1} - \ln s_{t-1}^C) \\ & + f_s\left(v_{\pi,t-1}; \Delta X_{t-1}, \Delta X_{t-2}, \Delta X_{t-3}; \Gamma_1, \Gamma_2, \Gamma_3\right) + \varepsilon_t^{strike}\end{aligned} \tag{25}$$

In both equations we have emphasized the two error correction terms of interest, $v_{e,t-1} = effort_{t-1} - \ln e_{t-1}^C$ and $v_{s,t-1} = strike_{t-1} - \ln s_{t-1}^C$. All remaining components not directly related to the adjustment coefficients α_e^g, α_e^l, α_s^g and α_s^l have been confined to the terms $f_e(.)$ and $f_s(.)$, and the equation-specific disturbances are ε_t^{effort} and ε_t^{strike}.

To isolate the strategic interaction between the government and the labour union, we partial out $f_e(.)$, $f_s(.)$, ε_t^{effort}, and ε_t^{srike}, putting these terms equal to zero in Eq.s (24) - (25). We impose the conditions $\Delta effort_t = 0$ and $\Delta strike_t = 0$, obtaining the *loci* in which the short run adjustments, for both $effort_{t-1}$ and $strike_{t-1}$, are null. By solving Eq.s (24) - (25) for $effort_{t-1}$ under the above conditions, we obtain the relationships

$$effort_{t-1} = \frac{-\alpha_e^g\left(\beta_g^0 + \beta_g^u un_{t-1} + \beta_g^s strike_{t-1}\right) - \alpha_e^l\left(strike_{t-1} + \beta_l^0 + \beta_l^w wage_{t-1}\right)}{\alpha_e^g + \alpha_e^l \beta_l^e} \tag{26}$$

$$effort_{t-1} = \frac{-\alpha_s^g\left(\beta_g^0 + \beta_g^u un_{t-1} + \beta_g^s strike_{t-1}\right) - \alpha_s^l\left(strike_{t-1} + \beta_l^0 + \beta_l^w wage_{t-1}\right)}{\alpha_s^g + \alpha_s^l \beta_l^e} \tag{27}$$

Appendix E illustrates a generic representation of the cointegrating relationships of a VEC system (interpreted as reaction functions) and the *loci* in which the short run adjustments are null (the strategic interaction between players being isolated), as made shown in Eq.s (26) and (27). Once we use the estimated parameters of our model, this generic representation specializes under some additional hypotheses. The phase diagram plotted in Figure 3 has been obtained by setting the parameters α_e^g, α_e^l, α_s^g, α_s^l, β_g^u, β_g^s, β_l^w and β_l^e in Eq.s (26)-(27) to their ML estimates presented in Table 3, and fixing un_{t-1} and $wage_{t-1}$ at their sample averages. The intercepts β_g^0 and β_l^0, instead, have been 'residually' calculated consistent with the following hypotheses: (i) since industrial conflict is costly, we assume that in the long run agents are rational and well-informed such that, following Hicks (1932), labour unions will not use strikes as instruments

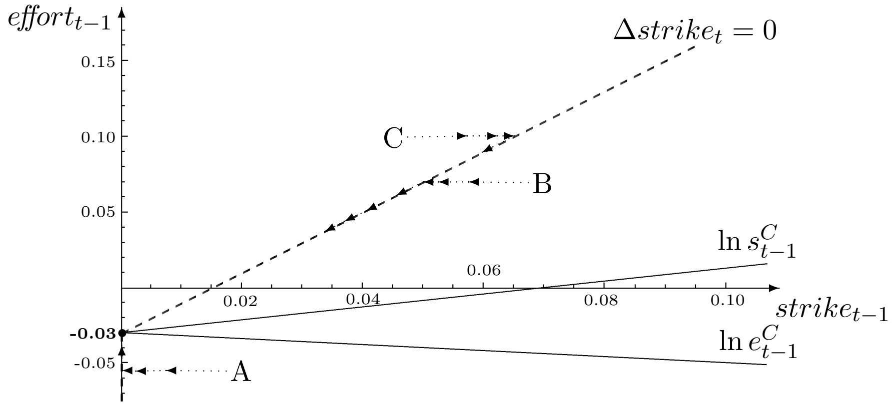

Figure 3: Estimated phase diagram for Italy under hypotheses (i) and (ii) in the text

