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A PIED-PIPER SITUATION: DO BUREAUCRATIC RESEARCHERS PRODUCE MORE SCIENCE?

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A PIED-PIPER SITUATION:
DO BUREAUCRATIC RESEARCHERS PRODUCE MORE SCIENCE?

REMO FERNÁNDEZ CARRO

Y VÍCTOR LAPUENTE GINÉ*

Resumen: ¿Puede un científico confiar en que el gobierno le va a pagar honestamente? En la relación entre la ciencia y el Estado, el gobernante sale ganando si no paga (o si no paga honradamente). Todo científico público, así, afronta el riesgo de que tras una carrera larga y difícil el gobernante cambie las reglas del juego. A pesar de que la solución a este problema de credibilidad es lo que da forma a las instituciones de la ciencia pública el problema ha sido rara vez estudiado teórica o empíricamente en los estudios de la ciencia. En este trabajo proponemos un modelo de esa relación entre gobiernos y cientí-

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ficos de acuerdo con la teoría de juegos que muestra la importancia del tipo de contrato que los vincula, el que sea más o menos burocrático en un sentido weberiano. Hasta cierto punto, los contratos burocráticos —como los de los funcionarios— protegen a los científicos contra el mal comportamiento de los gobernantes. Mediante esas reglas burocráticas, los contratos atan las manos del gobierno con lo que se hace creíble su compromiso a la vez que se protege el delicado sistema de recompensas de la ciencia. De esta manera se estimula la productividad tanto en calidad como en cantidad. Sin embargo, cuando se da el caso de gobiernos fiables los contratos burocráticos limitan los sistemas de incentivos y van en contra tanto de la receptividad de los científicos a las demandas de los gobiernos o de la sociedad como, al final, al interés de los gobiernos por el producto que ofrecen. En este trabajo utilizamos evidencia comparada entre países que confirma las proposiciones del modelo teórico y muestra cómo los contratos burocráticos estimulan la productividad científica en el caso de gobiernos poco confiables —como en el caso de las dictaduras— pero limitan esa productividad con gobiernos más fiables —como las democracias—.

ÍNDICE

Introduction

Can a scientist trust the government is going to pay her fairly? Fairness is important for a scientist who faces a long-time effort before her or his work is done, evaluated, and paid. A wrong evaluation or misconduct by the payer is a risk she has to consider before engaging in a long, difficult career. Usually, the political concern is the opposite: can the politician trust that the scientist would not take advantage of the obscurity of her subject to conceal the work she is really doing, or its quality. Most of the works in the subject had focused in this problem. In this paper, nonetheless we explore the other point of view. We contend that the relationship between powerful governments and scientists is subject to similar problems of credibility as the ones described in the interaction between, for instance, powerful governments and bankers (North and Weingast 1989) or between powerful governments and interest groups (Moe 1984, 1990; Horn 1995). The reason is that, once scientists have undertaken costly asset-specific investment in a given research, they are in a weak situation vis-à-vis the government, which may take opportunistic advantages such as not rewarding them properly.

When dealing with bankers or with interest groups, as most scholars point out, powerful governments, in order to solve their lack of credibility, tend to create institutional devices through which they *tie* their hands (Kydland and Prescott 1977): like Ulysses bound to the mast, by accepting limitations on its own caprice, one government can increase its capacity to achieve its ends (Holmes 1996). These limitations often take the form of bureaucratic rules that reduce government's discretion on the control of the administrative apparatus (Moe 1990, Horn 1995, Williamson 1999). This kind of arrangements can be extended to any problem of trust on the government's behaviour. Civil service arrangements, which grant public employees autonomy from political interference in staff policy, are a good example of those bureaucratic rules (Frant 1993). Although there is a wide consensus in that institutions matter for policy outcomes, it is not clear what the particular effects of bureaucratic rules over policy outcomes are (North 1999). Some authors highlight how bureaucratic rules are efficiency-enhancing (Rauch 1995); some others underline how rules are efficiency-decreasing (Moe and Caldwell 1994).

In this paper it is argued that, in the case of science, the effects of bureaucratic rules depend on the regime type. A game-theoretic model and its posterior empirical contrast show how *bureaucratic rules produce better science in dictatorships, but worse science in democracies*. In dictatorships it is a solution to the credible commitment problem created by autocrats, because benefits of bureaucratisation are higher than its costs (lack of flexibility). In democracies the problem of credible commitment is much less acute, since the rulers are constrained by checks and balances, and bureaucratic arrangements are less useful.

In science policy studies we lack both theoretical models and comparative empirical evidence to contrast the different impact of bureaucratic rules on scientific productivity. Science and technology policy is still an under-theorized field (Sapolski 1975, Guston 1996), without clear predictions on which factors lead to more bureaucratic rules in the relationship between governments and scientists. We intend to answer two general questions in this paper: **First**, why do governments tie their hands in the management of scientists through bureaucratic rules? **Second**, which are the effects of those bureaucratic rules over scientific productivity?

The paper is structured as follows. Section 2 explains why principal-agent theory offers an appropriate framework to model the relationship between governments and scientists. In section 3 we focus on the aspect of principal-agent relations — the problem of time inconsistency — that we consider key for explaining differences in the institutional devices that link a government and its scientists. Section 4 develops a game-theoretic model based on time-inconsistency problems. The model endogeneizes government's decision over the type of contract (more or less 'bureaucratised') with scientists. Besides, it predicts a country's science production in function of the regime type and the level of bureaucratisation of contracts. Section 5 and 6 offer evidence of the theoretical hypotheses for dictatorships and democracies respectively and Section 7 summarizes the findings.

1 Why a Principal-Agent Model?

In popular accounts of science, scientists are often portrayed as selfless individuals, working for humanity's sake. Earlier sociological explanations argue that extrinsic rewards, such as position and money, play a minor role in science (Hagstrom 1965: 19). In this paper, nonetheless, we assume that scientists are interested:[1] for simplicity, we assume position, money, and direct rewards as instrumental goods even for selfless actors. This position allows us to treat scientists as *agents* of the government (here the *principal*) in a principal-agent model. This paper relies on principal-agent explanations, and takes a contractual approach toward explaining public science organizations and hierarchies. This *contractualist* perspective fits concerns of science policy and science policy studies with the so-called "*social contract of science*", the tacit promise of science "*to deliver goods to society in return for its patronage with no string attached*" (Rip 1990, cited in Guston 1996).

A growing strand of literature in science policy has adopted this approach, (see for instance Braun 1993, Guston 1996, Caswill 1998, Van der Meulen 1998, and Morris 2003) in the same standard way: a *government* requests the *scientists* to perform certain tasks the principal is not able to perform directly (Guston 1996: 230). The main question we try to answer is "*How do non-scientists get scientists to do what we all, as citizens, have decided?*" (Guston 1996: 229) and the key aspect is information asymmetries between the two main actors. However, we depart from this literature in three different ways. First, we focus on the simplest model -with the government as the principal and the scientists as the agents-, ignoring intermediate actors.[2] In doing so, we are making a rough simplification, but our aim is analysing the interplay between the two essential actors in science: those who ultimately say what must be done and those who ultimately do it. Secondly, we use a one-shot game without repetition.[3]

[1] We follow the criticism about those assumptions made by the Interest Theory literature in sociology of science. See, for instance, Mulkay (1991), Barnes and Dolby (1970), or Barnes (1985).

[2] Other studies focus on intermediate agencies, such as research councils (Braun 1993: 139), or focus public or private laboratories as agents. We follow Abraham and Prosch (2000) who analyse technicians in high-tech companies.

[3] Van der Meulen (1998) suggests that repeated games could help stability of the relationship. But ultimately no clear predictions may be derived from repeated games, as the so-called Folk Theorem states.

Thirdly, coherently with the second way, our model focuses on the risks of principal's misbehaviour. We content in this paper that this contract suffers a problem of credible commitment on the side of the most powerful actor: the government establishes which goods scientists must deliver to society.[4] The problem addressed by principal-agent theory is usually the design of a contractual structure to limit agent's misconduct — the well-known issues of *moral hazard* and *adverse selection* (Pratt and Zeckhauser 1985, Moe 1990). The agent is seen as the main source of problems while the problems created by principals — such as the possibility of not rewarding the agent, for instance — have been overlooked.[5] However, principals are sources of problems as well, and especially in the public sector, where the principal has a political nature. As Moe (1990) has emphasized, principal-agent theories assume enforcement of contracts by a *third party*, but problems may arise when one of the parts happens to be that third party. In the public sector, governments are both one contracting part and that third party at the same time.

