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Air traffic control regulation with union bargaining

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Air traffic control regulation with union bargaining [1]

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Abstract

This paper studies the behavior of the air traffic control (ATC) centers in the EU. We investigate the functioning of the European ATC sector with a union bargaining model. In this model, working conditions are the outcome of a bargaining game between the public air traffic control agency and the unions of air traffic controllers. We use this framework to understand the behavior of the ATC centers for wage formation, their reactions to a price-cap, adoption of new technologies, congestion pricing, effect of vertical disintegration, competition and the possible success of mergers between different national ATC centers. The theory is able to explain the slow progress in ATC performance in a unionized environment. We also test the theoretical model and estimate its parameters. The empirical analysis is based on actual ATC performance data.

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1. Introduction

In the European Union, air traffic control is the responsibility of 37 air traffic control centers (ATC). Each has a national or regional monopoly. Most of these centers are public. The ATCs guide the flights through their territory. There is strong evidence that the European ATC organization is less efficient than systems in other parts of the world. The Performance Review Commission (2013) compared the EU and the US ATC systems and found that the former was 34% more expensive. The inefficiency is attributed to different factors: fragmentation as many ATC's are small, lack of incentives to introduce new technologies, more generally lack of incentives to reduce costs. The European Commission is proposing different strategies to improve the efficiency of the European ATC sector. These strategies include regulatory changes (price-cap instead of cost plus regulation) and efforts to introduce better ATC technologies.

The European policies rely largely on the traditional theory of regulation (surveyed in Laffont & Tirole (1993)). This is logical as, in most countries, ATCs are public utilities which have a monopoly. The main problem of the regulator is that he does not know the costs of providing services. Knowing the costs of different production options is difficult because it depends on the efforts of the management and the workers, and the production process is nonstandard. Every ATC has its own area, using its own work routines and equipment. This asymmetric information combined with the lack of incentives for the management of the firm is likely to produce the poor cost performance of the regulated firm. An obvious remedy is to replace the cost plus regulation that is in place in most ATCs by a price-cap, and this is what the EU Commission is doing.

This paper takes a different view on the functioning of the ATC sector and uses a union-bargaining model to understand the European ATC sector and the effects of different policies. The European ATC activity is regularly disturbed by strikes that protect the wage and employment levels, this is a clear difference with the US; where strikes are no longer allowed since Ronald Reagan fired air traffic controllers who had gone on strike.

In the union bargaining theory, surveyed in Oswald (1985), the main issue is not the asymmetric information of the regulator, but the bargaining position of the unions. Even if the regulator would know perfectly the minimum cost of the firm, it cannot force the firm to sell at minimum cost because the unions can threaten to strike and this reduces strongly the surplus of the users. The monopoly positions of the national ATC and the unions in the ATC are the main source of the high costs of the ATC. It is the bargaining position of governments, ATC's and labor unions that determines the economic outcome.

After a brief review of the literature we set up a simple one ATC zone model for the functioning of an ATC and use the model to understand the reference equilibrium. Next we use the model to assess the effects of exogenous changes in the regulation regime (from cost+ to price-cap), the standardization of technologies, the adoption of new technologies, changes in the pricing regimes, and the effects of mergers. The one-zone model is next extended to a two-zone model with competition between ATCs. In the penultimate section, we use data on labor productivity and on wages to estimate the union bargaining power as well as the labor union preferences for most of the ATC zones. A final section concludes.

2. Review of the literature

A large literature studies the behavior of unions. An early review of the literature can be found in Oswald (1985). Most of the literature deals with unions that are active in firms that are exposed to competition.

Usually one distinguishes between three types of models: the right to manage model, the monopoly union model and the efficient bargaining model. In the right to manage model, unions and firms bargain over the wage using a Nash-bargaining solution – the gains are the surplus over the fall back option (or no agreement option). For the firm, the fallback option is 0. For the union it is the market wage. Once the equilibrium wage is fixed, the firm decides on employment using its labor demand function. In the monopoly union model, all the power is with the union, there is no bargaining and the union maximizes the utility of the median member by selecting a wage level. The firm hires the number of workers according to its labor demand function. In the efficient bargaining model, there is a bargain over wages and over employment between the firm and the union. Interesting to note is that Oswald did not find any model that incorporates explicitly the role of strikes.

The literature on union power in public monopolies is more limited. De Fraya (1993) studies the difference between public and private enterprises to understand the effect on wages of privatization. He focuses on the effect of union power in public enterprises that form a duopoly with a private enterprise. Dalen, von der Fehr and Moen (2003) studied regulation of firms with wage bargaining. They generalize the Laffont & Tirole (1993) regulation model that assumed an exogenous competitive wage to a model where unions bargain with the manager over the wages.

There is also a labour union literature that deals with unions whose members have different qualifications and different seniority. We leave this for later as it adds another layer of complexity to our model.

3. Model

The simplest model has only one country, one air traffic control center , perfectly competitive airlines and airports that sell services at marginal cost. The air traffic control centers (ATC) employ controllers who are all identical. We opt for the efficient bargaining model as there is evidence that labour unions also care about the level of employment. We describe the different economic agents and next the equilibrium concept.

Economic agents

In this model we have the following agents:

Airlines as users of the air space, have an inelastic demand as long as the price is below $\bar{h}$. For prices below $\bar{h}$, the demand for flights equals $\bar{q}$. All airlines are homogenous so they all use the same type of aircraft and there is a fixed passenger occupancy rate. Moreover, we assume they are perfectly competitive so that changes in prices for ATC services translate fully into changes of prices for the passengers. We distinguish between local air space users $\bar{q}_L$ (those using the local airports) and foreign users of airspace $\bar{q}_F$ where $\bar{q} = \bar{q}_L + \bar{q}_F$.