of conflict resolution; (ii) since the Maastricht Treaty and the Stability and Growth Pact are in effect in Italy, we consider the Italian institutional constraints on fiscal policy in the long run, in particular a value of the deficit-to-GDP ratio equal to 3%. Based on (i) and (ii), Figure 3 plots the 'ideal' long run equilibrium for the Italian economy centered at $strike_{t-1} = 0$ and $effort_{t-1} = -0.03$.

As a conceptual experiment, we isolate the dynamics driven only by the deviations from the equilibrium reaction functions. Setting $f_e(.)$, $f_s(.)$, ε_t^{effort} and ε_t^{srike} equal to zero in Eq.s (24) - (25), we describe the adjustment process that emerges starting from the points A, B and C plotted in Figure 3. Since in our framework α_e^g and α_e^l are not significant (see Table 3), we expect an initial adjustment driven by strike. Once attained the locus of $\Delta strike_t = 0$, we expect a slow convergence to the long run equilibrium. Obviously, the farther a point from the locus, the stronger the push towards it (the VEC is stable by construction, hence the point will always be pushed towards the steady state). Finally, since strikes cannot be negative, the adjustment from the point A is bounded by the vertical axis.

5 Conclusions

In this paper, we have presented a novel approach to model the strategic interaction between governments and labour unions in unionized economies. Our contribution focuses on strikes, government budget, unemployment, wages and inflation interdependencies. It helps to explain how government's fiscal policy is implemented in the long run relative to labour unions' strike policy and vice versa.

Using time series methods, we have shown that the proposed policy-game model is based on sound empirical support. Our results are in line with a Keynesian fiscal policy implemented in Italy in the last half century, and are consistent with the Franzosi (2006)'s idea that a government's partisanship and fiscal policy affect union behavior and strikes: it takes two to tango. At equilibrium, the effect of a rise in unemployment on the level of effort and strike is negative, while the effect of a rise in wages on the level of effort and strike is respectively positive and negative. Since the Maastricht Treaty and the Stability and Growth Pact effectiveness imply a higher government's effort for Italy, our model predicts that this equilibrium's sustainability depends on both an increase in wages and a decrease in unemployment. The predicted effect on the level of strikes is ambiguous. Future research could test whether similar conclusions are also true for other European countries with or without the same Italian fiscal stability constraints and a dynamic game could be modelled with additional players (e.g. firms and central bank) to carry out an in depth study on the dynamic adjustment of macroeconomic variables.

A Italian institutional configuration

Italian industrial relationships have been marked by important political participation of the three biggest labour union confederations (CGIL, CISL and UIL) that cover almost all employees. In 2009, total CGIL members (including retirees) were 5,656,155, while analogous figure for CISL and UIL were respectively 4,531,040 and 2,164,276. There is a fourth confederation (UGL) but official data are not available for its members.[18] Despite their ideological divisions, when the labour unions negotiated economic and social policy issues with the governments, their differences were vague and confederations often cooperated with each other. Italian labour unions and Leftist parties have historical similar political positions as both pursue the interests of workers. However, while labour unions have fought for higher wages, left-wing parties have

[18] These big confederations are differentiated according to their political ideology: CGIL adheres to communist ideology, CISL to catholic ideals and UIL to socialist ideology. From the political point of view, and until the early 90s, CGIL was contiguous to the Communist Party (PCI), CISL to the Catholic Party (DC), and UIL to the Socialist Party (PSI). DC ruled for all terms from 1948 until 1994. In this period, PCI was always in opposition and PSI was in office with DC for several terms. In 1994, the electoral system turned from proportional representation to majority system and led to the disappearance of the traditional parties (PCI, PSI and DC) and the emergence of new Right (PDL) and Left parties (PD). The new Right party was in government in 1994 and ruled from 2001 to 2006 and from 2008 to 2011. The new Left party governed from 1996 to 2001 and from 2006 to 2008.

mainly sought to reduce the unemployment rate. The income policy model known as 'consultation', was applied in Italy in the early '90s to reduce the inflation rate and, indirectly, the interest rates. Thus, labour unions have been able to negotiate directly with governments using strikes as weapon of negotiation (strikes), while left-wing parties have been able to reduce the unemployment rate affecting fiscal policy (political cooperation or 'consociationalism').

