Regulating the revolving door of regulators

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Abstract

This paper analyzes the effects of the revolving door, focusing not only on the relationship between regulators and firms, but analyzing whether regulating the revolving door is optimal from the point of view of society.

This paper examines the tradeoff between these two elements linked to the revolving door: 'lack of competence' and 'greed'. On the one hand, the revolving door enables government to hire regulators which are highly qualified individuals due to their prospect of a high future compensation package.

On the other hand, the revolving door enables regulators to be greedy, and receive revenues after their term in office. There are two distinct motivations for being greedy: 'capture motive', which is unlawful and 'abuse of power', which is legal, although unethical.

This paper highlights that distinguishing whether a behavior is unlawful or unethical is of utmost importance for analyzing the optimal policy concerning regulators. Models of capture require that the revolving door should be regulated to prevent corruption, while models of abuse of power, in which regulators create 'bureaucratic capital', lead to allowing the revolving door practice.

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I. Introduction

This paper analyzes whether the revolving door should be regulated. The "revolving door" is a prevalent practice in developed countries, in which heads and top officials of state agencies, after completing their bureaucratic terms, enter the very sector they have regulated.

There is rising interest in whether the practice of the revolving door affects the balance of power between regulators and firms, and therefore should be reformed. Zingales (2017, p.127) who discusses the power of firms writes:

> The size of many corporations exceeds the modern state... To fight these risks, several political tools might be put into use, increase in transparency of corporate activities, improvements in corporate democracy, and better rules against revolving doors.

Zingales suggests that the revolving door should be reformed, to reduce the power of firms. Should it indeed be reformed? This paper analyzes the effects of the revolving door, focusing not only on the relationship between regulators and firms, but analyzing whether regulating the revolving door is optimal from the point of view of society.

There are two main ailments linked to the behavior of regulators, and both are related to the revolving door. The first is that some of the decisions taken by regulators are just erroneous due to the incompetence of the bureaucrat. Some regulators who have been appointed for this important job are not qualified and lack the know-how to do it properly.

We denote this problem as 'lack of competence'. The problem can arise because the salary associated with the job is not high enough to attract high-quality and competent individuals. They prefer to work in the private sector. In this paper, I show that this problem can be attenuated by allowing the use of the revolving door.

The second problem is that some decisions of the regulator are inaccurate, and it is not due to lack of competence, but to 'greed'. The regulator acts to increase her future compensation by issuing regulation, or by inaction. Greed can take many appearances. Let us focus on two main manifestations of greed: 'bribe-capture', and 'abuse of power'.

'Bribe capture' is when the regulator takes a decision in favor of a specific firm, in order to receive a payment. That is not legal. That type of behavior has been analyzed by capture theory.

The literature on the capture theory put forward by Stigler (1971), Peltzman (1976), Eckert (1981), and Laffont-Tirole (1996) perceives the power of the regulator as leading to bribery. The regulator is 'captured' during her term in office, and is then compensated after taking the revolving door and working for the firm that bribed her. So, the regulator who is supposed to prevent monopolistic power behaves in her own interest, and not in the interest of the people.

This behavior is illegal in most countries, so should we believe that this use of the revolving door is frequent in developed countries? This behavior entails collusion between a firm and a regulator, so it is somehow peculiar that the regulator will wait until the end of her term in office to be compensated. There are more effective ways for receiving bribes.

Moreover, the strongest power that firms have over a regulator is not bribes but threats of damaging her reputation and raising doubts about her competence. So, regulatory capture is not a primary motive which could explain the revolving door.

Which motive can then explain the frequent use of the revolving door? 'Abuse of power' by creating 'bureaucratic capital'. This is the second manifestation of greed, making money but without being corrupt.

Indeed, regulators can increase their lifetime income by producing 'bureaucratic capital' while in office. Bureaucratic capital are all the rules and regulations, enacted somewhat unnecessarily by the regulator. It also includes her achievement of accumulating an ample *Rolodex* by investing time in good relationships with the lower-level bureaucracy, ties which will benefit her in the future. As the architect of these rules, regulations, and relationships, the regulator has knowledge of the system, including any loopholes that might exist.