Air traffic control centers use a technology k that combines other costs OC with input of controllers. The technology choice determines the capital/labor input mix but it has a more crucial role here. First, it determines the minimum labor (controller) requirement per unit of output (flights) for the economic lifetime of the equipment. Second, it affects the bargaining power of the union. The choice of technology also determines how easy it is to train controllers, to hire controllers from abroad etc. and this can reduce or increase the bargaining power of the ATC union. In this paper, we start with a reference technology (k = 0) and we normalize units such that for one unit of ATC output (flights), one needs at least one ATC controller and OC^0 units of other services and equipment per flight.

The ATC-Union plays an important role in the functioning of the air traffic control center. This labor union cares only about the the wellbeing of the employees of the ATC and not about the utility of employees of airports, airlines or other sectors. The labor union benefits from wages w above the competitive wage $w°$ and also prefers to have more controllers than the minimum $L°$ that is needed to produce $\bar{q}$. There can be different reasons for this: more relaxed work conditions or importance of the union leaders. The union trades off these two objectives, as a larger work force cannot claim as high a wage. There is some evidence that labor unions use their power (strikes, work to rule) to defend high wages as well as to avoid large reductions in employment levels. We use the following goal function for the union[2] :

$$U = (w - w^{\circ})^{\alpha} (L - L^{\circ})^{1-\alpha} \ , \tag{1}$$

where the weight α determines how important is a higher wage compared to more relaxed working conditions.

Equation (1) lends itself also for a second interpretation. The number of employees L° can be seen as the minimum number of controllers one needs per flight but can also be interpreted as the level of employment in the past. Unions have difficulties to accept employment cuts and then the second interpretation is more useful.

Labor unions and their members are probably risk averse and this requires specific concavity of the utility functions (Oswald, 1985).

The national government regulates the ATC and bargains with the ATC union on wages and employment. The government wants to maximize the sum of the consumer surplus of the users and its own revenues. We assume that the national government is instructed by the international regulator (ICAO agreement) not to levy any taxes on air traffic control operations and this implies to sell services at prices equal to or below average cost. As we consider only two inputs (controllers and other costs) and as we assume constant returns to scale in production, the sum of ATC and government profits and consumer surplus equals ($\bar{h}\,\bar{q} - W\,L - OC^0\,\bar{q}$) when there is average cost pricing. At present we do not distinguish between consumer surplus and government profit as we want to focus on the role of unions. We could add another layer to the regulation game by including an ATC manager that bargains with the unions on wages, technologies and employment[3] . Another possible extension is to add a lobbying game where different suppliers of equipment try to influence the procurement decision in their favor.

Lastly, we can include a supra-national regulator (EU level) that maximizes the joint surplus of the different national regulators. To simplify, we will assume that this regulator maximizes the consumer surplus of all the airspace users. Whenever there is transit traffic, when the air space is used by non-national users, or by users that only use the airspace but not the local airports, the supra-national regulator and the national regulators will pursue different objectives.

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[2] This can be seen as a Nash bargaining solution between those members that favor high wages and those that want to maximize employment.

[3] Dalen, von der Fehr and Moen (2003) develop a regulation game with a regulated firm that is incentivized to supply more effort and to bargain with the unions.

Equilibrium

The game has two stages. In the first stage, one chooses the technology k. The choice of technology will determine the bargaining power δ, the minimum number of controllers per flight L^0 as well as the costs of other inputs needed per flight OC^0. As the choice of technology affects many dimensions of the equilibrium, the solution of the game is not straightforward. There are also several variants possible. First, the choice of the technology can be fixed for a longer period than the wages. The level of employment and the choice of technology can be represented using a fixed cost that is sunk because of equipment specific training of controllers. Second, one can have the ATC unions involved or not involved in the choice of technology. But as the choice of technology determines strongly the outcome of the wage and employment stage, it is difficult to see why the ATC-union would be completely absent in the choice process.

We will proceed as follows:

We only examine two discrete types of technologies: the reference technology k=0 and the alternative technology k=1 where technology 0 is characterized by δ°, L°, OC° and where technology 1 is characterized by δ^1, L^1, OC^1. We start by analyzing the choice of employment and wages for the reference technology k=0 and analyze the effects of the choice of other technologies later.

For a given technology (here k=0), the equilibrium of the game is a choice of wage and employment. This is determined by the bargaining game between the regulator and ATC unions. We opt for an asymmetric Nash bargaining solution where the bargaining power δ° of government and union (1- δ°) is a result of different factors. These factors are the labor regulations, effectiveness of the strike weapon, the possibilities to hire new controllers that are quickly operational, the possibilities to rely on other control centers to take over operations etc.

The Nash bargaining solution, for technology k=0 requires that the number of controllers $L \geq L^{\circ} = \bar{q}$ and is obtained by maximizing the following function

$$\varphi = \left(\bar{h}\,\bar{q} - W\,L - OC^0\,\bar{q}\right)^{\delta}\left((w - w^0)^{\alpha}(L - L^0)^{1-\alpha}\right)^{1-\delta} \qquad (2)$$
$$s.t.\, w \geq w^0 \text{ and } L \geq L^0$$