Governments can either renege their pacts, because they control the party that enforces contracts (judiciary), or unilaterally change the terms of these contracts, by passing new legislation or regulations. Principal-agent models applied to politics often overlook this 'public authority', according to Moe (1990). Governments have an extraordinary and, up to a certain extent, unpredictable power: governments at time t cannot bind those at time $t + 1$, and the incentives to renege are often substantial (Moe 1990: 220). Once agreements are struck, there is no external enforcement mechanism to police them when one of the parts is government. Following Moe (1990: 213) we will include this 'neglected side of the story' in the analysis of science and technology policy.

[4] In behalf of society, or not.

[5] Some authors has stress this problem in microeconomics has stressed this problem (see Laffont and Tirole 1990).

2 Time-inconsistency problems

Once upon a time on the banks of a great river lay a town called Hamelin. The citizens of Hamelin were honest folk who lived contentedly in their grey stone houses. The years went by, and the town grew very rich. Then, one day, an extraordinary thing happened to disturb the peace: a black sea of rats swarmed over the whole town. The terrified citizens flocked to plead with the town councillors to free them from the plague of rats. But the council had, for a long time, been sitting in the Mayor's room, trying to think of a plan.

*Just then, while the citizens milled around outside, a stranger proposed to the city council: "*for a thousand florins, I'll rid you of your rats!*". "*A thousand florins!*" exclaimed the Mayor. "*We'll give you fifty thousand if you succeed!*" Next day, by the time the sun was high in the sky, there was not a single rat in the town. There was even greater delight at the town hall, until the piper tried to claim his payment. "*Fifty thousand florins?*" exclaimed the councillors, "*Never…*". "*A thousand florins at least!*" cried the pied piper angrily. But the Mayor broke in. "*The rats are all dead now and they can never come back. So be grateful for fifty florins, or you'll not get even that…*".*

Written by economists (see for instance Kydland and Prescott, 1977) the plot of this traditional tale could have been different: the pied piper would have rationally anticipated that, once the town were free of rats, it would not be in the interest of the Mayor and Council to reward him properly. It would be more rational for the Mayor to divert the 50 000 florins to building hospitals or directly to their own pockets. Therefore, the pied piper would probably have stayed at home and the story ends right at the beginning. Anyhow, the Tale of the Pied Piper illustrates nicely the problem of time-inconsistent preferences that is inherent to politics and it has been extensively used to show problems of credibility that arise in the relation between government and citizens (Sala-i-Martin 2005). But, ironically, it has not been used to shed light into the relationship between real-world Mayors and real-world Pied Pipers. In this paper, we will use it to highlight the relation between governments and a particular group of *pipers* who work for governments, scientists.

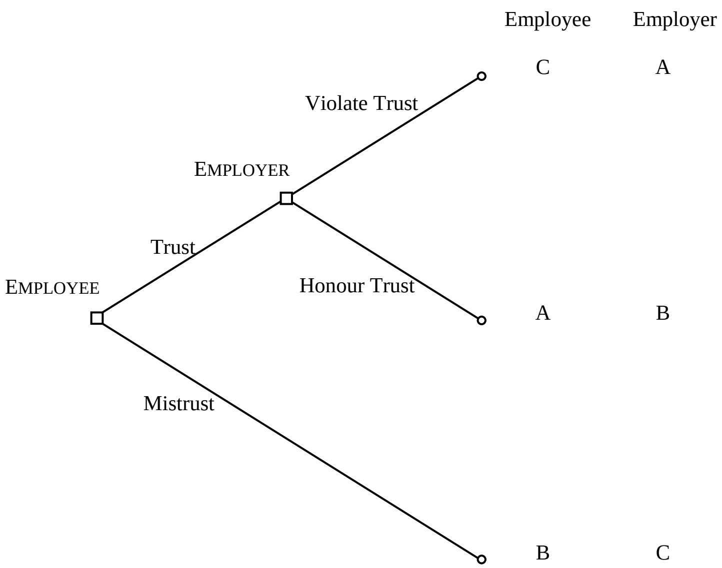
Time-inconsistency problems affect not only those transactions detailed in a written contract between a principal and an agent, but also those 'relational' transactions that cannot be established in a formal contract, as a stream within organizational economics has extensively showed: "*Every firm requires its employees to take actions that cannot be coerced — quality-improving suggestions, transaction-cost decreasing cooperation with other employees, customer-pleasing* *friendliness. These actions, by their very nature, cannot be induced by any formal incentive system*" (Miller and Falaschetti 2001: 406; see also Abraham and Prosch, 2000). For example, in any firm, if rational workers *believe* their manager will reward them as she promised, they will engage in higher levels of effort. Similarly, scientists need the confidence that they will be properly rewarded. Our theoretical model uses insights from the literature dealing with this problem — especially from the work of Gary Miller (1992, 2001, 2002) — to understand the relationship between governments and scientists.

Gary Miller's *Managerial Dilemmas* (1992) analyses the relationship between employers and employees in private-sector companies. Although he explores the case of a "piece-rate" system, the underlying problem of credibility he shows can be extended to any kind of relation between a boss and her subordinate where the employer has incentives to ex post opportunistic defections — like asset specific investments, information flows, promotion or wage increase promises (Gibbons, 2001: 334). In this paper it is contended that it is also a key problem in the government-scientists relationship. In the example of the piece-rate contract the employer pays the employee an amount based on the number of units, or pieces, the employee produces. In principle, this system of incentives is an ideal way of solving the principal-agent problem in production, because it aligns the self-interest of employers with organizational goals. However, as Miller recalls after research on the piece-rate contract, it is not used so often as standard principal-agent theory would predict.

According to Miller, there is an underlying game between the employer and the employee, whose essence is the issue of information asymmetry. Managers can never be sure about what the employee's marginal cost of effort functions are, and employees are systematically trying to protect that information asymmetry. With a price p for each piece produced, if the employee discovers a more efficient production technique or if she decides to work harder, she may start to earn more money than employer expected, and the employer has incentives to adjust piece rates downward (for example to $p - x$) in response to high salaries. Then, the employee has incentives to a strategic misrepresentation: not to implement new techniques and not to work hard. The result is inefficient: the employer fixes a lower piece-rate and the employee makes a lower effort than is socially desirable. It is a stable outcome, but it is not efficient, because there is range of outcomes in which both the employee and the employer can be better off.

Therefore, Miller considers that the relation between employer and employee is similar to the "commitment problem" game developed by Kreps (1990). In Miller's adaptation of the commitment problem game (Figure 1), the employee moves first and has a choice of trusting the employer (work hard) or not trusting the employer (minimum effort). If the employee trusts the employer, the latter has a choice of honouring trust (proper reward) or violating trust (cut piece rates to a minimum or lay off excess employees). In this movement, the employer has an incentive to violate trust, because she obtains a benefit from adjusting piece rates downward, and this would leave the subordinate worse off than if she failed to trust the employer. Anticipating this violation of trust, the employee refuses to trust the employer, which results in an outcome of minimum effort, a Pareto-suboptimal Nash Equilibrium.

Figure 1.– Commitment Problem



Employer's outcome ranking A > B > C. Employee's outcome ranking A > B > C Mistrust (payoffs B and C represents a Pareto-suboptimal Nash equilibrium. (Figure adapted from Miller 1992).

3 The credible commitment game between government and scientists

Similar to Braun (1993: 139), we assume here that it is not economic efficiency what guides the actions of politicians in their relations with scientists. Both authoritarian and democratic rulers are driven by what Moe (1990) defines as political efficiency: they are interested in remaining in office. Following Bueno de Mesquita *et al.* (2003), we understand that survival in office depends on two main strategies for both democratic and authoritarian rulers. Providing public goods (science, for instance) is the first mechanism, which seems obvious for democratic rulers, and, as Olson (1993) showed, it is also the case for many dictators who see the development of the economy (and therefore the progress of science in the country) as an asset that will help them keep office.

