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The codetermined firm in a Cournot duopoly: A stability analysis

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ABSTRACT

This paper aims to study the stability issue in a Cournot duopoly with codetermined firms. We show that when both firms codetermine employment together with decentralised employees' representatives, a rise in wages acts as an economic (de)stabiliser when the wage is fairly (high) low, while under profit maximisation a rise in wages always acts as a stabilising device because the parametric stability region monotonically increases with the wage in such a case. Moreover, a rise in the union's bargaining power has a destabilising effect, except when the wage is low and the firm power is already high. Therefore, under codetermination a change either in the wage or firm power in the Nash bargaining plays an ambiguous role on stability. We also show with numerical simulations that complex dynamics can also occur.

1. Introduction

A well known stylised fact about labour markets is the existence, especially in some important European countries such as Germany, of codetermination laws, according to which workers in large firms have nearly the same decision rights as capital owners. On the one hand, codetermination rights mainly concern employment, with wages being apart from the field of application of such laws. On the other hand, even if one abstracts from codetermination laws,[2] in several countries it is observed that: (1) a distinction is made, especially in Europe (for instance, Scandinavian countries and Austria) between centralised (e.g., national or economy-wide level) unions that set the wage for an entire industry in a country, and decentralised (e.g., firm or district level) unions that negotiate over employment alone, and (2) decentralised wage setting procedures, which however establish wage contracts of long lasting effectiveness (e.g., the three-year contracts often observed in the US), and local bargaining over employment of higher periodicity do exist. Both make the case of bargaining over employment relevant.

An interesting study that has tackled this issue out from a point of view of a static bargaining game in a Cournot duopoly, is Kraft (1998). The author interestingly shows that: (*i*) bargaining over employment alone is the dominant strategy with respect to profit maximisation if the union power is not too large (which seems to be the case under codetermination laws),[3] and (*ii*) "codetermination is welfare maximizing!" (see Kraft, 1998, p. 200). Therefore, given both the empirical relevance of decentralised bargaining on employment alone and the surprising theoretical features about welfare maximisation evidenced by the literature above mentioned, we observe that so far nobody has considered, at the best of our knowledge, the effects of codetermination on product market stability in a duopoly with quantity competition. However, this is not an irrelevant issue to be dealt with given the long lasting debate on pros and cons of union power in both decentralised and centralised bargaining. The present paper aims to fill this gap in the economic theoretical literature by extending the duopoly model by Kraft (1998) in a dynamic context. The out-of-equilibrium dynamics is based on the assumption of "bounded rational" firms as suggested, for

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[2] According to co-determination laws "employment determination are handled by the supervisory board in codetermined firms. On the supervisory board employees have near-parity rights. In the iron and steel industry as well as in mining employees have explicit parity decision rights." (Kraft, 1998, p. 195).

[3] Indeed Kraft (p. 199) notices, at least when co-determination is regulated by law, that a situation in which workers have higher bargaining power than firm owners would rather be unrealistic. Indeed, he argues that "the assumption of $\beta > 0.25$ seems to be acceptable for codetermination in German firms, given the fact of near-parity representation of the employees."

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instance, by Dixit (1986) and recently popularised by the literature on dynamic oligopolies (see, e.g., Bischi and Kopel, 2001; Fanti and Gori, 2012; Naimzada and Tramontana, in press; Puu, 1998; Tramontana, 2010).

We find that an exogenous increase in the labour costs under codetermination destabilises the Cournot–Nash equilibrium when the wage is low enough (while playing a stabilising role for further increases in the wage when it is already high, but only whether the unions' power in determining employment is fairly low), while under profit maximisation a rise in wages plays an unambiguous stabilising effect. Moreover, raising the relative union's bargaining power essentially tends to destabilise the equilibrium (by increasing the parametric instability region), except when the wage is low and the firm's power is already high.

Therefore, in order to keep the Nash equilibrium in a Cournot duopoly stable, the union's power in determining employment should be as low as possible: it should at most be close to the near-parity when the wage is fixed at not too high a level. In a similar way, we observe that an increase in wages, which is beneficial for stability when unions are absent or when their power in fixing employment is low, tends to destabilise the market equilibrium when the power of unions is high, unless the wage is high enough. This leads to a counterintuitive remark: under codetermination, when the power of unions in fixing employment is high (i.e., higher than the power of firms), it is convenient for stability to reduce (increase) wages when they are already low (high).

The present study contributes to two growing strands of literature on: unionised oligopolies (see, e.g., Bughin, 1995; Correa-López and Naylor, 2004; Dowrick, 1989, 1990; Fanti and Meccheri, 2011; Kraft, 1998), and dynamic oligopolies (see, e.g., Bischi et al., 2010), and provides a novel analysis on the dynamic effects of bargaining on employment without wage negotiation.

The rest of the paper is organised as follows. Section 2 builds on the model, Section 3 introduces expectations and analyses the local stability properties of the unique positive Cournot–Nash equilibrium, showing the existence of local bifurcations and the emergence of complex dynamics with numerical simulations. Section 4 concludes.