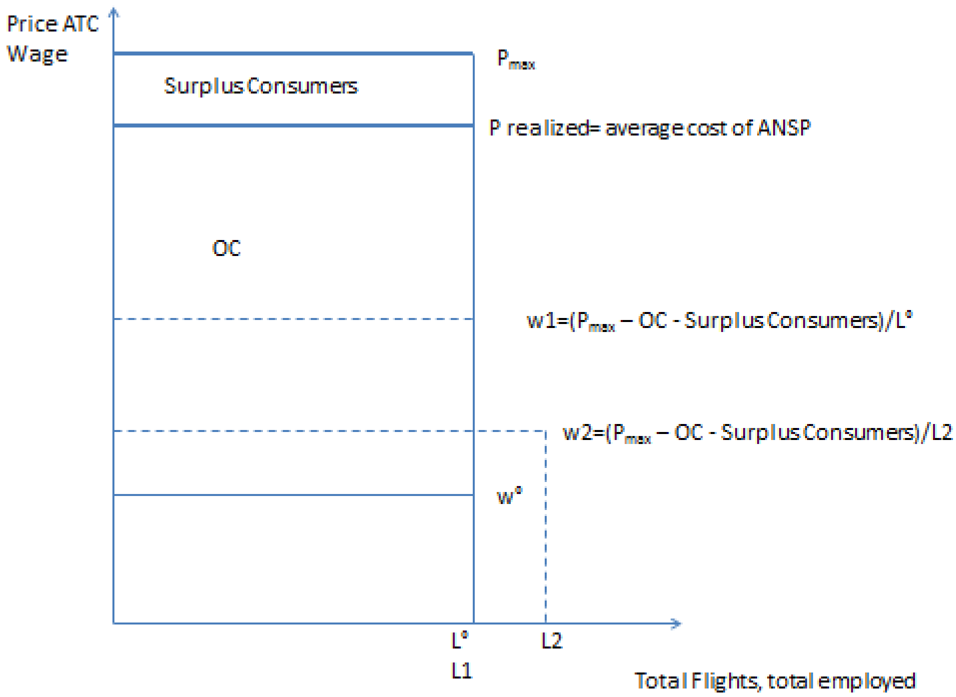
This generates equilibrium prices, wages and employment for the ATC.

An alternative to a union bargaining representation is to rely on a common agency solution where politicians are responsible towards a political system but are also lobbied by unions (Dixit, Grossman, Helpman,(1997)). This makes more sense in the US where unions don't have the strike option

Graphical illustration of the equilibrium

We can illustrate this problem graphically using two steps. In the first step, the union and the ATC regulator bargain over the total wage sum $w\,L$ as represented in Figure 1. As long as the price is below $\bar{h}$, demand is at level $\bar{q}$. After paying for the non-wage costs, this leaves a total surplus to be distributed between consumer surplus and government surplus equal to $(\bar{h}\,\bar{q} - W\,L - OC^0\,\bar{q})$ = $(\bar{h}\,\bar{q} - p\,\bar{q})$ + $(p\,\bar{q} - W\,L - OC^0\,\bar{q})$. Using a charge for ATM of p, the total surplus is divided between consumer surplus $(\bar{h}\,\bar{q} - p\,\bar{q})$ and surplus for the government $(p\,\bar{q} - W\,L - OC^0\,\bar{q})$. The share of surplus for the union $(w - w^0)^{\alpha}(L - L^0)^{1-\alpha}$ depends on its bargaining power. We assume it can obtain w^*L^*. Then the union can still decide to allocate its surplus differently and opt for a higher employment level (say L**) if it accepts to reduce the wage from w* to w**.

Figure 1: Bargaining over surplus between ANSP and labor union



In the second step, the union allocates this total wage bill given by the hyperbola "w^*L^*=constant" over wages and employment. The preference function of the union will always opt for a solution with w≥w° and L ≥ L°.

Analytical solution of the reference case

Solving for the equilibrium value of w and L by maximizing the bargaining function φ defined in (2) (assuming a meaningful solution $\bar{h}\,\bar{q} - W\,L - OC^0\,\bar{q} \geq 0$), one obtains:

$$w = \frac{1}{\delta + (1-\delta)\alpha}\left[\delta w^0 + (1-\delta)\alpha \frac{\bar{h}\,\bar{q} - OC^0\,\bar{q}}{L}\right]$$

$$L = \frac{1}{\delta + (1-\delta)(1-\alpha)}\left[\delta L^0 + (1-\delta)(1-\alpha)\frac{\bar{h}\,\bar{q} - OC^0\,\bar{q}}{w}\right]$$

(3)

An explicit solution for w and L is not very insightful but we can understand the result of the bargaining process as a result of two steps, just like the graphical interpretation. Maximizing the utility function of the union for given total wage bill wL gives us the ratio:

$$\frac{w}{L} = \frac{1-\alpha}{\alpha}\frac{w - w^0}{L - L^0}$$

(4)

We consider four extreme cases in order to understand the role of the different parameters:

1) Consider first the case where the union has no power at all. This implies that δ=1 and w=w° and L=L°. The consumer surplus and/or ANSP profit is maximized as the service is now produced at the minimum marginal (and average cost) w°+OC°. This would be the perfectly competitive solution and the efficiency of the ATC operations is maximized for the given technology.

2) Next consider the case where the union has all the power (δ=0). In this case, the maximum willingness to pay is used fully for higher wages and/or more employment in the ratio given by(4).

3) Take now the case where the employment level is not important for the union (α=1), then L=L° and w is maximized.

4) Finally, consider more mixed cases where δ=α=0.5, then one obtains:

$$w = \frac{2}{3}w^0 + \frac{1}{3}\left(\frac{\bar{h}\,\bar{q} - OC^0\,\bar{q}}{L}\right)$$

$$L = \frac{2}{3}L^0 + \frac{1}{3}\left(\frac{\bar{h}\,\bar{q} - OC^0\,\bar{q}}{w}\right)$$

(5)

So when unions have bargaining power, wages are higher than the market wage and this may be combined with excessive ANSP employment. We can use this model to analyze different questions.

4. Understanding the reference equilibrium

The reference equilibrium has cost-plus regulation. This means that the price p has to be equal or lower than the average cost so that $p\,\bar{q} - W\,L - OC^0\,\bar{q} \leq 0$ with w ≥ w° and L ≥ L°. In the union bargaining model we used up to now, we only specified the bargain between the union surplus (wL) and other surplus ($\bar{h}\,\bar{q} - W\,L - OC^0\,\bar{q}$).