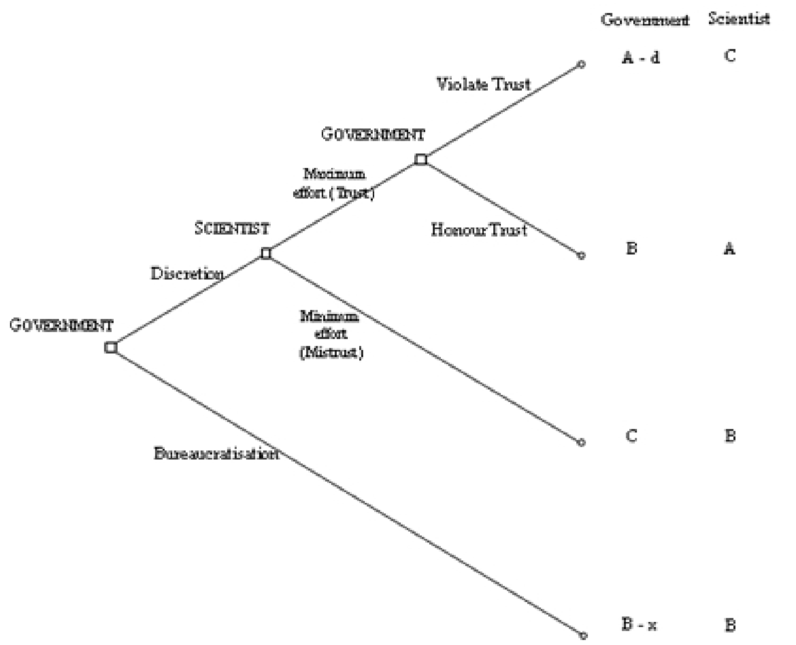
The other mechanism is the provision of private goods to some strategic interest groups: from privileges to key voters (a given social group, or bureaucrats themselves) in democracies, to money transfers to foreign bank accounts in kleptocracies. For the sake of simplicity, in the theoretical model developed in this section we assume that rulers are interested in providing the public good called science, because they have the political perception that science may directly contribute to societal ends (Braun 1993; 142), and, therefore, to their survival in office. The model, then, predicts, what should politicians do if they were interested in providing such public good though, as we will see at the end of this section, sometimes providing private goods to some groups may be more important than providing science.

Braun (1993: 139) states that financial incentives to motivate scientists are seldom feasible in the political system. Political actors are restricted in their ability to use resources in a flexible way because of tight administrative regulations. However, as the extensive literature on administrative procedures has shown,[6] *tight administrative regulations* are not universal: certain policies in certain polities are constrained by administrative procedures while in certain others politicians enjoy a high discretion. It is a politicians' decision to establish tight administrative regulations under certain conditions or, on the contrary, to keep a high degree of discretion in managing pub-

[6] Huber and Shipan (2002) provide a comprehensive summary of this literature in *Deliberate Discretion: The Institutional Foundations of Bureaucratic Autonomy*.

lic employees (Scholz 1991, Moe and Caldwell 1994). Sometimes rulers prefer to use resources in a flexible way and sometimes they prefer to tie their hands with detailed administrative procedures. For that reason, contrary to Braun, who treats them as exogenous factors, tight administrative regulations are here endogenous to the theoretical model. The model will try to answer how rulers choose the level of discretion they want to enjoy in their relationships with scientists.[7]

Figure 2.– The Positive Control Game



Scientist's outcome ranking A>B>C. Governments' outcome ranking A>B>C.

[7] The game deployed here formalizes in a simple way an argument that appears recurrently, implicit or explicitly, within the literature on science policy: scientists should be isolated from politicians, because the latter lack credibility and they are prone to make arbitrary decisions. For example, Bush in the classical *Science: the Endless Frontier* (1945) claimed that scientists should be as autonomous as possible from governmental interventions in order the society to obtain the optimal returns from investments in science. For Merton (1973), the scientific ethos requires that politicians be inclined to the autonomy of science. See also Van der Meulen (1998).

The interaction between government and scientists can be modelled by a two-person game such as the one shown in Figure 2. A simplification is done here: several government politicians from several departments are reduced to a single actor, the Government — and, therefore, we are ignoring their internal collective action problems. Even worse, thousands of scientists are reduced to another single actor, the Scientist. All intermediate layers of the hypothetical hierarchy, and all the separate institutions that mediate among actors (research councils, or universities, among others) are outside the scope of this analysis. Although a more comprehensive and more realistic approach would require including some of those actors in a more complex setting, the game representation used here is a heuristic device to depict the relationship between the two main actors.

The game is similar to the Miller's trust game between an employer and an employee depicted above, but now the government (the employer) has the choice of playing the trust game — retaining its discretion in the management of scientists — or not playing it and *tying its hands* in the management of scientists through a bureaucratisation process. The concept of *bureaucratisation* used here follows the standard definition of bureaucratic rules used by economists (Tirole 1994). Bureaucratic rules are limits to the discretion governments have in their relationships with scientists: government enact bureaucratic rules that constrain ex ante its power in hiring, firing, promoting and fixing incentives to scientists. Governments may tie their hands in the management of scientists in two ways. First, bureaucratisation can be done through delegating the staff policy to a politically autonomous institution such as the *Corps* of university professors (or other type of scientists) existing in countries like France or Spain. Governments are not free to select, promote, fire or introduce monetary incentives to those scientists. Secondly, within the concept of bureaucratisation, we include the enactment of laws and statutes through which governments limit their future actions in the relationship with scientists. For example, when governments issue rules that guarantee secure tenure or automatic promotion in function of seniority, governments are reducing their discretion in personnel management.

Bureaucratisation gives predictability to actors' payoffs. The assumption behind the model is that, instead of confronting relatively unpredictable rewards and incentives from political governments, scientists will deal with predictable rules about rewards and punishments — rules enforced by relatively autonomous bodies such as University councils or Administrative Corps of scientists. Incentives also exist in bureaucratised institutions but they are low-powered. For example, because in principle there are more subordinates than superiors within organizations, there are almost always several candidates for a promotion in any kind of organization.

The idea is that in a *bureaucratised* organization you must follow a more step-by-step promotion system, from one level to that right above it. In absence of bureaucratic rules, the government could promote any scientist to whatever position. In other words, incentives are high-powered, and faster promotions are expected. Instead of the high-powered (although less credible) incentives from governments, with bureaucratisation scientists will have low-powered incentives (although more credible because they are made by non-political peers) which will be clearly issued in statutes and regulations. With bureaucratisation, scientists will not obtain the maximum payoff (A) because governments will not be able to offer them high monetary rewards or fast promotions to the top levels of administration as a reward for maximum effort. But, at the same time, bureaucratisation also prevents the worst outcome for scientists (C), because there is no option for being betrayed by governments in case of choosing a maximum effort. As a result, bureaucratisation induces scientists to exert a *medium effort*, halfway between the maximum effort and the minimum effort. Scientists will work harder than the minimum effort, because they know that if they work they will have some reward (like a slow promotion), but they will work less harder than when they expect high-powered rewards from government.

At the same time, governments do not enjoy the benefits of a high-powered system of incentives when they decide to bureaucratise, but they also avoid the worst payoff (C). If government could credibly promise it is going to honour trust with a fast promotion or with a big reward, it would obtain a higher effort than the medium effort it can obtain from bureaucratised scientists. However, if that is not the case, scientists will exert a lower effort than bureaucratised scientists. In general, bureaucratisation prevents best and worst outcomes for both players, and it can be seen as a second-best option that is preferred when the best solution involves too many risks for the actors.

The payoff structure of the game may be illustrated with the example of Germany in the 1930s. Before Nazi's seizure of power, there was a high bureaucratisation among scientists. German universities were state institutions and all faculty members were subject to a bureaucratised career civil service (Beyerchen 1977). And there is wide consensus that German government obtained good scientific returns as a result. When Nazis came into power, they developed a high discretional approach for science challenging many of the bureaucratic rules existing so far in Germany.[8]

In terms of the model depicted here, Nazis moved from the predictable lower branch of the tree (Bureaucratisation) to the more unpredictable higher branch (Discretion). That implies that sometimes Nazis could achieve extraordinary results: scientists loyal to the Nazi party, or those who believed they would be properly rewarded, were ready to exert a 'maximum effort' in their research. The Nazis' great scientific and technological achievements in weaponry are an example of that.[9] However, Nazis were not able to obtain maximum effort from the bulk majority of scientists. Apart from the fact that many scientists were either purged or forced into exile, most of those who remain at their positions opted for a 'minimum effort', taking advantage of informational asymmetries: in spite of close monitoring, Nazis did not know for sure which type of scientific breakthrough those scientists could make.