This behavior is unethical and should be discouraged. But it is not illegal. The difference between ethical and legal behavior is essential. Public policy related to unlawful behavior should eradicate it. What about unethical behavior? The revolving door leads to unethical behavior but not to illegal behavior. Should we reform it so that regulators may not work in firms they have regulated?

This paper highlights the main difference between unlawful and unethical behavior. Unlawful behavior may not be allowed even if there are also some benefits from allowing it. In opposite, unethical behavior can be allowed if there are benefits to this unethical behavior. This is exactly the case with the revolving door, as we show in this paper.

 This paper examines the tradeoff between these two elements linked to the revolving door: 'lack of competence' and 'greed'. On the one hand, the revolving door solves the

problem of hiring competent and qualified regulators in the civil service. The prospect of high future compensation package, after passing through the revolving door enables to attract competent workers into the civil service.

On the other hand, the revolving door enables regulators to be greedy, and receive compensation after their term in office. The motive of 'greed' is analyzed in two diverging motivations related to the revolving door: the first is capture of the regulator, which is unlawful and should therefore be eradicated. In this case, the existence of a tradeoff is irrelevant for the choice of optimal policy, and the revolving door should not be allowed since it leads to unlawful behavior.

The second motivation related to the revolving door is the abuse of power taking place when the regulator creates bureaucratic capital. This motivation is unethical, but not illegal. Since there is a tradeoff between the positive effects of the revolving door (highly qualified regulators) and the negative effects of the revolving door (bureaucratic capital), the optimal solution is to allow the revolving door practice. Some greedy behavior should be accepted.

In other words, this paper highlights that distinguishing whether a behavior is unlawful or unethical, is of utmost importance for analyzing the optimal policy concerning regulators. Models of capture require that revolving door should be regulated to prevent corruption, while models of abuse of power, in which the regulator creates bureaucratic capital, leads to accepting the revolving door and unethical behavior.

The model is presented in part III. The model incorporates the two problems of regulation – competence and greed. The model shows that we should not completely avoid unethical behavior. Part IV concludes. But why would an economist pay attention to issues of ethics? That is the topic of the next section.

II. Ethics and Economics

The literature on economic development, which has analyzed the importance of the legal system has shown that lack of 'property rights' in particular, and the legal system in general, block economic development. In other words, the existence of a trustworthy legal system is the *sine qua non* for economic development.

What of social norms and ethics? While the importance of a good legal system is admitted by all economists, ethics have never been part of the economic game. Although Adam Smith was head of a chair in ethical matters, the goal of our economic system is

profit and gain, thus efficiency, and the *cursus* of an economist never asked for knowledge in ethics or philosophy.

Moreover, the literature on the perspectives of economic theory and normative view of economics tend to pinpoint that economics should be 'values free'. Values do not enter the arena of economic solutions. The economic perspective on regulation has no affinity with ethical quests. We don't find ethical norms in the models based on Laffont-Tirole principal-agent, nor in the public choice theory of Buchanan and Tullock. All agents are homo-economicus.

Even more blunt, Stigler in his *Tanner* lectures on 'Ethics or Economics' wrote: "economists have seldom spent much time exhorting individuals to higher motives or more exemplary conduct" (1980, p.148). Stigler even claimed: "the economist does not need ethics but only arithmetic."

So, when did the West begin to raise questions about ethical behavior and social norms related to economics?

Ethical behavior entered the economic scene when research showed that immoral behavior has negative effects on economic growth. Then the modern world began to accept that corruption could be bad. The study that had a strong impact on policy was a paper by Mauro, (1995) on corruption.

While this might surprise us today, it was revolutionary in the 1990s, because for decades, corruption was perceived as an efficient element of society.

In the 1960s, American political scientist Samuel Huntington espoused the economic and social virtues of corruption. He first suggested that corruption provides immediate, specific, and concrete benefits to groups that might otherwise be thoroughly alienated from society. Corruption may thus be functional to the maintenance of a stable political system.

Huntington's second argument in favor of corruption is more subtle. He argued (1968, 69): "The only thing worse than a society with a rigid, over centralized, dishonest bureaucracy is one with a rigid, over centralized honest bureaucracy." Huntington was not alone in his views about the positive benefits of corruption.