In a cost-plus regime, the choice is between low prices and a high consumer surplus or higher costs and a low consumer surplus. Higher costs means in our setting a higher wage bill and a higher surplus for the union. Each national ATC is probably only interested in the consumer surplus of its local users and this means that the national regulator has the following surplus definition he will use in the bargaining game with the unions:

$$\left[\bar{h}\,\bar{q}_L - p\,\bar{q}_L\right] + \left[p(\bar{q}_L + \bar{q}_F) - W\,L - OC^0\,\bar{q}\right]$$

$$p(\bar{q}_L + \bar{q}_F) - W\,L - OC^0\,\bar{q} \leq 0 \tag{6}$$

Under cost plus regulation, only the first term is a positive surplus, and this implies that the national regulator will tend to bargain less strongly for lower prices as local use is only a part of the total use. One more Euro of surplus for the unions (via an increase of wL) costs the national regulator less than one Euro of consumer surplus.

This would imply, ceteris paribus, that ATC's with a higher share of transit traffic tend to have a relatively higher wage bill.

Introducing a price-cap

Up to now, we assumed cost-plus regulation that resulted in a price higher than the competitive outcome because unions with bargaining power can obtain a wage higher than the market wage as well as a level of employment that can be larger than necessary. The EU has recently moved to a partial price-cap system. Why did most countries never make this move but approved an EU regulation? There are two reasons. One explanation is that every individual country is interested in its home traffic (landing at their own airport) and so did not object too much to a higher price generated by the cost+ system. Individually, there was no reason to move to a price-cap system. But when all countries can agree to implement a price cap system, they will all benefit for the transit part to their airport.

A second explanation is that the distance between the regulator and the unions becomes larger at EU level. There are fewer possibilities for collusion . One can also think about the difficulties for ATC unions to lobby the EU decision making while lobbying the country government is easier with a national union of air traffic controllers.

A price cap can have different effects. First it lowers the total sum available for other costs and for the wage bill. It can be that other costs can be reduced and this would keep the total wage bill untouched. But if this offers little leeway, then the national regulator has to reduce the wage bill itself and reduce directly the utility of the union. Assume this happens, what will be the effect on the equilibrium? The result can be derived by inserting the price cap p^c that is lower than the result of the cost p°; this increases the consumer surplus of local and foreign users. The national regulator can reduce the price even below the price cap or he can earn a profit or tax revenue on the ATC operations. But this is unlikely as p^c is below his preferred price p°. The result will be a lower wage bill and a reduction of wages and employment in line with the preferences of the ATC union. When the union attaches more weight to the wage level, the wage bill reduction will be more than proportionally translated into reduced employment:

$$w^c L^c = p^c - OC^0\,\bar{q} < p - OC^0\,\bar{q}$$

$$\frac{w^c}{L^c} = \frac{1-\alpha}{\alpha}\frac{w^c - w^0}{L^c - L^0} \qquad (7)$$

One could imagine that in countries with strong ATC unions, the union will not accept the price cap and use the strike option to force the national governments to start subsidizing the ATC operations. The price-cap is respected but operations are not becoming more efficient.

Take the example of the Belgian ATC where a strikes broke out in the summer of 2014 as a consequence of the imposed reductions in the tariff.

The model can be extended to include a manager of the ATC, who aim to get a profit and can be incentivized to put more effort and reduce costs. Costs can be personnel and others. This complicates somewhat the model but we can borrow some insights from Dalen, von der Fehr and Moen (2003). They show that when the wage and employment are the result of bargaining:

a) the manager needs to be incentivized more as unions work hard to increase costs

b) the timing matters: when the union can set the wage before the contract is made (this is the case if there are frequent renegotiations of the management contract), then the manager takes the wage as given and the incentive contract for the manager has no effect on wages.

c) when a maximum wage is set, the equilibrium will be the maximum wage.

Dalen, von der Fehr and Moen (2003) cite evidence by Hendrickx (1975) who showed that wages were higher for utilities that expected the regulator to adjust prices following a new wage agreement.

Will the ATC invest in new technologies?

We make a distinction between two types of new technologies.

An **operational innovation** keeps the bargaining power of the union unchanged but reduces the costs. This can be through better equipment , better procedures etc.. What result can one expect?

Consider first a reduction of the equipment costs $OC^0\,\bar{q}$ to $OC^1\,\bar{q}$ and assume a cost-plus regime. This increases the total surplus ($\bar{h}\,\bar{q} - W\,L - OC^1\,\bar{q}$) that can be redistributed over consumer surplus and union surplus. When the union has strong bargaining power, the operational innovation will mainly lead to an increase of the wage and the employment. Consider now a price-cap. With a price cap, when the operational innovation is not needed to achieve the price cap, the result will again be an increase in wages and in employment. The result may be that the national regulator does not find it worthwhile to invest in this type of innovation.

There are also operational innovations that can reduce the bargaining power of the unions. These can take the form of standardization of equipment, of training, of procedures etc. This implies that the bargaining power of the ATC unions is reduced. The regulators may be in favor but the unions tend to be strongly opposed. It could even be that standardization initially increases costs but that the reduced bargaining power of the unions ultimately reduces the employment and the wage levels so that total costs become lower.