The story of Curt Herzstark, inventor of first pocket calculator, exemplifies the unpredictability of Nazi's closely controlled science.[10] Thanks to his informational advantages, Curt Herzstark did not want to exert a maximum effort to develop a tool that could be nationalized by the Nazi regime — with probably no reward, especially since he was Jew. However, while he was imprisoned in the Buchenwald concentration camp an old competitor and colleague recognized him among the prisoners and, as he knew Herzstark had been previously working in the development of a revolutionarily small calculator, he informed the concentration camp commander of it. Soon, a Nazi official — using his high discretion — took Herzstark aside and proposed him an exchange: "*I understand you've been working on a new thing, a small calculating machine. I'll give you a tip.*

[8] Just two months after the Nazi seizure of power, Hitler issued the "Law of the Restoration of Career Civil Service" (April 7, 1933) through which Nazi officials took over the reins of scientists' tenure, promotion and incentives. As a consequence, many political unreliable and non-Aryan scientists, up to a 25 per cent in some disciplines, like physics, were soon dismissed from their positions (Beyerchen 1977:12-14, and 43-47). The law affected anyone, not only those directly affected by it, "*those of "non-Aryan" descent*", because it became discretional the interpretation of the second condition required to remain civil servant: "*those whose previous political activities did not guarantee that they would at all times unreservedly serve the new state*".

[9] See Wintrobe and Breton (1986) for an extensive analysis of the incentives created by Hitler to induce loyal collaborators to maximize their efforts.

[10] See *The Curious History of the First Pocket Calculator* by Cliff Stoll (2004).

We will allow you to make and draw everything. If it really functions, we will give it to the Führer as a present after we win the war. Then, surely, you will be made an Aryan" (Stoll 2004:86). Under those conditions, rational calculation was difficult to Herzstark: *"'My God!' I thought to myself, 'If I can make this calculator, I can extend my life.' Right there I started to draw the calculator, the way I had imagined it*" (*Ibid.*). Nazis had overcome the informational asymmetry problem: they knew quite precisely which type of discovery Curt could do. And they were ready to induce him through their incentive system.

Herzstark understood that if he could develop the calculator he would enlarge his life at least some months; otherwise, his fate would be the same as the rest of the prisoners. Not lighten of his workload, he was allowed to spend his spare time working on the calculator, later called *Curta*. He worked much harder than what he had worked previously in the camp ('minimum effort') or what he would have worked under standard bureaucratic incentives ('medium effort'). And he could have produced the highest payoff (A) for the Nazi officials if Allies would not have freed the camp before the invention was completed and, eventually, won the war.[11] This example shows the benefits and costs for both government and scientist of government's option for a discretionary science.

Before analysing governments' decision about bureaucratisation, we should see the similarities and differences between Miller's trust game described above and this trust game (the decision of the scientist of trusting or not trusting the government and the posterior government's decision of honouring or not honouring trust). In doing research, the scientist can make a maximum effort (trust) or a minimum effort (mistrust). What does 'maximum effort' mean? We are referring here to two types of research effort that are potentially subject to governments' time-inconsistency problems.

In the first place, 'maximum effort' would be working hard and overtime, similar to what Curt Herzstark did. In the second place, 'maximum effort' would be making asset-specific investments, an effort that is intrinsic to science. Once the asset specific investment has been made, the scientist is in a weaker bargaining position vis-à-vis the government, and the latter may abuse that position of power. On the contrary, 'minimum effort' would mean maintaining a

[11] There is no way to know if camp officials would have kept their word or would have chosen *violate trust*, though this is the most likely choice. Herzstark probably anticipated this outcome. Nonetheless, for him extra time as insurance pay was more valuable than the alternative "being killed tomorrow", even if the commitment to the incentive payoff was not credible at all.

level of effort enough to avoid being fired. This minimum level of effort may take very different forms. It may just be fulfilling the minimum criteria of performance subject to government's monitoring. But it may also imply a sabotage of politicians' interest. That would be, for example, the case of Ludwik Fleck, a Polish epidemiologist who was forced by the Nazis to make a typhus vaccine for the German army. When he and his collaborators discovered that the vaccine was assigned to German troops, they managed to make it totally impotent by using an innocuous substance, which looked like a vaccine and was able to overcome German quality controls.[12] Like in Miller's game, if the scientist chooses minimum effort, the result is an inefficient outcome: both actors would be better off with the other result (maximum effort/honour trust).

If the scientist makes a maximum effort, the government can honour trust, which in this case means rewarding the scientist. And this probably happens in many cases. For instance, many scientists were properly rewarded by the Nazis. Governments are not reneging on the promises — they have given to scientists — all the time. However, in the cases of maximum effort depicted above, the government has an incentive to violate trust, like in Kreps' or Miller's games. Governments have incentives in $t + 1$ to violate trust (i.e. diverting the 50 000 florins promised to the piper) and often do so. That also happens in democratic settings. A close example is that of Mariano Barbacid.

In the yet uncertain Spanish research system the 1996 new conservative government recruited Barbacid, co-discoverer of the human oncogenes and kind-of a national celebrity, to manage the new state-of-the-art Spanish National Cancer Centre (*Centro Nacional de Investigaciones Oncológicas*, CNIO). Hired as a *star signing* in 1998, Barbacid was promised total support from the Government and a €20 million budget a year. However, in its third year, the centre's budget was unexpectedly threatened with a one-third cutback. A journal commented at that time: "*The budget* (…) *is hardly over a 0.1 % of the National Health System, but it surely represents an irresistible temptation for a manager in distress*".[13] Barbacid faced the same threaten again in 2001 and in 2002. He then commented to a

[12] Consequently, under the label 'minimum effort' we sum the *shirking* and *sabotage* activities that Brehm and Gates (1997) carefully differentiate. For sake of simplicity in the theoretical model, we assume that both activities produce, although at different levels, the worst possible outcome for the politician — "C" in the game.

[13] From 19.83 million to 13.82 million Euros that year. See *El País*, June 20, 2000, on the budget reduction, and *El País*, May 28, 1999, on the Government's initial support and the main facilities budget.

journalist: "*We have achieved a great deal, but without a long-term commitment from the Government, our efforts may be wasted*" (…). "*I am rather disappointed because when I came back* [from the USA] *I thought that the CNIO would change the attitude of the government regarding science*".[14]

Up to this point the game is identical to the one used by Kreps or Miller and showed in Figure 1 (page 10). However, the *decisiveness* — in words of Cox and McCubbins (2000) — or capacity for taking a decision that changes the status quo such as reneging on a promise like the one given to Barbacid is limited in some political settings. This limit to the decisiveness of governments is captured by the parameter d (costs for taking decisions) in government's payoff.

Those constraints come from the existence of *separation of powers* within a polity. For example, the incumbent or her political party may be the only relevant actor, and then she is entirely free to violate trust. However, the government can also be only one of the several relevant political actors in a polity. In this case, the government will need an agreement with those other *veto players* — using the terminology of Tsebelis (1995, 2002) — in order to break a promise given to the scientist. Veto players are the actors whose agreement is necessary to introduce a change in the status quo of a political system. They can be the members of another party in a coalition government. If the Spanish conservative party had governed in coalition, it would have been likely that other coalition members had vetoed government's decision to cut Barbacid's budget. In absence of coalition partners, some political regimes have other limits to governmental decisiveness that can be put into action.

For example, in the case of Barbacid, the public opinion acted as a veto player that prevented the government to renege on the promise given. The scientist resisted the first attempt to curve down the CNIO's budget in 2000 when the story went to the press. He managed to use his public visibility and his reputation to change the planned cutback. Early in 2001, he granted a two-full-pages interview to the main Spanish newspaper, *El País*, closer to the social-democrat opposition party.[15] In the interview he underlined the difficulties to do research in Spain and, specially, the troubles he had with the government. As a result of the impact of those statements in

[14] *The ELSO Gazette*, 13, February 2003.
http://www.the-elso-gazette.org/magazines/issue13/features/features3.asp Retrieved November 2005.
[15] *El País*, January 7, 2000: "Si no cumplen, regresaría a EE UU" ("If they do not keep their word, I will go back to the USA").

the Spanish media, the government was forced to cancel the planned cutback.

Therefore, when there are 'veto players' that make governments less 'decisive' (either coalition partners or strong civil societies with free press) it is more difficult for the government to suddenly shift the budget from a department to another if it implies violating trust. In other words, a mayor of Hamelin in a context of multiple veto players would have had more problems to move the 50 000 florins from the 'department of pipers' to other departments.

Very decisive governments [d < (A – B)] have a higher payoff for violating trust (A – d) than for honouring trust (B). Dictatorships, where in principle there are no players who can veto ruler's decisions, would fall into this category. On the contrary, in those polities where the constraints for decision-making are strong enough [d > (A – B)], like well-established democracies, the government will prefer honour trust rather than violate it. The existence of a government with *limited* decisiveness [d > (A – B)] can paradoxically solve the problem of trust behind the model because scientist's choice has changed in relation to Miller's Trust Game: now the options are choosing minimum effort, which gives the scientist a payoff of B, or choosing maximum effort, which gives her the highest payoff A.