The high Italian debt originated from the fiscal policy set out in the 1970s and 1980s. During this period, characterized by the oil crises of the 1970s and the first slowdown in economic growth after the economic boom of the 1960s, the Italian government implemented expansionary policies via a continuous increase in public spending (deficit spending) to support the economic growth and to satisfy the claims of the workers (welfare state).

B Data

We base our empirical analysis on a hand-collected dataset comprising quarterly macroeconomic time series relative to the Italian economy. The data cover the period 1960.Q1-2009.Q4. Some descriptive statistics are presented in Table B.1. The five variables in Table B.1 are obtained as follows (subscript t denotes quarter):

- $effort_t = \ln\left(1 + \frac{S_t}{GDP_t}\right)$, where $S_t = -\Delta B_t$ is minus the deficit (source: Bank of Italy) and GDP_t is the seasonally adjusted Gross Domestic Product (source: OECD);
- $strike_t = \ln\left(1 + \frac{H_t}{POP_t}\right)$, where H_t is the amount of hours not worked due to labour disputes arising from the labour contract (source: Italian National Institute of Statistics) and POP_t is the active population aged 15-64 (source: OECD);
- $un_t = \ln\left(1 + \frac{U_t}{LF_t}\right)$, where U_t are the unemployed workers, LF_t is the labour force and $\frac{U_t}{LF_t}$ is the seasonally adjusted unemployment rate (source: OECD);
- $wage_t = \ln\left(1 + W_t^{06}\right)$, where W_t^{06} is the hourly wage index of the manufacturing sector relative to its basis equal to 100 in the quarter 2006.Q1 (source: Italian National Institute of Statistics);
- $\pi_t = \ln\left(1 + \Delta P_t\right)$, where P_t is the Harmonised Index of Consumer Prices (source: Italian National Institute of Statistics).

Table B.1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
effort	-0.077	0.056	-0.214	0.031
strike	0.305	0.321	0.007	1.751
un	0.068	0.025	0.026	0.108
wage	0.336	0.264	0.013	0.761
π	0.016	0.014	-0.005	0.070

Number of observations: 200

C VAR specification analysis

In this appendix, we summarize the specification analysis which lead us to the estimation in Section 4 of the VAR model (20) for X_t=($effort_t$, $strike_t$, un_t, $wage_t$, π_t)$'$ with four lags. We selected the optimal number of VAR lags by combining standard information criteria with some residuals diagnostic tests. Results are reported in Table C.1, where we consider VAR systems with 1 up to 5 lags. The first three columns of Table C.1 reports the Akaike information criterion (AIC), the Hannan-Quinn information criterion (HQ) and the Schwartz information criterion (SC). The last two columns sketch the Lagrange multiplier vector test for the null of uncorrelated VAR disturbances against the alternative of correlation up to 5 lags (LM-AR 1-5), and the Lagrange multiplier vector test for the null of Gaussian disturbances (LM-Normality), respectively. See e.g. Hendry (1995) for details about the information criteria and diagnostic tests in Table C.1.

Table C.1: Lag determination and diagnostic checks on the estimated VAR system

lags	AIC	HQ	SC	LM-AR 1-5	LM-Normality
1	-29.8641	-29.5627	-29.1194*	2.61 [0.00]	134.4 [0.00]
2	-30.0860	-29.6154	-28.9235	1.95 [0.00]	148.4 [0.00]
3	-30.1729	-29.5319	-28.5896	1.69 [0.00]	129.4 [0.00]
4	-30.4420*	-29.6295*	-28.4350	1.07 [0.30]	135.0 [0.00]
5	-30.3440	-29.3585	-27.9102	1.25 [0.048]	117.6 [0.00]

The estimation sample is 1960.Q1-2009.Q3, including initial lags. AIC is the Akaike information criterion; HQ is the Hannan-Quinn information criterion; SC is the Schwartz information criterion. LM-AR 1-5 is a Lagrange multiplier vector test for the null of absence of autocorrelation in the VAR disturbances against the alternative of autocorrelations up to lag order 5. LM-Normality is a Lagrange multiplier vector test for the null of normally distributed disturbances against the alternative of a non Gaussian distribution. P-values are reported in squared brackets.