2. A Cournot duopoly with codetermined firms

The model is outlined in accordance with Kraft (1998). Without loss of generality, we consider a normalised Cournot duopoly for a single homogenous product with a negatively sloped inverse demand given by $p=1-q_1-q_2$, where p denotes the price and q_1 (q_2) is the output produced by firm 1 (firm 2). The average and marginal costs for each single firm to provide one additional unit of output in the market are equal and constants at $0<w<1$, where w represents the wage negotiated by unions at the economy-wide level, with employment L_i being determined at (i th) firm-specific level ($i=\{1,2\}$). The hypothesis of constant average and marginal costs implies that firm i produces through a production function with constant (marginal) returns to labour, that is $q_i=L_i$ (see, e.g., Bughin, 1995; Correa-López and Naylor, 2004; Dowrick, 1989, 1990).

The objective of every firm is to maximise profits $\Pi_i(w,L_i)=pq_i-wL_i$ with respect to employment, while the objective of unions is to maximise utility $U_i(w,L_i)=(w-w^\circ)^\theta L_i$ with respect to employment, where $\theta>0$ is the relative weight attached by unions to wages and w° is the reservation or competitive wage. Without loss of generality, we set $\theta=1$ and $w^\circ=0$ henceforth. We assume that both firms codetermine employment with firm-specific unions. Since the production function is $q_i=L_i$, the Nash bargaining between firms and unions takes the form:

$$V_i=\left[\left(1-q_i-q_j-w\right)q_i\right]^{\beta}(wq_i)^{1-\beta},\ 0\le\beta\le1, \tag{1}$$

where the control variable is q_i and β ($1-\beta$) is the relative bargaining power of firms (unions). Therefore, the best reply function of the ith firm is determined by:

$$\frac{\partial V_i}{\partial q_i}=\frac{\left[\left(1-q_i-q_j-w\right)q_i\right]^{\beta}(wq_i)^{1-\beta}\left[1-q_i(1+\beta)-q_j-w\right]}{\left(1-q_i-q_j-w\right)q_i}=0\Leftrightarrow \tag{2}$$

$$q_i=\frac{1-q_j-w}{1+\beta}.$$

3. Expectations, equilibrium and local stability

Let $q_i(t)$ be firm i's quantity produced at time $t=0,1,2,\ldots$. Then, $q_i(t+1)$ is obtained as:

$$q_i(t+1)=\arg\max_{q_{i(t)}}V_i\left(q_i(t),q^e{}_j(t+1)\right), \tag{3}$$

where $q^e{}_j(t+1)$ represents the quantity that the rival, i.e. firm j, today (time t) expects will be produced in the future (time $t+1$) by firm i. Assuming now heterogeneous (i.e., bounded rational[4] and Cournot-naïve[5]) expectations by each firm (see, e.g., Tramontana, 2010) about the quantity that the rival will produce in the future period, the two-dimensional system that characterises the dynamics of the economy is the following[6]:

$$T:\begin{cases}q_1(t+1)=q_1(t)+\alpha q_1(t)\dfrac{\partial V_1}{\partial q_1(t).}\\ q_2(t+1)=q_2(t)\end{cases} \tag{4}$$

where $\alpha>0$ is a coefficient that tunes the speed of adjustment of player 1's quantity with respect to a marginal change in V_1 when $q_1(t)$ varies. Notice that the intensity of the reaction of the bounded rational firm is given by $\alpha q_1(t)$, which is proportional to the quantity produced by firm 1. Therefore, through the use of Eqs. (2) and (4) we get:

$$T:\begin{cases}q_1(t+1)=q_1(t)+\dfrac{\alpha[(1-q_1(t)-q_2(t)-w)q_1(t)]^{\beta}(wq_1(t))^{1-\beta}[1-q_1(t)(1+\beta)-q_2(t)-w]}{1-q_1(t)-q_2(t)-w}\\ q_2(t+1)=\dfrac{1-q_1(t)-w}{1+\beta}\end{cases}. \tag{5}$$

From Eq. (5) it can be seen that a rise in β has a threefold effect on the marginal value of the Nash product of player 1 and, hence, on the intensity of the reaction, i.e. the quantity it will produce, in the future period. First, it increases the relative bargaining power of firm 1. Second, it tends to reduce the reaction of player 1 through a direct negative effect. Third, it reduces the quantity produced by rival (firm 2) at time t and then it tends to increase the reaction of player 1 through an indirect positive effect. As regards wages, an exogenous positive shock on w, by increasing production costs, tends to reduce firms' profits while also raising the utility of unions. Moreover, as a direct effect, a rise in w plays an ambiguous role on the marginal value of the Nash product and then both the direction and intensity of the reaction of the bounded rational firm are ambiguous through this channel. Indeed, as an indirect effect, an increase in wages tends to reduce the

[4] In the standard dynamic Cournot duopoly with profit-maximising firms, each bounded rational player uses information on current profits to adjust (i.e., to increase or decrease the quantity produced at time $t+1$) depending on whether marginal profits are either positive or negative (see Dixit, 1986).

[5] Cournot (1838) was *de facto* the first author to use naïve expectations in an oligopoly model.

[6] It is important to note that we have chosen to present the model with heterogeneous (i.e., bounded rational and naïve expectations) for analytical tractability. Indeed, the results of the present study holds even when both (codetermined) firms have bounded rational expectations as well as when one firm is profit-maximising and the rival is a codetermined firm, and both are bounded rational players.