Consequently, the initial choice of the government (about bureaucratising or not) depends on its decisiveness. When the limits to the decisiveness are high [d > (A – B)], as the scientist makes the maximum effort the government obtains a higher payoff by choosing 'Discretion' over 'Bureaucratisation'. The payoff for the government in case of 'Discretion' will be B. On the contrary, in case of 'Bureaucratisation', the government obtains (B – x),[16] which is always a lower payoff. Thus, when there is low decisiveness, the government does not need to bureaucratise its scientists. Conversely, when the limits for taking decisions are low for the government [d < (A – B), a situation of *high decisiveness* or relative concentration of powers], as the scientist makes a minimum effort, the government must balance the payoff C of 'Discretion' against the payoff B – x of 'Bureaucratization'. If the costs *x* are not high enough [x < (B – C)], the government would prefer Bureaucratization.

[16] The reason for this payoff is that governments face a cost (–x) for using bureaucratisation: many times they have to pay scientists for life, and they lose flexibility to respond to external shocks demanding, for example, fast changes in the scientific priorities or in the size and composition of scientific units.

To sum up, there is a substitution effect between the separation of powers and the bureaucratisation of a public administration. *In order to induce scientists to exert a level of effort above the minimal one, governments must either possess a system of separation of powers or delegating staff policy to autonomous institutions.*

The game have been assuming up to this point that politicians are in a void, so they can freely choose whether to keep discretion or to introduce bureaucratic rules. And we have seen that, in absence of bureaucratic rules, their introduction implies costs (–x) for the governments: payment to scientists mostly for life, and losing flexibility to respond to external shocks demanding for fast changes in scientific priorities. To complete the theoretical section, it is going to be assumed a different status quo. Imagine for a second that the starting point is, instead of an absence of bureaucratic rules, a situation of high bureaucratisation of scientists. If the elimination of bureaucratic arrangements did not imply costs, the prediction of the model would be that very decisive countries (i.e., dictatorships) would keep the level of bureaucratisation while less decisive countries (i.e., democracies) would change towards a more flexible and discretionary approach. However, *de-bureaucratisation* processes involve costs for governments, because they may imply the elimination of, for example, secure tenure or other bureaucrats' privileges, and the reduction of the level of autonomy enjoyed by certain administrative Corps. For instance, most civil service reforms in Western European countries aimed at reducing bureaucratic autonomy have been opposed by intense public service unions' mobilisations.

As a result, there must be contexts where the costs of de-bureaucratisation are so high that parameter x in the game may have a positive sign: it could enter adding to payoff B instead of subtracting And government, facing a choice between a high bureaucratisation (which gives it a payoff of B + x) and recovering some degree of discretion (which gives it a payoff of B), will tend to keep the actual levels of bureaucratisation. To sum, the following hypotheses may be derived from the model developed in this section:

> <u>Hypothesis 1</u>: Ceteris paribus, when governments are not very decisive [$d > (A - B)$] bureaucratisation of scientists is not necessary, and if the costs of an eventual de-bureaucratisation are not high [if $B > (B - X)$], governments will choose a high level of discretion in scientific policy. In this case, the outcome of the game

would the most socially efficient: **Discretion/ Maximum Effort/ Honour Trust**.

Hypothesis 2: Ceteris paribus, when governments are not very decisive [d > (A – B)], bureaucratisation of scientists is not necessary, but, if the costs of an eventual de-bureaucratisation are high [(B – X) > B], governments will keep the high level of bureaucratisation. The outcome of the game would be the second-best one: **Bureaucratisation.**

Hypothesis 3: Ceteris paribus, when governments are very decisive [d < (A – B)], bureaucratisation of scientists is necessary, and, if bureaucratisation costs are not high [x < (B – C)], there will be a bureaucratisation of scientists. The outcome of the game would be the second-best one: **Bureaucratization.**

Hypothesis 4: Ceteris paribus, when governments are very decisive [d < (A – B)], bureaucratisation of scientists is necessary, but, if bureaucratisation costs are very high (x < B – C), there will not be bureaucratisation of scientists. The outcome of the game is the worst one: **Discretion / Minimum Effort**.

Table 1 summarizes the predicted scientific productivity according to the four theoretical hypotheses. It shows scientists' incentives under different combinations of regime type (dictatorship or democracy) and type of scientific contract (more or less bureaucratised). In sections 5 and 6, an empirical contrast of these hypotheses is provided. Section 5 analyses the different scientific outcomes of the two types of dictatorships: those who have bureaucratised its scientists and those who have not. The empirical contrast shows how, for dictatorships, the more bureaucratisation, the higher the scientific productivity of a country. Section 6 studies the differences in scientific productivity across democracies. As predicted by the theoretical model, the effect of bureaucratisation over scientific productivity is the contrary than for dictatorships: the more bureaucratisation, the lower scientific productivity.

Table 1.– Predicted Scientific Productivity in function of the regime type and the level of bureaucratisation.

	Low Bureaucratization of Scientists (politicians enjoy more Discretion)	High Bureaucratization of Scientists (politicians enjoy less Discretion)
More Decisive Governments (Dictatorships)	a) Hypothesis 4: Minimum Effort. **Low Scientific Productivity**	b) Hypothesis 3: Medium Effort. **Medium Scientific Productivity**
Less Decisive Governments (Democracies)	c) Hypothesis 1: Maximum effort. **High Scientific Productivity**	d) Hypothesis 2: Medium Effort. **Medium Scientific Productivity**

4 Bureaucratization, scientific productivity, and dictatorships

The relationship between regime type and scientific productivity analysed in this paper is based on a two-step argument. In the first step, the ruler decides the type of scientific contract: more or less bureaucratisation of scientists. In the second step, the type of contract induces scientists to choose their 'research effort' and this level of effort ultimately affects the scientific productivity of the country.

For the case of dictatorships, the first step implies that those dictatorships where the costs of bureaucratisation are no very high will tend to establish bureaucratised contracts, while in those dictatorships where those costs are high enough rulers will tend to keep a high degree of discretion. And the second step entails that dictatorships with bureaucratised scientific contracts will tend to perform better in terms of scientific productivity than dictatorships with high discretion. The first step is difficult to contrast from a quantitative point of view and in this section we will provide qualitative examples of how some dictatorships, facing problems of credibility with scientists, decide to bureaucratise them, while others, facing the same problems of credibility, decide not to do that because the costs are too high in relation to the potential benefits. On the contrary, a quantitative analysis of the second step is provided and one can observe how, controlling for the money spent in science, those dictatorships with high levels of bureaucratisation have higher scientific productivity.

4.a Why some dictatorships bureaucratise their scientists

Why do not all dictatorships establish bureaucratised contracts with scientists if they know that bureaucratisation gives them a higher scientific productivity? In the theoretical model we have used the parameter x to symbolize the costs rulers must pay for bureaucratisation. When those costs x are lower than the difference between the payoff with bureaucratisation (a scientific productivity type 'B': medium) and the payoff without (a scientific productivity type 'C': low), then rulers will decide to bureaucratise. Costs x may be assumed to be quite similar across countries, but the difference between payoffs B and C may vary a lot in function of what political economy authors define as the dictator's strategy for survival in office (Olson 1993, Bueno de Mesquita *et al.* 2003).

As Robert Bates (2000) suggests, the study of Modern Europe Absolutism can shed light on some problems that some African states are having nowadays. Early Modern Absolutisms contributed with active public policies to the economic development of their societies while kleptocrats do not show much interest in providing public goods. For Bates, with few exceptions, African governments are less likely to view their economies as a strategic resource to survive in office. Contrary to Louis XIV — who needed to develop his economy if he wanted to raise taxes in order to have an army able to win wars abroad and to suffocate rebellions within French borders — Mobutu did not need to do so, because he had many natural resources and he was receiving foreign aid from the US and other Western countries.