Table C.1 shows that the the Akaike and Hannan-Quinn criteria select 4 lags, while the

Schwartz criterion selects 1 lag. The LM-AR 1-5 test suggests that only in the VAR with 4 lags the disturbances are serially uncorrelated at the 5% level of significance. The absence of serial correlations in the VAR disturbances is a key necessary condition to rule out the case of omitted factors/variables from the estimated model. For this reason, we decided to conduct our empirical investigations with the VAR with four lags. Detailed diagnostic tests on this VAR are sketched in the last two columns of Table 1. This table shows that for all lags considered, the null of Gaussian VAR disturbances is strongly rejected.[19] As remarked in Sub-section 4.1, mild deviations from normality are not a major obstacle to the empirical investigations we have conducted in the paper (Gonzalo 1994).

Table C.2: Diagnostic tests on the estimated VAR system

Equations:	$\hat{v}_{e,t}$	$\hat{v}_{s,t}$	$\hat{v}_{\pi,t}$	$\Delta wage_t$	$\Delta\pi_t$
LM-AR 1-5 test:	0.51	0.83	1.29	1.27	1.44
	[0.77]	[0.53]	[0.27]	[0.28]	[0.21]
LM-Normality test:	2.72	19.24	39.02	10.44	40.00
	[0.25]	[0.00]	[0.00]	[0.00]	[0.00]
System:	LM-AR 1-5 vector test:			1.06	
				[0.32]	
System:	LM-Normality vector test:			57.6	
				[0.00]	

The estimation sample is 1960.Q1-2009.Q4, including initial lags. LM-AR 1-5 is a Lagrange multiplier test for the null of absence of autocorrelation in the VAR disturbances against the alternative of autocorrelations up to lag order 5. LM-Normality is a Lagrange multiplier test for the null of normally distributed disturbances against the alternative of a non Gaussian distribution. P-values are reported in squared brackets.

We conclude this appendix by reporting in Table C.2 some diagnostic tests relative to the transformed VAR model $Y_t = (\hat{v}_{e,t}, \hat{v}_{s,t}, \hat{v}_{\pi,t}, \Delta wage_t, \Delta\pi_t)'$ we have used to check for the absence of I(2) components from the estimated model, see Sub-section 4.1. Recall that the transformed model was obtained as re-parametrization of the VEC in Eq. (21), replacing β_I with the cointegration relationships $\hat{\beta}_I$ estimated in Table 3. The results in Table C.2 point out that the specified model captures the dynamics of the system fairly well. We have thus provided another piece of (indirect) evidence, along with the cointegration rank test in Table D.1, against the case of omitted I(2) components.

[19] Further investigations, not reported here to save space, show that the variables $strike_t$, un_t, $wage_t$ and π_t are affected by Autoregressive Conditional Heteroskedasticity (ARCH)-type effects (Engle 1982), which probably lead to the rejection of the hypothesis of Gaussian disturbances.

D I(1) approximation analysis

We are fully aware that modeling nominal wages and the inflation rate as I(1) processes leads to a paradox: since the price level is I(2), real wages, obtained as the difference between (log) nominal wages and the (log) price level, must be also I(2). However, as we explain throughout the paper, we work under the following approximation: the price level is treated as an I(2) process but is assumed to have persistence 'close' to the persistence of I(1) processes; in turn, nominal wages are treated as I(1) but are assumed to have persistence 'close' to the persistence of I(2) processes (Juselius 2014). This allows us to claim that real wages can be roughly approximated as I(1) in our setup.