Then the wind changed direction. Views on corruption changed, and it became recognized that corruption harms the economy. Today, the number of NGOs addressing the negative effects of corruption are numerous: *Transparency International* for providing data, the Norwegian NGO *U4-Anti-corruption Center*, *OpenSecrets* in the US, and *Corporate-Europe Observatory* in the EU. Economic theorists and practitioners of behavioral economics also began to analyze the effects of virtuous behavior on economic

success and economic growth.[1] In the next section, we analyze the effect of the revolving door on virtuous behavior. We show that the optimal solution will not be zero tolerance.

III. Regulating the revolving door: a model [2]

1. Introduction

The "revolving door" is a practice in which heads of state agencies, after completing their bureaucratic terms, enter the very sector they have regulated. Are there any legal or ethical problems with the revolving door? Indeed, yes. As emphasized in the introduction, the main literature on the revolving door has emphasized the legal problems, the bribery-capture channel which is unlawful in most Western countries.[3] It is therefore difficult to believe that most cases of revolving door, which are numerous, are explained by fraud and unlawful behavior.

A new literature has put the emphasis on the ethical problems of the revolving door. In this literature, conflicts of interest arising from the revolving door are not *unlawful*, as is in the case of regulatory capture, but still lead to economic distortions, and to an ethical problem. This type of conflict of interest has been coined '*abuse of power'* and encompasses the creation of excessive regulation while in public office. As defined by Transparency International (2011), this 'abuse of power' arises when "bureaucrats abuse their power to ingratiate themselves to potential future employers".

The model focuses on two of the problems of regulation we have mentioned in the introduction: the abuse of power due to greed, and the lack of competence. First, there are the distortions due to the *abuse of power* that takes the general form of *over-regulation*. In other words, the bureaucrat takes actions and makes decisions while in office enabling her to cash in later on when joining a firm she has regulated. While her actions can take various forms, they all incorporate what is termed the creation of *bureaucratic capital*.

The most common manifestation of bureaucratic capital is investing in good relationships with the lower-level bureaucracy, ties which will help the senior bureaucrat in the future. *Bureaucratic capital* also takes the form of developing excessive regulation. These are the negative effects of the revolving door stressed in this paper.

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[1] Lately, game theorists are analyzing the success of societies wherein altruism is part of the system versus societies where it is not, but the goal is not the value per se of being moral and ethical, but rather the fact that when all people are altruistic, society benefits.

[2] The model is based on some parts of Brezis, 2017.

[3] Note that the wrongdoing arises while the worker is employed as a regulator, and it might be difficult to prove it in court.

The second problem of regulation is that regulators can be incompetent. The revolving door enables recruiting competent and qualified bureaucrats. Indeed, bureaucrats are heterogeneous in their abilities, and more able bureaucrats do a better job of regulation, so that allowing the revolving door enables recruitment of high-quality bureaucrats, leading to higher economic growth. These are the positive effects to the revolving door.

In other words, by incorporating positive as well as negative effects of the revolving door, and only those that are not *unlawful*, this section enables us to analyze the net effects of the conflicts of interest, arising from the revolving door on economic growth. This small model enables deriving two main conclusions.

The first is that it is not optimal to prevent the revolving door, even if it is unethical. The second conclusion is that in equilibrium, the revolving door leads to an excessive level of bureaucratic capital, which in turn leads to over-regulation and to lower economic growth.

We first define what the regulators are doing. Then the firms. We then define optimality from the point of view of society.

2. The demand and supply of bureaucratic capital

During her time in office, the regulator regulates, but at the same time, she creates *bureaucratic capital*. The bureaucratic capital are all the unnecessary regulations she is developing. Bureaucratic capital is supplied by the bureaucrats, while the demand comes from the firms.

Let us start with the regulators, who are appointed by the government to regulate the economy efficiently. Yet the regulators do not merely enact efficient regulation; they also create bureaucratic capital.

Bureaucratic capital therefore enables the regulator to cash in later thereon, after exiting the public sector and joining a firm in the sector she previously regulated.

The regulator maximizes her lifetime income net of efforts, since the production function of bureaucratic capital, H is a nonlinear function of effort, E (equation 2).

The utility function, V, she maximizes is:

$$V = \Omega + qH - \lambda E \qquad (1)$$

where Ω is her lifetime salary when appointed as regulator. After leaving her job as regulator, the regulator works in the industry that she regulated. She receives on top of

her lifetime salary, a rent, qH, which is a function of the amount of "bureaucratic capital", H she has accumulated at price q less her effort, E.