The survival strategy of Mobutu-type rulers does not depend on the efficiency of policies — and thus increasing scientific productivity is not an asset for their survival in office. The main risk those rulers are facing is internal conspiracies within their own rank-and-files.[17] On the other hand, back to at least Modern European Abso-

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[17] As Acemoglu et al.(2004) have identified in Mobutu's and Trujillo's regimes, instead of inducing public employees to deliver public goods — such as science —, those rulers tried to "divide-and-rule" their administrations in order to avoid public employees' collusion and plots against them. As a result, the level of office rotation within Mobutu's and Trujillo's administration was extraordinarily high.

lutism, there are examples of rulers who considered that their survival depended critically on the economic (and thus scientific) development of their countries. Two of the most known absolutist rulers were precisely the creators of two of the first state institutions of employed and salaried scientists: in 1666, Louis XIV — under the advice of Colbert — established the French Academy of Sciences and in 1700 Frederick II of Prussia put in place the Berlin Academy of Sciences (Fisher and Lundgreen 1975:546-549). From the beginning the scientists of the French Academy enjoyed a remarkable level of bureaucratisation and, soon afterwards, their Prussian counterparts would also achieve an important degree of autonomy from politicians' interferences in science.

In sum, one could classify dictatorships in those whose rulers' survival in office mainly depends on the provision of public goods like overall economic performance and thus they could be interested in increasing scientific productivity; and those where rulers' survival in office mainly depend on the provision of private goods and have no interest in scientific outcomes. To illustrate this difference in survival strategies, we are going to depict briefly the evolution of science under Franco's regime (1939-1975) in Spain.

Francoism can be divided into two periods. During the first one (1939-1957), cabinets chose a very discretionary approach to science. In the aftermath of the Spanish Civil War (1936-39), Franco's rule was based on repression and on the loyalty of the ruling elite's factions. In the university, loyal scholars replaced those dead, purged or exiled professors, nearly half, during the early 1940s. Although the university traditionally recruited its members through a classic career system, the regime implemented in its first years the so-called "patriotic examinations" that primarily evaluated the loyalty to the *Francoism* ideological principles. The aim of this selection, explicitly expressed in the University Ordering Law (1942), was ideological control.[18] In an environment of total uncertainty, scientists exerted a minimum effort and the result was a very low scientific productivity (Fernández-Carro 2002).

[18] This Law put the university under the National-Catholic ideals and the *Falange*'s mainly fascist principles: *"Third Article. The University, inspired by the Catholic sense, inherent to the Spanish academic tradition, will bring its teaching to the catholic moral and dogma, and to the rules of the current Canon Law. Fourth Article. The Spanish University, in harmony with the ideals of the National-Syndicalist State, will adjust its teaching and its educational tasks to the Movement programmatic concerns"*. From University Ordering Law: *Ley de 29 de julio de 1943 sobre Ordenación de la Universidad española, Boletín Oficial del Estado 212*, July 31st, 1943, pages 7.406 to 7.431. The Movement (*Movimiento* or *Movimiento Nacional*) dubs the ruling coalition.

Government scientific centres were also explicitly controlled. Although Theology was the only addition to the scientific program in the new CSIC,[19] it exerted the ideological control of the scientists along the ideals of National-Catholicism and of a vindicated imperial scientific tradition.[20]CSIC was also intended to help the development of a self-sufficient national industry, imitating the Nazi German autarchy model. 'Unshakeable loyalty' to the new state principles was a requisite to become a CSIC scientist and researchers were not under the civil service status.[21] Except for those committed with the regime from the beginning, the remaining scientists were limited opportunities to direct research, to compete for senior positions, or to direct a laboratory.[22] As a result, again, productivity was extremely low. As González Blasco and Jiménez Blanco (1979:100-) remark, after the CSIC was established Spain had not a Nobel laureate in science any more. Science in early Francoism suffered scientists' mistrust of government. As far as prizes and positions were not related to performance, the incentives for the remaining scientists were low and the best response was to limit effort to a minimum.

Nevertheless, Franco's survival strategy changed during the 1950s. After the sunken economic situation had produced serious riots and demonstrations in several cities in 1951, Franco shifted his policy priorities towards the provision of public goods.[23] He appointed several ministers known as *the Technocrats*, uncommitted with the fascist ideology, who began to reform the Spanish economy to a market-oriented model. They began the so-called *Desarrollismo* — a period of fast economic development. The reforms included a transformation of the Public Service to make it more professional and

[19] The *Consejo Superior de Investigaciones Científicas*, Higher Council on Scientific Research, is the main research institution in Spain. Created in 1939, it merged some former public and private institutions.

[20] In a speech to the general council of the CSIC, General Franco stated explicitly its mission: "*The Spanish regime does not hinder or hamper the legitimate scientific freedom but wants and demands that the research activity subordinates and adjust itself to the spiritual and material needs of the country (…). This is all about our yearning for empire*" (CSIC Annual Report, 1946-47). See also Santesmases and Muñoz (1993a: 15-16).

[21] The CSIC had not regulations on labour contracts until 1951 (Decrees of July 13th, 1951, and 6th June, 1958).

[22] Although the disciples of Ramón y Cajal — Nobel laureate in Medicine — had enjoyed a good international reputation before the war they were both dismissed (for instance Francisco Tello, director of the Laboratory of Biological Research, who was purged) or were relegated and prevented from having senior positions in the CSIC (Santesmases, 1998:323).

[23] Given the medium-long term threat that an underdeveloped economy could pose on Franco's survival in office, his Minister Martin Artajo had suggested that *"the moment is appropriate for opening a new stage"* (quoted in Garcia Delgado 2000:142)

career oriented.[24] Government scientists' career, in the CSIC and in other new laboratories, came under the Civil Service Act and it became life-long. In other words, Spanish scientists became bureaucratised and more autonomous from politicians' interferences and scientists moved from minimum to higher levels of effort. There are not reliable bibliometrical accounts of the period, but the SCI database records a sharp increase in scientific productivity at the end of the dictatorship: 831 publications in Science and Social Sciences in 1973 and only 9 publications in the period until 1972.

4.b Quantitative evidence of bureaucratisation and scientific productivity in dictatorships

The historical evolution of Franco's rule shows how dictators, when their survival depends on fostering economic development, choose to tie their hands in the management of scientists through what has been called here bureaucratisation. If the predictions of the model are correct, one should observe a higher scientific productivity in those dictatorships that bureaucratised their scientists than in the ones that did not so.

One of the best proxies to the scientific productivity of a country is its Science Production — measured as the number of publications recorded in the Science Citations Index database (SCI).[25] Since the science production depends on the country inhabitants and we must divide Science Production by the total population of the country.[26] There is a great consensus in the literature that the degree of economic development of a country is the most important determinant of its scientific productivity (Price 1963; Cole and Phelan 1999:14). Given that agreement, for Cole and Phelan (1999:15), the relevant question that should be answered nowadays is not the degree of impact of GDP over scientific productivity, but why there are countries — like Israel — which produce far more science than what one should expect according to its wealth, while there are others —

[24] A new decree on Civil Service was stated that normalized the procedures: *Decreto-Ley de 25 de Febrero de 1957 sobre Reorganización de la Administración Central del Estado*.

[25] Cole and Phelan (1999) discuss extensively why SCI is the best feasible alternative to use as a proxy to a country's science production. It could also be argued that some of SCI publications do not come from state scientists but from private sector scientists to whom, obviously, our theoretical predictions do not apply. However, private firms publish very basic science papers — ranging from almost none in developing countries and only between a 6% and a 9% in developed ones (Hicks 1995). The proportion may increase in some areas, mostly those close to application, and related with physics and chemistry, but nevertheless it is a small fraction of a country's total publications.

[26] More accurately, it depends on the number of scientists, but data are scarce and unreliable; following Cole and Phelan (1999), we use the total population as a proxy.

like Italy — which produce far less scientific achievements than those expected according to its GDP.

We want to address this question in this section. Besides, given the low number of observations in our regressions both for dictatorships and democracies — and, therefore, the reduction in degrees of freedom that comes from including many control variables — there is an additional reason to introduce country's degree of development within our dependent variable.[27] As a result, we define Scientific Productivity of a Country (SPC) as Science Production by the Gross Domestic Product of that country.[28] In other words, SPC is an artificial construct aimed at measuring the capacity of a country to produce science independently of its population and wealth. SPC is the capacity a country has to produce science controlling for its population and level of development. The proposition of our theoretical model is that this scientific capacity may be affected by changes in scientists' type of contracts.