An innovation that reduces the minimum employment level L°(k=1) < L°(k=0) – say a more effective controller post that allows to follow two planes simultaneously rather than only one plane – at an extra equipment cost (0C°+Δ) means that total surplus becomes ($\bar{h}\,\bar{q} - (OC^0 + \Delta)\bar{q} - w^0(L^0 - \Delta)$. The total surplus to be divided between consumers and unions may remain constant but the wage per employee (w/L) will decrease as it is the labor input additional to the minimum L° that is appreciated by the union:

$$\frac{d\left(\frac{W}{L}\right)}{-dL^0} = \frac{1-\alpha}{\alpha}\frac{w - w^0}{(L - L^0)^2} \leq 0$$

(8)

This implies that a labor-saving technology leads to less employment reduction than allowed by the technology.

The unions will be even less enthusiastic for **drastic innovations**. A drastic innovation is an innovation that allows the takeover of whole market. This could take the form of a **virtual center** that, situated in the country or abroad, takes over all the ATC activities. Imagine that there are several virtual centers that could take over the activities of the air traffic control centers and could do this at a cost VC.

Now the union is much more limited in its bargaining power. All the union could do is to offer services at a cost $WL - OC^0\,\bar{q} < VC < \bar{h}\,\bar{q}$. It is important to see that the virtual center gives a very strong incentive to the ATC management to bargain for a much smaller wage and employment level. The expected outcome for the union is given by the maximum of:

$$\varphi = (VC - W\,L - OC^0\,\bar{q})^{\delta}((w - w^0)^{\alpha}(L - L^0)^{1-\alpha})^{1-\delta} \tag{9}$$

And this will cause either the end of the traditional air traffic operations (if $VC < W^0 L^0$) or lower equilibrium wages and employment because $VC < \bar{h}\,\bar{q} - OC^0\,\bar{q}$.

$$w = \frac{1}{\delta + (1-\delta)\alpha}\left[\delta w^0 + (1-\delta)\alpha \frac{VC - OC^0\,\bar{q}}{L}\right]$$

$$L = \frac{1}{\delta + (1-\delta)(1-\alpha)}\left[\delta L^0 + (1-\delta)(1-\alpha)\frac{VC - OC^0\,\bar{q}}{w}\right] \tag{10}$$

This implies that the union loses much of its bargaining power and will only survive if it can produce at an average cost equal or below the cost of the virtual center. Note that what matters is the availability of a cheaper alternative; it does not have to be used.

There is a literature on unions and innovation (Ulph & Ulph (EER, 1994) and Haucap & Wey (EJ, 2004). This literature focuses mostly on the role of unions in a duopoly where the market share depends on the success in innovation. Innovation is a costly investment for the firm and how unions share in these costs matters. This literature may not be that applicable here because air traffic control is a national monopoly. It may be more useful to study the regional forerunner scenario.

Congestion, capacity and congestion pricing

Assume that the air traffic corridor suffers from congestion of the bottleneck type (see Arnott, de Palma, Lindsey, 1993). It is not easy to attribute the congestion to air traffic capacity problems and to airport capacity problems as air traffic control and airport operations are processes that are closely linked in time, we assume that we can separate both issues and can concentrate on the congestion in the air.

We are interested in the following questions. How does an ATC chose capacity in the absence of congestion pricing? How does this change when congestion pricing can be implemented and is there an incentive for the ATC to do this?

We keep the number of flights fixed at $\bar{q}$ and the maximum willingness to pay for a flight is now redefined as $\bar{h}$ minus the costs of queuing and delay: the lower the generalized costs for airlines and passengers, the higher is the maximum value of a flight. As we assume that all flights are identical and have all the same preferred arrival times, we know that the costs of schedule delay and queuing per flight are given by , where K stands for the capacity, β is the cost of being too early and γ the cost of being too late.

$$\mu \frac{\bar{q}}{K} \; with \; \mu = \frac{\beta\gamma}{\beta + \gamma} \quad (11)$$

Capacity in our model with only one main input (controllers) corresponds to the number of extra air traffic controllers that are used to deal with the queuing traffic. We continue to assume we need at least one controller for every flight under no queuing conditions. To reduce queuing we can increase capacity by one unit by adding λ controllers so that $K= \lambda L^s$. The number of additional controllers brought in for the peak equals L^s.

One can deal with congestion by adding capacity and/or by changing the pricing of the facility. We consider as pricing alternative fine tolling. Fine tolling is a toll that varies over time so as to equalize departure times and throughput capacity of the bottleneck. The result will be that all queuing disappears and is transformed into congestion toll revenue and the generalized price of a flight (airline costs + fine toll + SDC) will be identical to the generalized cost without pricing.

Note first that a welfare-maximizing ATC will need to invest much less with congestion pricing. Maximizing welfare means minimizing schedule delay and queuing costs minus costs of additional controllers. In the absence of congestion pricing this implies:

$$Min \; \frac{\mu}{\lambda L^s} (\bar{q})^2 + (w + OC^0) L^s$$

$$\rightarrow \mathrm{L}^s = \bar{q}\sqrt{\frac{\mu}{\lambda(w + OC^0)}}$$

(12)

So the additional capacity is proportional to the number of flights and increases less than proportionally with higher schedule delay costs and decreases less than proportionally with higher wages and costs of other inputs.