The production function of bureaucratic capital, H as a function of effort, E takes the specific form:[4]

$$H(E) = [(1+\gamma)E]^{1/1+\gamma} \quad \gamma > 0 \tag{2}$$

Taking the FOC of equation (1) with respect to H, when H is a function of effort as described in (2), we get the optimal level of bureaucratic capital she wants to accumulate:

$$H = (q/\lambda)^{1/\gamma} \tag{3}$$

The second player in this framework are the firms. These firms consist of monopolistic firms each with its own intermediate good, and in consequence, they are regulated by regulators nominated by the government (I follow the model of Romer, 1990).

Entrepreneurs maximize profits of the regulated firms. Those firms find the knowledge accumulated by the bureaucrat valuable, since the bureaucratic capital under the board's control enables increasing the firm's revenue. In consequence, I develop the demand of these firms for the "knowledge" of the "revolver" regulators, i.e., the bureaucratic capital, H.

When a firm j hires a bureaucrat with a bureaucratic capital H_j, the production of output j becomes more efficient. This is so, because the regulator has knowledge and connections on the system. More specifically, it depends on the relative level of bureaucratic capital by the different regulators of the different firms, since it is only the relative knowledge which matters. So, the production function in sector j takes the form:

$$x_j = k_j (\frac{H_j}{\overline{H}})^\phi \quad \phi > 0 \tag{4}$$

where H_j is the level of bureaucratic capital produced by the regulator entering firm j, and as in the Romer model, output is also a function of capital, k_j.[5]

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[4] In other words, Ω is the lifetime salary of the regulator, which includes also what she gets after retiring from being a bureaucrat. qH is the 'bonus' she gets by the company which will hire her after leaving office, for her over-regulation.

[5] Note that if $H_j = \overline{H}$, then the output is just: $x_j = k_j$, no matter the average level of bureaucratic capital. Although having hired a bureaucrat to increase the productivity of the firm may bring advantage from an individual point of view, it is pure waste from a social point of view.

So, the profit maximization, π for an intermediate good firm, j is:

$$Max\, \pi_j = p_j(x_j)x_j - rk_j - qH_j \tag{5}$$

where the output is x, the price of the output is p. The two costs of factors of productions are (i) capital, k_j where r is the interest rate, and (ii) the bureaucratic capital, H at cost q. The last term in equation (5) is the amount paid to the regulator for her bureaucratic capital.

Each firm maximizes profits by finding the optimal amount of output, x_j prices p, and bureaucratic capital, H_j.

$$p_j = p = \frac{1}{\alpha}r \tag{6}$$

$$H_j = \overline{H} = \frac{\phi rK}{qA} \tag{7}$$

Equation (7) represents the demand for bureaucratic capital, as a decreasing function of q. This is the demand from the side of the firms.

Recall that from the side of the bureaucrats, we get the supply equation of bureaucratic capital (equation 3). By equating demand with supply, we get the equilibrium stock of bureaucratic capital, H*

$$H^* = (\phi rK / \lambda A)^{1/1+\gamma}$$
$$\text{and} \tag{8}$$
$$q^* = [\lambda(\phi rK / A)^\gamma]^{1/1+\gamma}$$

Is this level of bureaucratic capital optimal from the standpoint of the economy? In the following section, we show that it is not, but we also show that the optimal bureaucratic capital level is not zero.

3. The effects of bureaucratic capital on the economy

The question to be asked is why does a government, for which economic growth is a priority, not find a way to prevent the regulators from creating *bureaucratic capital*?

We now show that the government indeed does not act to eliminate the revolving door. On the contrary, they find it optimal to allow the regulator to create a certain

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amount of *bureaucratic capital*. Solution to ethical problems will never be to choose the extreme.

The explanation behind this result is the following: regulators are heterogeneous in their abilities, and more able regulators enable higher productivity and higher economic growth. In order to recruit high-quality regulators, governments must pay them well. An easy way to let regulators have high income is by legislators' closing their eyes to the fact that the regulator can cash in on the bureaucratic capital they create while serving as heads of agencies.