If X_t were I(2), the empirical analysis we have developed so far under the maintained I(1) assumption would be flawed by an omitted variables-type issue, see e.g. Kongsted & Nielsen (2004) and Kongsted (2005). Given the three estimated cointegration relationships reported in Table 3, we define the transformed vector $Y_t = (\hat{v}_{e,t}, \hat{v}_{s,t}, \hat{v}_{\pi,t}, \Delta wage_t, \Delta\pi_t)'$ as a re-parametrization of the estimated VEC, obtained by replacing β_I with the $\hat{\beta}_I$ in the left panel of Table 3, see e.g. Paruolo (2003).[20] By estimating this transformed VAR on the period 1960.Q1-2009.Q4, we find that the largest eigenvalue of the companion matrix is equal to 0.85 when we impose the zero constraints on the not significant VAR coefficients. Stationarity of Y_t, albeit marginally, is confirmed by the results of the LR Trace test for cointegration rank applied to the VAR system for Y_t, reported in Table D.1. Combined with the evidence reported in Footnote 13, these findings suggest that our approximation does not lead to serious misspecification issues.

Table D.1: LR Trace cointegration rank test applied to the transformed VAR for Y_t

$H_0 : r \leq j$	Trace	asym. p-value
$j = 0$	124.97	0.000
$j = 1$	80.24	0.000
$j = 2$	43.60	0.001
$j = 3$	21.08	0.006
$j = 4$	4.08	0.043

The estimation sample is 1960.Q1-2009.Q4, including initial lags. 'asym. p-value' denotes p-values computed using asymptotic critical values.

[20] Obviously, the results that follow do not change substantially if we replace β_I with the $\hat{\beta}_I$ in the right panel of Table 3. The results are available upon request to the authors.

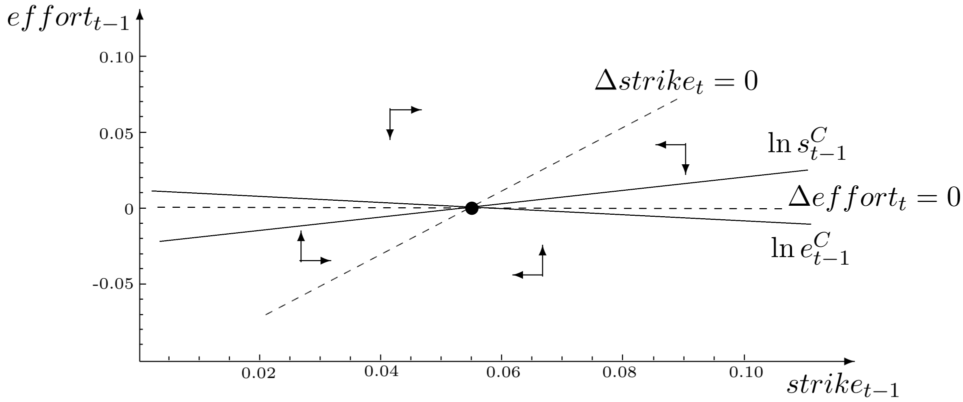

Figure 4: Unified phase diagram

E Unified phase diagram

The phase diagram in Figure 4 is obtained for generic values of the parameters in α and β_I. It represents in a unified way: (continuous lines) the cointegrating relationships of a VEC system, that we also interpret as the players' reaction functions of our theoretical model; (dashed lines) the *loci* in which the short run adjustments are null (the strategic interaction between players being isolated), as made explicit in Eq.s (26) and (27). The long run equilibrium values of effort and strike, net of the short run disturbances, are determined, ultimately, by the historical and socio-economic conditions of a country. For instance, for any given level of *un* and *wage*, the phase diagram is centered at a different steady state equilibrium, i.e. the intercepts of the reaction functions and the *loci* change. The contribution of this phase diagram representation is to highlight the interdependencies among the steady state equilibrium (Cournot-Nash equilibrium), the long-term relationships (reaction functions), and the short run and long run dynamics. Notice that, since the VEC is stable by construction, wherever we start from the graph, the dynamics of the system is such that it pushes us directly towards the steady state. This point, identified by the intersection of $\ln e^C_{t-1}$, $\ln s^C_{t-1}$, $\Delta \mathit{effort}_t = 0$, and $\Delta strike_t = 0$, is both the long run equilibrium and the Cournot-Nash equilibrium.

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