As a proxy for the bureaucratisation of scientists in dictatorships we use the Weberianess Score developed by Evans and Rauch (1999), which is the most comprehensive attempt to build up a quantitative index of bureaucratisation for non-OECD countries. The Weberianess Score and the other indexes of bureaucratisation we use for democracies are similar since they are focused on non-political recruitment or promotion and long-term career rewards for the public servants. Therefore, they are coherent with our model because they try to capture the autonomy of civil servants in relation to politicians. However, we need to emphasize that those indicators are just proxies because their authors do not restrict their focus to scientists' bureaucratisation but they study general public service organization. We assume that public researchers and academics in public universities enjoy the same recruitment and incentives systems than their colleagues in other sectors of the public administration, but it might not be always the case.[29] The Weberianess Score — a continuous

[27] Nevertheless, the results do not change if we use country's science production divided by population as a dependent variable and the level of economic development as an independent variable. It simply decreases the degrees of freedom in our already small-N statistical analysis. For that reason, we prefer to control for GDP in our dependent variable.
[28] It is equivalent to dividing Scientific Productivity (by population) by per capita GDP because 'population' is dividing both in the numerator and in the denominator. Real GDP figure is taken from the Penn World Tables (constant 1996 international $).
[29] Public research centres and universities often have personnel policies that differed of those of the public administration, for instance. But there are no datasets specifically devoted to science public bureaucracies. Nevertheless, when a Civil Service Act exists within a country, in general, scientists are covered by

variable which ranges from 0 to 14 — measures bureaucratic autonomy for 35 developing countries around 1993 and, since in this section we are interested in dictatorships, we have removed the democracies from the sample.[30]

The model 1 in Table 2 shows the effect of Bureaucratisation over the scientific productivity of a country. In spite of the relative low number of observations (28), Bureaucratisation exerts a positive significant impact on the quality of science. Therefore, it seems that the type of contract between government and scientists — bureaucratised or not — makes a difference in the scientific productivity of a country (the science production of the country according to its population and economic development).

In the literature on developed countries,[31] scientific productivity has been found to be dependent also on the country's expenditure in research and development (R&D) and on its stocks in human capital — and we use control variables for those factors in our posterior analysis of democracies. However, the unavailability of reliable data on dictatorships on those variables prevents controlling for the money invested in science and for countries' human capital. In spite of that, the existence of some data on R&D for some countries and some years should allow us undertaking control tests — although limited — as the ones deployed in models 2 and 3. We take data on Expenditure from the World Development Indicators, which collects the percentage of the GDP devoted to scientific activities.

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it. Therefore, we consider that the indexes of civil service' level of bureaucratisation are good proxies to scientists' level of bureaucratisation.

[30] The Score was Evans and Rauch's original list includes *Argentina, Brazil, Chile, Colombia, Congo Democratic Republic, Costa Rica, Dominican Republic, Ecuador, Egypt, Greece, Guatemala, Haiti, India, Israel, Ivory Coast, Kenya, Malagasy Republic, Mexico, Morocco, Nigeria, Pakistan, Peru, Philippines, Portugal, Singapore, South Korea, Spain, Sri Lanka, Syria, Taiwan, Thailand, Tunisia, Turkey,* and *Uruguay*. We have removed those countries that had a score lower than 2.5 as an average of Freedom House's freedom ratings between 1972 and 1992 (Costa Rica, Israel, Greece, Portugal, Dominican Republic, and Spain). The lack of information in some of the independent variables limits the final number in the analysis to about 25 countries.

[31] See Cole and Phelan (1999) for a review of the main findings.

Table 2.– Determinants of Scientific Productivity in Dictatorships

Model	1	2	3
Variables			
Constant	1.935 (2.540)	*-6.275* *(4.899)*	*7.438*** *(2.701)*
Bureaucratisation (Weberianess Scale)	0.762** (0.330)	*1.593** *(0.739)*	*-0.472* *(0.366)*
Expenditure in Science 1990		*1.459* *(4.23)*	
Expenditure in Science 2000			*7.639**** *(1.587)*
R^2	0.170	0.725	0.675
N	28	9	16

Unstandardized Regression Coefficients; Standard Errors in parenthesis
*p < 0.10 , **p < 0.05 , ***p < 0.01 (two-tailed)

The dependent variable is **Scientific Productivity of Countries (by Real Constant GDP) in 2000**

There are two major problems that question the validity of those controls. First, the number of observations in control models 2 and 3 is very low (9 and 16 respectively) to extract any relevant conclusion. Secondly, the independent variables in models 2 and 3 do not show a consistent behaviour: while the significant impact of Bureaucratisation makes no-significant the 1990 Expenditure in Science in model 2, the effect of the 2000 Expenditure in Science makes Bureaucratisation no-significant in model 3. This behaviour points out to problems of multicollinearity, confirmed by the high bivariate correlations existing between Bureaucratisation and the available measures of expenditure (0.7 and 0.8 respectively). We would need further observations to control properly the effect of expenditure and we would also need further theoretical exploration — which is out of the scope of this paper — on the possible causal relationships between bureaucratisation and expenditure in science.[32] To sum, in spite of the data limits, it seems that our independent variable, bureaucratisation, acts according to the theoretical prediction and it exerts a positive effect on the scientific productivity of dictatorships.

5 Bureaucratization, scientific productivity, and democracies

Similar to dictatorships, there are two steps to be empirically contrasted in democracies: first, the decision of governments over which type of contract with scientists they should have; and, secondly, whether democracies with lower bureaucratisation perform better in terms of scientific productivity than democracies with high bureaucratisation. Again, the first step is difficult to contrast from a quantitative point of view and in this section we will provide fragments of evidence of how some democracies that inherit highly bureaucratised scientific contracts decide to de-bureaucratise their science system. On the contrary, a quantitative analysis of the second step is provided and one can observe how, contrary to what happened with dictatorships, controlling for the money spent in science and a measure of country's human capital, democracies with lower levels of bureaucratisation have higher scientific productivity.

5.a Why some democracies de-bureaucratise their scientists

As a result of the theoretical model deployed here, we expect that democratic governments do not need bureaucratisation to prevent scientists to undertake a 'minimum effort' in research. However, if the status quo of a democracy is bureaucratisation,[33] democratic rulers will have to balance the potential benefits of a de-bureaucratisation (the difference between a 'maximum research effort' and the 'medium research effort' under bureaucratisation) with its costs: the potential opposition of some scientists who enjoy secure tenure and other privileges of autonomy.

[32] Rauch's (1995) findings may be useful in this sense. He shows how higher levels of bureaucratisation — measured this time through the adoption of Civil Service — led to allocation of greater resources of US cities' governments to long-gestation period projects such as infrastructure during the Progressive Era (1900-1920). Something similar could be happening in dictatorships, but further research is needed to falsify it.

[33] The explanation of the historical roots of the bureaucratisation of scientists in contemporary democracies is out of the scope of analysis of this paper. In some cases it should be traced back centuries ago. However, in line with the arguments of credibility deployed here, we have seen that the bureaucratisation of scientists in both France and Germany started to take shape in their 18th century authoritarian regimes with the enactment of semi-autonomous Academies of Science. In the case of another contemporary democracy like Spain, we have also seen that bureaucratised contracts in research centres were developed under an authoritarian regime as well. As a result, past periods of authoritarian rule may explain the adoption of a bureaucratised science in many contemporary democracies.

In most countries, scientists — like other civil servants — have shown strong resistances against any attempt of de-bureaucratising them (Peters and Pierre 2001:1-11). There is strong evidence that shows how opposition platforms have been created against many attempts of changing the status quo of scientists, university professors or other civil servants (Pierre 2001:133). Conversely, in other contexts, costs of reducing bureaucracy have tended to decrease for different reasons: for instance, voters could not support an overprotected and less efficient bureaucracy with some power to change decisions from a democratically elected and checked government.

The United Kingdom de-bureaucratised its science through partial or total privatisations of public laboratories.[34] Even though the profile of protests was low and some scientists welcomed the opportunity to compete for better salaries — coherently with our model — resistance to change came both from scientists and the civil society who feared a loss of independence in public advice.[35]

5.b Quantitative evidence of bureaucratisation and scientific productivity in democracies.

Now we move to the second step, the impact of bureaucratisation over scientific productivity in democracies. Table 3 and Table 4 show the results obtained by two different proxies to bureaucratisation in democracies: *Closed-ness* and *Bureaucratization*. Results are similar in both cases. We use the same dependent variable as for dictatorships — the Scientific Productivity of a Country — and we add variables to control by *expenditure in R&D* and the *country's level of human capital*.

In Table 3, the proxy to bureaucratisation is the variable *Closed-ness*, which was prepared by Kai-Uwe Schnapp (2000) using data from Auer, Demmke and Polet (1996).[36] *Closed-ness* — a continuous variable that ranges from 1 to 6 — portrays the career systems of 17 European countries in the 1970s, 1980s and 1990s and its purpose is capturing the degree of autonomy of civil servants in relation to politicians. Open civil service systems are those systems where politicians enjoy more discretion in managing public employ-

[34] Boden, Cox, Nedeva and Barker (2004).