Thus, a government that wants to maximize the rate of growth of the economy, faces a tradeoff between on the one hand, having high-quality regulators, and on the other hand, letting the high-quality regulators create *bureaucratic capital*, which has a negative effects on growth.

In other words, if the government wants to hire a high-quality bureaucrat, her income must be high. Since wages in the public sector are lower than the reservation wage of the regulator, they must let her accumulate bureaucratic capital so that she will be indifferent between being working as bureaucrat, or providing private services as lawyer or economist. This trade-off is the QH curve in equation (9), depicted in Figure 1.

This QH curve is the production possibility frontier between bureaucratic capital, *H* and quality of the regulator, *Q*, in equation (9). The maximum amount of quality is reached at H=H* (see appendix 1 for the details).

$$Q_i = \frac{1}{\xi}[\Omega - \lambda \frac{H_i^{1+\gamma}}{1+\gamma} + qH_i] \quad \text{(The QH curve)} \qquad (9)$$

The QH curve is the curve representing the decision of the regulator.

We are left with the question, which bundle of quality and bureaucratic capital is optimal for the country? For matter of simplicity, this paper assumes that the goal of the government is to maximize the rate of growth of the economy.

Following Romer (1990), the intermediate goods develop new technology through a sector of R&D, and the final good is produced with labor and the intermediate goods in the following way:

$$Y = L_y^{1-\alpha} \int_0^A x_j^\alpha \, dj \qquad (10)$$

where Y is the output at each period; L_y - the number of workers in the production sector; x_j the number of intermediate goods from type j; and A, the level of technology, measured by the range of capital goods available. The power of monopolist firms is also embedded in the parameter α.

In consequence, the growth rate in the economy which is constant (since we focus only on the balanced growth path) is:

$$g = \frac{\dot{A}}{A} = \delta(Q)L_r \qquad (11)$$

where δ is a positive parameter function of the quality of the bureaucrat, Q, $\delta' \geq 0$ and $\delta'' < 0$. L_r is the size of the labor force in the R&D sector.

In consequence the rate of growth in the economy is:

$$g = \delta(Q)[1 - \frac{r}{\alpha\delta(Q)} - \frac{q^* H}{\alpha(1-\alpha)\tau}] \qquad (12)$$

Equation (12) describes the rate of growth of the market economy as a function of the behavior of the bureaucrat described by H and Q. The rate of growth in the economy is a positive function of the ability of the bureaucrat, Q, and a negative function of the level of bureaucratic capital, H. In Figure 1, we present the iso-growth curve as a function of Q and H (see Appendix 2 for details). We get that the rate of substitution is positive, and the iso-growth curves are concave.

So, the two main equations of this model are the QH function (equation (9), which describes the production possibility frontier of the regulator faced by the government in terms of quality and bureaucratic capital. The second one is the equation of the iso-growth curves, equation (12), which describes for each Q and H chosen by the regulator, what is the level of growth rate, g obtained in the economy.

We now determine the amount of bureaucratic capital which leads to the highest rate of growth.

4. Equilibrium and optimal choice

Let us focus on the iso-growth curves in Figure 1. As we move further to the right, an iso-growth curve depicts a higher growth rate (higher quality of a bureaucrat leads to higher growth). In consequence, the highest rate of growth which is also on the

production possibility frontier is point M. This is the optimal solution from the point of view of the country. At this point, the level of H is positive, and non-zero.

In other words, *the optimal level of bureaucratic capital is non-zero: It is in the public interest to allow the bureaucrats to create bureaucratic capital. The solution to an ethical problem is a non-absolute solution.*

This result stresses that despite the negative effects of bureaucratic capital on the economy, the economy has an optimal mix of level of redundant bureaucracy and quality of the regulator. While the government could restrict the possibility of the revolving door, this would mean reducing the quality level of the regulators in the economy, which is not a good solution. This result states that the highest rate of growth is attained when there is creation of bureaucratic capital which is *non-zero*.

Although the market economy reaches its highest economic growth at point M, we now show that the regulators choose a level of bureaucratic capital which is higher than the one the economy would prefer. The regulator chooses to create bureaucratic capital at the level of H*, which gives her the highest utility. Therefore, in a market equilibrium, the regulators choose the amount of H*, and the economy will be at point F. Comparing F to M, we obtain that at F, the amount of bureaucratic capital is higher, and the rate of growth is lower.