With congestion pricing, the optimal number of controllers is strictly smaller as only the schedule delay can be reduced by additional controllers. The queuing costs are already taken care of by the fine tolling. As we know that schedule delay is equal to the queuing in the no congestion pricing equilibrium, we have:

$$Min\ \frac{\mu}{2\lambda \mathrm{L}^s}(\bar{q})^2 + (w + OC^0)\mathrm{L}^s$$

$$\rightarrow \mathrm{L}^s = \frac{1}{\sqrt{2}}\bar{q}\sqrt{\frac{\mu}{\lambda(w + OC^0)}}$$

(13)

To examine the incentives for addressing congestion with more controller capacity in the union bargaining model we need to know how the introduction of congestion affects the total bargaining surplus function:

$$\varphi = \left(\bar{h}\,\bar{q} - \frac{\mu}{\lambda(\mathrm{L} - \bar{q})}(\bar{q})^2 - W\,L - OC^0\,\bar{q}\right)^{\delta}((w - w^0)^{\alpha}(L - L^0)^{1-\alpha})^{1-\delta}$$

$$s.t.\, w \geq w^0 \text{ and } L \geq L^0$$

(14)

This results in wages and employment:

$$w = \frac{1}{\delta + (1-\delta)\alpha}\left[\delta w^0 + (1-\delta)\alpha\frac{\bar{h}\,\bar{q} - OC^0\,\bar{q} - \frac{\mu}{\lambda(\mathrm{L} - \bar{q})}(\bar{q})^2}{L}\right]$$

$$L = \frac{1}{\delta + (1-\delta)(1-\alpha)}\left[\delta L^0 + (1-\delta)(1-\alpha)\frac{\bar{h}\,\bar{q} - OC^0\,\bar{q} - \frac{\mu}{\lambda(\mathrm{L}-\bar{q})}(\bar{q})^2}{w}\right] + \frac{(\bar{q})^2\delta\mu}{\big(\delta + (1-\delta)(1-\alpha)\big)\lambda(\mathrm{L}-\bar{q})w}$$

(15)

We can check that for δ=1 (the union has no bargaining power), we obtain the optimal capacity investment for the welfare maximizing case as in with w=w°. In the reverse case, so that the union has all the bargaining power, the result will depend on the importance of employment versus wages for the union.

Consider next the case where congestion pricing is possible. Congestion pricing increases the total surplus for two reasons. First the queuing costs are transformed into toll revenue, the generalized price does not increase and so there is extra surplus to be distributed to consumers (as a price reduction because demand is inelastic) or to regulator's profits or to unions under the form of higher wages or more employment.

Standardization of equipment

This reduces the power of the local unions as they cannot easily be replaced by foreign personnel. This implies an increase of the bargaining power δ of the regulator and this will lead to a reduction of wages and employment in the proportion α/(1- α) according to (4).

5. Estimation of union bargaining power in European air navigation service providers sector

It is difficult to obtain an indicator that measures union bargaining power. Union membership is a candidate, but is difficult to obtain. Another indicator could be the number of strikes or the number of strike announcements, but the actual union bargaining power need not be related to this number. Therefore, we estimate the union bargaining power from the actual ATC, more specifically from the Air Navigation Service Providers (ANSP) performance data, reported in the yearly Air Traffic Management (ATM) cost-effectiveness reports.

Methodological framework

We estimate the bargaining power parameter δ and the union preference parameter α by minimizing the difference between the actually observed labor conditions (wages and employment) and fitted values for wages and employment. We can derive fitted values for wages and employment, as a representation of the expected working conditions, from the union bargaining model. But these fitted values depend on the parameters of the bargaining model also. Therefore, our estimation strategy consists in estimating the bargaining power parameters that minimize the error between fitted and actual values.

Using (3), we first derive an explicit solution for wages w and employment L as a function of exogenous variables:

$$\begin{cases} \hat{w}\left(w^0, L^0, \bar{h}, \bar{q}, OC^0, \alpha, \delta\right) \\ \hat{L}\left(w^0, L^0, \bar{h}, \bar{q}, OC^0, \alpha, \delta\right) \end{cases}$$

We need observations for the variables $w^0, L^0, \bar{h}, \bar{q}$ & OC^0 . We compute the difference between actual and fitted values as a function of parameters α and δ:

$$\begin{cases} w - \hat{w}(\alpha, \delta) \\ L - \hat{L}(\alpha, \delta) \end{cases}$$

Finally, we obtain estimated parameters $\hat{\alpha}$ and $\hat{\delta}$ through minimization of the sum of squared differences between w and $\hat{w}$, and between L and $\hat{L}$. The estimation is thus based on non-linear least squares technique and consists in joint estimation of the two equations. This estimation method was implemented in the Mathematica software package.

We do this estimation for Europe as a whole to calculate a European average. We also estimate the bargaining power parameters in each country separately, for each of the national ANSPs, since we expect that significant national differences exist.

<u>Data</u>

As explained in the methodological section, we need observations for the variables $w^0, L^0, \bar{h}, \bar{q}$ & OC^0 to estimate the parameters $\hat{\alpha}$ and $\hat{\delta}$. Information at country/ANSP level allows to obtain estimates at country/ANSP level.

The yearly ATM cost-effectiveness benchmarking reports allow us to collect these data for the time period 2004-2011. We chose to exclude the year 2012 from this period because we think that our model is most applicable in a context where charges are equal to average costs, without any price caps. The RP1 performance targets took effect starting in the year 2012, so our dataset ends in 2011.

The ATM cost-effectiveness reports contain yearly data per ANSP on a number of performance areas. In particular, they contain a lot of detail in the area of costs and traffic volumes. This allows us to construct our dataset, as documented in Table 1.

Table 1 Construction of dataset for estimation

Variable	Definition	Derived from
$\boldsymbol{w^0}$	'Outside option' wage for ANSP employee, different per country and per year	See explanation below
$\boldsymbol{L^0}$	Lower boundary on number of employees per ANSP per year per unit of traffic measured by composite flight hours served	The 'most efficient' ANSP in our dataset was the IAA (Ireland) in 2007 with a ratio of 0.0012 employees per composite flight hour served. We extrapolated this ratio to the other ANSPs and other years, to compute each time what would be the number of employees at the ANSP if he would provide services as 'efficiently' as IAA in 2007.
$\boldsymbol{\bar{h}}$	Upper boundary on maximum willingness to pay for ATM services by airlines	Derived from the 'most expensive' ANSP in terms of revenues collected per composite flight hour served, equal to 1.085 €/comp flight hour. This was the case for Belgocontrol in 2005. We assume that this charge is the upper boundary on the willingness to pay for ATM.
$\boldsymbol{\bar{q}}$	Demand for ATM services per ANSP charging zone per year, expressed in composite flight hours controlled	ATM cost-effectiveness reports
$\boldsymbol{OC^0}$	Yearly cost for providing ATM services by an ANSP except labor costs; these costs contain non-labor operating expenses, cost of capital and depreciation cost	ATM cost-effectiveness reports