[35] In the failed attempt of full privatisation of the Forensic Science Service, the police opposed for this reason (Deborah Cox, personal communication).

[36] Schnapp calls it *openness*. We have called it *closed-ness* because we have inverted its values to make the comparison with the other empirical analysis easier.

ees; closed civil service systems are those whose public employees are 'closed' to politicians' interferences. A paradigmatic example of the latter would be the already mentioned organizational structures based on very autonomous administrative corps like those existing in France or Spain. Examples of the former would be the Netherlands, Sweden or the UK.

Table 3.– Determinants of Scientific Productivity in Democracies (I)

Model	**1**	**2**	**3**
Variables			
Constant	59.396*** (6.144)	38.622*** (11.778)	34.769* (16.827)
Bureaucratisation (*Closed-ness*)	-5.554*** (1.573)	-3.804** (1.679)	-3.562* (1.883)
Expenditure in Science 2000		7.516** (3.748)	7.487* (3.874)
% of Population with Tertiary Education			0.194 (0.585)
R^2	0.454	0.576	0.579
N	17	17	17

Unstandardized Regression Coefficients; Standard Errors in parenthesis
*p < 0.10 , **p < 0.05 , ***p < 0.01 (two-tailed)

The dependent variable is **Scientific Productivity of Countries in 2000**

The model 1 presents the results without any control variable and bureaucratisation exhibits a highly significant effect on scientific productivity. As predicted in the theoretical part, this effect is *negative*: the more bureaucratisation in democracies, the less scientific output. The availability of more reliable data for democracies than for dictatorships allows us to introduce more sophisticated controls in this case. In models 2 and 3, we include two independent variables which, according to the literature and according to the analysis of this dataset, show -on their own- a significant and positive effect on scientific productivity: Expenditure in Science for the year 2000 (again from the World Development Indicators) for controlling the quantity of the GDP actually devoted to science, and the Percentage of Population with Tertiary Education, which is the available human capital variable that correlates most with science production. Contrary to what happened in dictatorships, the bivariate correlations among the independent variables are relatively low (in all cases < 0.6) and do not point out to any serious problem of multicollinearity.

The inclusion of the Expenditure in Science in model 2 reduces the significance of Bureaucratisation, but the latter keeps an independent and significant (at 5%) effect on scientific output. Model 2 can be interpreted in this way: an increment of one point of Closedness, in a range of 1 to 6, decreases in 3.8 the number of scientific papers by unit of country's wealth in 2000, controlling by Expenditure. To complete the picture, model 3 includes a second control variable — a proxy of human capital. With the inclusion of the new variable, bureaucratisation and expenditure in science present slightly lower coefficients to those in model 2 and they have lost some significance (falling from 5% to 10%). Nevertheless, both keep their significant effect (negative in the case of bureaucratisation and positive in the case of expenditure) on the scientific productivity — which is especially remarkable given the decrease of degrees of freedom in an analysis with only 17 observations.

One of the important results of model 3 is that the percentage of population with tertiary education — which showed a strong significant effect on scientific productivity in previous studies on the field and which exhibited also here a significant impact when it was included as the only independent variable — loses completely its significance when expenditure and bureaucratisation are included. Although no definite conclusions may be extracted from small-N analysis like the one in Table 3, it seems that the bureaucratic nature of the scientific contract may affect the scientific outputs of a country while reducing the effects of other variables that have received more attention in the literature.

These results are more firmly confirmed in the analysis shown in Table 4 where the proxy to bureaucratisation is a combination of two indexes of public administrations' human resources practices created by an OECD team (OECD 2004: 17). They capture the *De-bureaucratisation* of public administrations: up to which extent OECD countries have substituted new public management practices (more flexibility and more discretion for political managers) for traditional bureaucratic contracts (more rigidity and more predictability in civil servants' careers).[37] We have added the two indexes of de-bureaucratisation and have reversed the final values in order to have a measure of the degree of bureaucratisation of each country — instead of de-bureaucratisation — to compare better this table with the previous ones.

Table 4.– Determinants of Scientific Productivity in Democracies (II)

Model	**1**	**2**	**3**
Variables			
Constant	15.228** (6.168)	7.881 (6.772)	7.488 (7.798)
Bureaucratisation (OECD Bureaucratisation)	-1.864*** (0.501)	-1.538*** (0.497)	-1.519*** (0.537)
Expenditure in Science 2000		6.217** (2.947)	6.070* (3.299)
% of Population with Tertiary Education			0.055 (0.915)
R^2	0.339	0.435	0.435
N	29	29	29

Unstandardized Regression Coefficients; Standard Errors in parenthesis
*p < 0.10 , **p < 0.05 , ***p < 0.01 (two-tailed)

The dependent variable is **Scientific Productivity of Countries in 2000**

Generally speaking, the results in Table 4 are very similar to those in Table 3. The major difference is that the proxy to the bureaucratisation of scientists used here remains highly significant —

[37] The two OECD indexes of public administrations' human resources practices are *individualisation* and *delegation*. "*Individualisation*", explain the authors, "*is measured by the degree to which the management rules and practices vary according to the individuals and less according to the group*" (OECD 2004: 17) and focuses in the way incentives are applied to public servants. "*Delegation*" levels *are measured by where decision making power is located, from the central bodies* (normally out of the control of politicians) *to line departments and lower administrative levels* (where elected politicians enjoy more discretion). We have combined both indexes for sake of simplicity, but it is important to remark that the results are almost identical if we use any of them as proxy to bureaucratisation instead of their combination.

at 1% — even when the two control variables are included (model 3)[38]. Like in Table 3, the inclusion of the type of contracts (bureaucratisation) between government and scientists diminishes the explanatory power of two variables traditionally associated with scientific productivity. In the first place, bureaucratisation decreases — even to a greater extent than in Table 3 — the significance of the money spent in science (Expenditure in Science 2000); and, second, it completely eliminates the effect of the available human capital variable which is more highly correlated with scientific productivity (Percentage of Population with Tertiary Education).

6 Conclusions

In this paper, the relationship between regime type, administration type and policy outcomes (in particular, science policy outcomes)[39] has been closely analyzed. The paper complements the work of Fernández-Carro (2002), who focuses on the relationship between regime type and science policy outcomes. He shows theoretically and empirically how democracies provide a better environment for scientific productivity. This paper also complements the one by Lapuente-Gine (2005), who analyses the relationships between regime type and administration type. He develops and tests a game-theoretic explanation — building up from Miller (1992) and Kreps (1990) — on why regimes with high decisiveness (like dictatorships), when interested in providing public goods, tend to bureaucratise their public administrations.

This paper brings the three elements together — regime type, administration type and policy outcomes — in a game-theoretic explanation that produces falsifiable propositions that are subject afterwards to empirical contrast. As Moe (1997) points out, formal models applied to understanding bureaucratic structures tend to be too complex, and their implications threaten to be so hedged about by qualifications and conditions that they are either trivial or difficult to interpret or apply. On the contrary, the model presented here is simple, with propositions not dependent on complex qualifications and conditions. The propositions are easy to interpret and test, as it is shown in the empirical section of the paper. Despite being simple, they are not trivial, since they contain two up to a certain extent counter-intuitive findings: first, when rulers are interested in produc-

[38] This is also due to the fact that the number of observations has increased from 17 (Table 3) to 29 (Table 4)

[39] Science policy outcomes allow better cross-country comparisons than other policies thanks to the existence of international data-sets such as the Science Citations Index database (SCI).

ing science, the more powerful a ruler is, the more she or he will tend to bureaucratise her or his administration; and, second, bureaucratisation produces an opposite effect on policy outcomes depending on the political regime, it increases the efficiency of policies in dictatorships and decreases the efficiency in democracies.

In sum, this paper shows that there are differences in the scientific productivity between dictatorships and democracies. But there are also differences within political regimes. This work contends that those differences are due to the effect of an intermediate variable, the bureaucratisation of scientific contracts. Through this mechanism dictatorships reduce the high uncertainties and time inconsistencies inherent to the relationship between powerful principals (governments) and agents that need to make high asset-specific investments (scientists). Bureaucratisation is a second-best solution to prevent the 'minimum research effort' expected in less credible environments, like dictatorships. But also precludes the 'maximum research effort' expected in more credible environments like democracies. In other words, bureaucracy makes science more productive when governments are not reliable, but it makes science less productive when governments are trustworthy.

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