This fact stresses that the amount of bureaucratic capital chosen by regulators and firms, H is higher than that favored by the government, and the public.* The equilibrium is at a point wherein ability is at its maximum. The public would rather have less bureaucratic capital, even at the price of having less able bureaucrats.

The reason we are not at the Pareto optimum of point M in Figure 1 is due to the social waste, bureaucratic capital leads to. In consequence, we obtain that at the maximum growth rate (point M), the amount of bureaucratic capital is not zero, which is the message of this paper.

IV. Conclusion

This paper has analyzed whether the revolving door should be regulated. The short answer is no. The longer answer is complex. In the past, the literature on the revolving door has mainly emphasized the regulatory capture model which encompasses corruption, fraud, and unlawful behavior. In those cases, obviously, revolving door should be reformed, and it is necessary to regulate the revolving door.

However, this is not the case nowadays. Today, the regulator takes actions while in office enabling her to cash in later when joining a firm she has regulated. While her

actions can take various forms, they all incorporate what is termed the creation of *bureaucratic capital*. Thus, the regulator can abuse her former position to increase her compensation package in a perfectly legal way, although unethical.

It is in the interest of government to allow this behavior, since regulators are heterogeneous in their abilities, and more able regulators enable higher productivity and economic growth. But in order to recruit high-quality regulators, governments must pay them well.

However, salaries in the public sector are lower than in the private sector. An easy way to let regulators receive higher compensation, so as to attract higher quality civil servants is by allowing the revolving door. So, the optimal solution is not a 'zero tolerance' to unethical behavior embedded in the revolving door. The first conclusion of the paper is that the answer whether to regulate the revolving door is: no.

The second conclusion of our paper is related to a taxonomy of social behaviors. Individual actions can be divided into two types: lawful and ethical. Our second conclusion is that the optimal solution to behavior related to legal matters is: 'zero tolerance'. Matters of law should be absolutely regulated, and we should not take into consideration possible tradeoffs.

However, policies related to ethical matters should not try to adopt absolute solutions. Ethical dilemmas are not solved by choosing 'zero tolerance'. This may apply to many kinds of human behavior; this paper has shown that it is also the case for the revolving door.

Indeed, the reason for this non-zero solution related to the revolving door is that while bureaucratic capital is wasteful for society, it enables regulators to be more competent and efficient. Restricting the revolving door, would mean lowering the quality of civil servants, which would lead to lower economic growth. There is a tradeoff between competence and greed.

Ethical problems are not solved by choosing extreme solutions. We should allow some bureaucratic capital, as we allow some unethical behavior. The economy needs competent and qualified regulators, who can face the challenges of a changing world.

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Figure 1: The amount of Bureaucratic Capital in equilibrium, and the Trade-off between Quality and Bureaucratic Capital
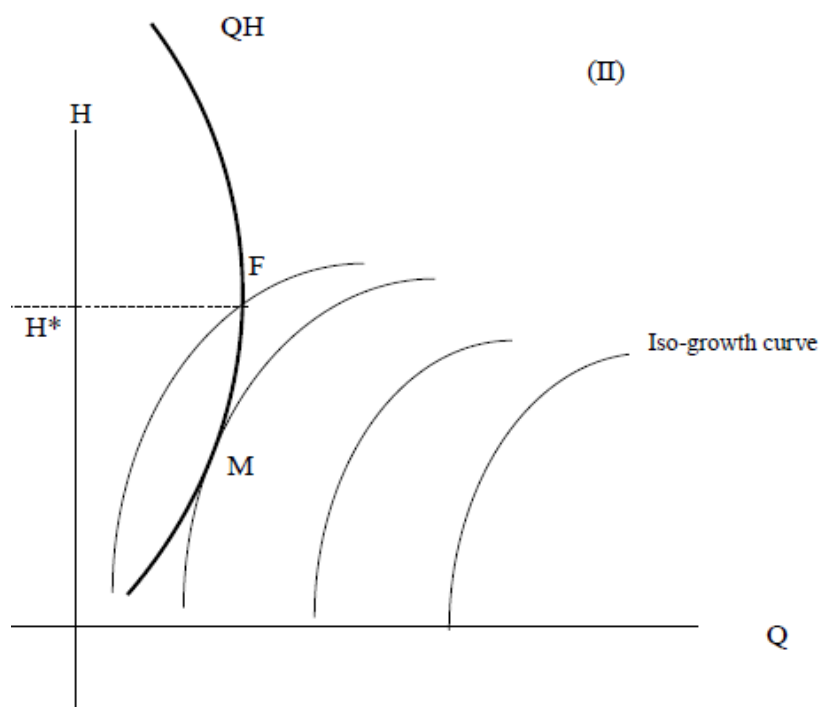
Appendix 1