To compute the 'outside option' wages w^0 for ANSP personnel, we calculate how much an ATCO or a support person at an ANSP could earn at another employment, in a similar profession that requires similar skills. To estimate this number, we consulted several data sources because no single data source provides sufficient coverage for all the countries in our dataset. The data sources we use are outlined in Table 2. The first source (ILOSTAT) has the highest priority. If data for a country or a year are not available in the ILOSTAT database, we use the second source (Eurostat). For data that is not available neither in ILOSTAT nor in Eurostat, we rely on national data sources.

Table 2 Overview of data sources for 'outside option' wages for ANSP personnel

Derived from	ATCO	Support personnel	Source
International Standard Classification of Occupations	ISCO 2 'Professional'	ISCO 3 'Technician and associate professional'	ILOSTAT – International labor organization
NACE sector	NACE section M 'Professional, scientific and technical activities'	NACE section N 'Administrative and support services'	Eurostat
National data	Specific activity as defined at national level	Specific activity as defined at national level	Various (National Economics Statistics Bureaus)

We also did a quality check on the 'outside option' wages that we obtained using general statistics on average personnel cost (personnel cost per employee) and nominal GDP per capita.

Notice that estimating the maximum willingness to pay $\bar{h}$ for a flight by taking the highest price paid for ATC services in the Eurocontrol area (Belgocontrol in 2005), means that we can only estimate relative bargaining value of the government. As the true maximum willingness to pay can only be higher than the value we used, the real bargaining power of the government can only be higher than the values we report. If the maximum willingness to pay is identical for all zones, our estimation procedure allows to estimate the relative bargaining power.

The same caveat holds for the estimation of the union preferences. In the estimation of the union preferences the value of L° is important. This is approximated by taking the lowest value in the EUROCONTROL zone (Ireland). But if this observation already contains relaxed labour conditions, one underestimates the union preferences for good working conditions.

Results

We first estimate the model for all ANSPs jointly and for all years (2004-2011) of our dataset. We obtain an estimate for the government's bargaining power of:

$$\hat{\delta} = 0.745$$

This number indicates that the governments' bargaining power is higher than the labor union's bargaining power ($1 - \hat{\delta} = 0.255$) in the union bargaining model. As our values are based on a WTP for flights that is a lower bound, the real bargaining power of the government can only be larger.

Focusing on the union preference between 'excess wages' and 'labor hoarding', we obtain an estimate of:

$$\hat{\alpha} = 0.41$$

This number suggests that, for Europe on average, unions have a smaller preference towards excess wages than towards labor hoarding ($1 - \hat{\alpha} = 0.59$). Again, because of the way the data have been constructed, the preference for labor hoarding is probably larger than this estimate.

We also estimated these parameters for each country/ANSP separately. Results are shown in Table 3.

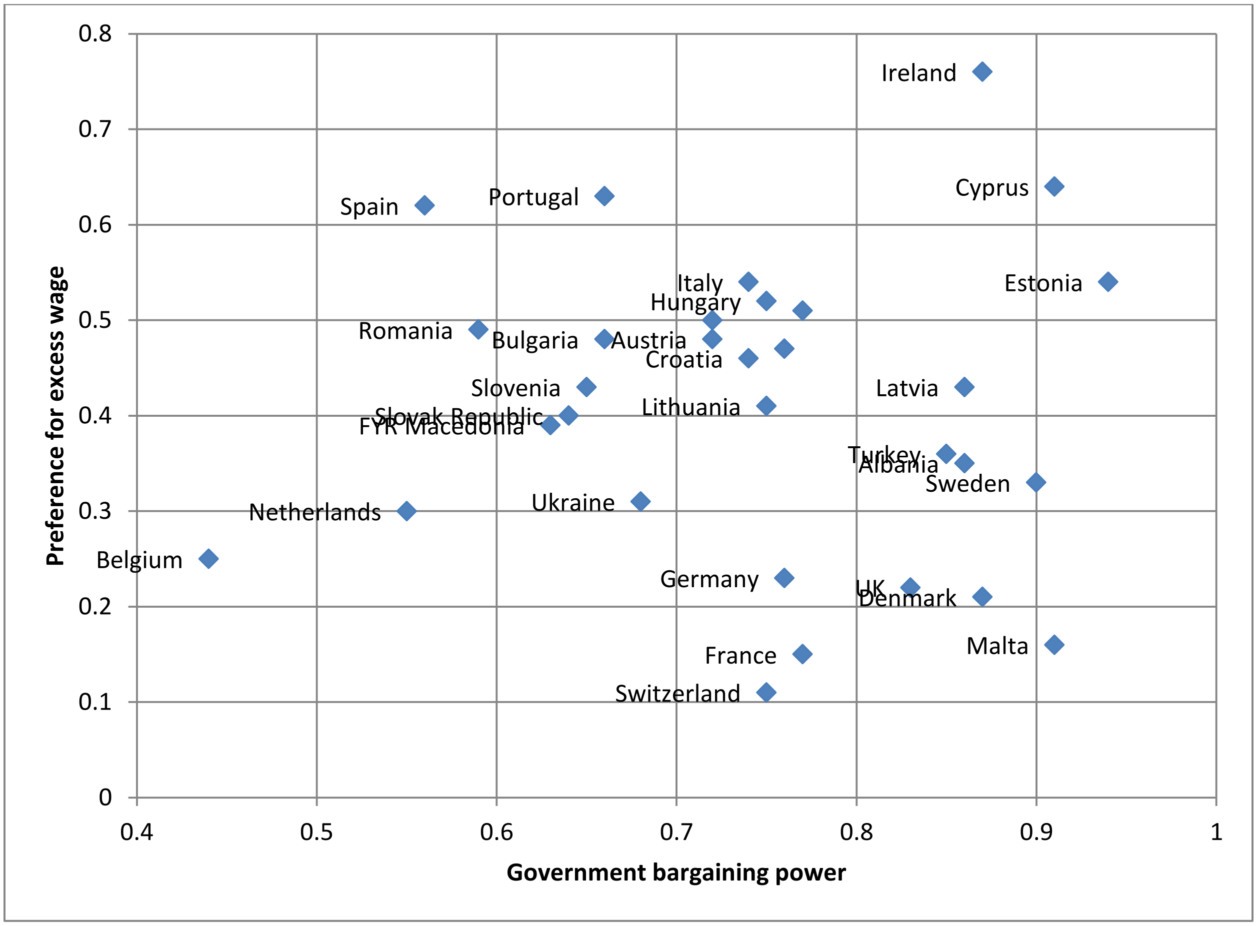
There are important differences across countries in relative bargaining power and relative union preferences. We find that in some countries/ANSPs , like Belgocontrol (Bekgium) or AENA (Spain), there seems to be relatively high union bargaining power . Some of the countries have a strong preference for 'labor hoarding. We find examples of this at Belgocontrol or LVNL in the Netherlands. In other cases, the union presence is rather translated into higher wages or other types of payment. This seems to have been the case in Spain (AENA) and Portugal (NAV Portugal). Still other countries with strong union power seem to have a mixed interest between wages and employment, such as Slovenia and Romania, for example.