One instrument in the hand of government is to appoint regulators who regulate monopolistic firms. Regulators are chosen from among the individuals with specific abilities and skills. These individuals are heterogeneous in their abilities, and as emphasized by Weiss (1980), when ability affects the productivity of a person, then wages are not equal for all: "workers' wage is an increasing function of his ability". Individuals with high ability and quality earn more than ones with less ability.

In consequence, without loss of generality, we assume the following form:

$$W_s = \xi Q_s \tag{A1}$$

where W_s is the income of a specific individual, and Q_s is the ability of this individual.

Since quality of the regulator affects economic growth (equation 11), the government will choose a regulator with the highest ability possible and who gets an income related to quality given by equation (A1). We assume that the legislator possesses perfect knowledge of each candidate's ability. In consequence, he knows that the reservation income of the potential regulator is given by (A1) and therefore the choice faced by the legislator is to hire a regulator with ability such that:

$$Q_i = Max \langle Q_s \,|\, \xi Q_s \leq V_s \rangle \tag{A2}$$

and the solution is:

$$Q_i = \frac{1}{\xi} V_i \tag{A3}$$

where V_i is the lifetime income of the bureaucrat i. Substituting equation (1) into equation (A3), we get the relationship between ability and level of bureaucratic capital faced by the political elite:

$$Q_i = \frac{1}{\xi} [\Omega - \lambda \frac{H_i^{1+\gamma}}{1+\gamma} + q H_i] \quad \text{(The QH curve)} \tag{9}$$

Appendix 2

Based on Romer, the equilibrium is obtained by equating wages earned by workers in the output and the R&D sectors. So, we have:

$$w_r = w_y \tag{B1}$$

where w_r and w_y are wages in the R&D and production sectors respectively. The total labor force working in the production and the research sectors is constant and denoted by $\overline{L}$.

$$L_r + L_y = \overline{L} \tag{B2}$$

where L_r is the size of the labor force in the R&D sector, and L_y the labor force in the output sector. Since the salary earned by workers in the R&D sector is the value of the patent of their invention, we have that:

$$w_r = \frac{\dot{A}}{L_r} P_r \tag{B3}$$

where P_r is the price of a new-design patent, and $\dot{A}$ is the number of new inventions developed. Moreover:

$$w_y = (1-\alpha)\frac{Y}{L_y} \tag{B4}$$

$$rP_r = \pi + \dot{P}_r \tag{B5}$$

where $\dot{P}_r$ is the change in the price of patents and π are profits. Since there is no increase in population, along the balanced growth path, output Y, and inventions, A grow at the same rate, so that patent prices also are constant, and we get:

$$P_r = \frac{\pi}{r} \tag{B6}$$

Moreover, the profit for each of the firms is:

$$\pi = \alpha(1-\alpha)\frac{Y}{A} - qH \tag{B7}$$

In consequence, we get that:

$$\frac{(1-\alpha)Y}{L_y} = \frac{\delta A}{r}[\frac{\alpha(1-\alpha)Y}{A} - q^*H]$$

Then we obtain: [6]

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[6] Interest rate is determined by the demand of goods, as in Romer (p. 88), and is not a function of the endogenous variables of equation (9).

$$L_y = \frac{r}{\alpha\delta(Q)} + \frac{q^*H}{\alpha(1-\alpha)\tau} \tag{B8}$$

In consequence the rate of growth in the economy is:

$$g = \delta(Q)[\bar{L} - L_y] = \delta(Q)[\bar{L} - \frac{r}{\alpha\delta(Q)} - \frac{q^*H}{\alpha(1-\alpha)\tau}] \tag{12}$$