In many countries, union power seems to be much less outspoken, or less effective, than in others. Examples of countries with only limited evidence of union power are: Cyprus, Estonia, Sweden and Denmark. The results for the various ANSPs on the two Union Bargaining parameters are shown in Figure 2.

Table 3 Overview of estimation results at country level

ANSP	Country	Government bargaining power $\hat{\delta}$	Union bargaining power $\widehat{1-\delta}$	Union preference for excess wage $\hat{\alpha}$	Union preference for labor hoarding $1-\hat{\alpha}$
AENA	Spain	0.56	0.44	0.62	0.38
ANS CR	Czech Republic	0.72	0.28	0.50	0.50
Austro Control	Austria	0.72	0.28	0.48	0.52
Belgocontrol	Belgium	0.44	0.56	0.25	0.75
BULATSA	Bulgaria	0.66	0.34	0.48	0.52
Croatia control	Croatia	0.74	0.26	0.46	0.54
DCAC Cyprus	Cyprus	0.91	0.09	0.64	0.36
DFS	Germany	0.76	0.24	0.23	0.77
DHMI	Turkey	0.85	0.15	0.36	0.64
DSNA	France	0.77	0.23	0.15	0.85
EANS	Estonia	0.94	0.06	0.54	0.46
ENAV	Italy	0.74	0.26	0.54	0.46
Hungarocontrol	Hungary	0.75	0.25	0.52	0.48
IAA	Ireland	0.87	0.13	0.76	0.24
LFV	Sweden	0.90	0.10	0.33	0.67
LGS	Latvia	0.86	0.14	0.43	0.57
LPS	Slovak Republic	0.64	0.36	0.40	0.60
LVNL	Netherlands	0.55	0.45	0.30	0.70
MATS	Malta	0.91	0.09	0.16	0.84
M-NAV	FYR Macedonia	0.63	0.37	0.39	0.61
NATA Albania	Albania	0.86	0.14	0.35	0.65
NATS	UK	0.83	0.17	0.22	0.78
NAV Portugal	Portugal	0.66	0.34	0.63	0.37
NAVIAIR	Denmark	0.87	0.13	0.21	0.79
Oro Navigacija	Lithuania	0.75	0.25	0.41	0.59
PANSA	Poland	0.76	0.24	0.47	0.53
ROMATSA	Romania	0.59	0.41	0.49	0.51
SkyGuide	Switzerland	0.75	0.25	0.11	0.89
Slovenia Control	Slovenia	0.65	0.34	0.43	0.57
SMATSA	Serbia & Mont.	0.77	0.23	0.51	0.49
UkATSE	Ukraine	0.68	0.32	0.31	0.69

Figure 2: Overview of union bargaining parameter estimates for different countries



6. Conclusion and caveats

This paper studied the behavior of the air traffic control (ATC) centers in the EU using a union bargaining model. We assume that the decisions of an air traffic control center are the outcome of a bargaining game between the public air traffic agency and the unions of air traffic controllers. This framework allows to understand better the behavior of the ATC center for wage formation, their reactions to a price-cap, adoption of new technologies, congestion pricing, effect of vertical disintegration, competition and the possible success of mergers between different national ATC centers.

The estimates of union bargaining power for 31 European ANSP's suggest that union bargaining power is important in many countries and gives rise to excess wage levels and excess employment levels. The important empirical question that is left unanswered is what determines the bargaining power of one country. Is it the country's legal framework, is it the social negotiation tradition, the role of the government ? etc. A caveat in the empirical estimation is that we do not take airspace heterogeneity into account currently.

A second important question is to know how to improve the overall efficiency of ANSP's. In our model, price regulation is largely ineffective in inducing higher efficiency in the sector. Small operational innovations also provide only modest incentives for change. On the other hand, drastic innovations (of the virtual center type) could have a strong impact on bargaining positions of different actors and therefore lead to very different outcomes than what we observe today.

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