Theory of Collusion in the Labor Market

Pedro Gonzaga ¹
António Brandão ¹
Hêlder Vasconcelos ¹

¹ FEP-UP, School of Economics and Management, University of Porto
Theory of Collusion in the Labor Market

Pedro Gonzaga
Faculdade de Economia da Universidade do Porto

António Brandão
Faculdade de Economia da Universidade do Porto

Hélder Vasconcelos
Faculdade de Economia da Universidade do Porto

Abstract
Despite the major concern of the competition authority to forbid and prosecute formal cartels who cooperatively fix prices, limit production or divide markets, there seems to be little regulation and investigation of collusive practices in the labor market. For that reason, this article analyzes the economic effects of cooperative wage fixing in industries that use one type of labor as the only input, while the other assumptions are kept as general as possible. Under the one input assumption it was found that collusion in the labor market and collusion in the product market have exactly the same results, which include the rise in prices and the fall in output, employment and wages. The higher prices and lower wages in cartelized industries are not only associated with the elimination of the well known business stealing effect, but also with the elimination of the labor force stealing effect. The conclusions in this paper can be generalized to industries that use more than one input, as long as the cartel is able to fix the prices of all the inputs.

Key Words: Collusion, labor market, oligopoly, oligopsony, business stealing effect, labor force stealing effect.

JEL Classification: L11, L13, L41, L44, J01, J08
1. Introduction

Most advanced market economies have currently some form of legislation and authority that forbid and investigate collusive practices on behalf of the interest of the consumer. In United States the first ever federal anti-trust law, the Sherman Act, was created in 1890 and it stated in its first section that:

“Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is declared to be illegal. Every person who shall make any contract or engage in any combination or conspiracy hereby declared to be illegal shall be deemed guilty of a felony, and, on conviction thereof, shall be punished by fine not exceeding $10,000,000 if a corporation, or, if any other person, $350,000, or by imprisonment not exceeding three years, or by both said punishments, in the discretion of the court.”

In the meantime other anti-trust laws have been created, as the Federal Trade Commision Act and the Clayton Act, both published in 1914, besides several state anti-trust laws. All these acts constitute criminal laws prosecuted by the Department of Justice and by the Bureau of Competition of the Federal Trade Commision and their violation have been punished with growing fines and prison sentences.

In Europe most countries have their own competition authorities, but general rules on competition have been provided by the Treaty of Rome since 1958 and by the Treaty on the functioning of the European Union after 2009, whose first paragraph of the article 101 states that:

“The following shall be prohibited as incompatible with the internal market: all agreements between undertakings, decisions by associations of undertakings and concerted practices which may affect trade between Member States and which have as their object or effect the prevention, restriction or distortion of competition within the internal market (...)

The fact that anti-trust laws are imposed by the Federal government in United States and by one of the main treaties composing the constitutional basis of the European Union clearly shows how much cartels injure the economy. However, when we actually analyze the cases investigated and sentenced by competition authorities we observe that almost all relate to collusive practices in the final product market, as fixing prices, limiting production or dividing markets, while the investigation of collusion in the labor market is extremely rare.
Yet one shall not conclude that collusion in the labor market does not exist just because it is not properly investigated. For that reason we discuss here three important cases that evidence how firms are willing to cooperatively set wages below the competitive level or to restrain the number of workers hired, if they have the chance to do so.

In 1997, an employee of Exxon Mobil Corporation, Roberta Todd, initiated a lawsuit alleging that the company was able to save over 20 million dollars in annual wages paid to managerial, professional and technical employees, due to cooperative interactions between the firm and fourteen other oil companies, as BP, Shell and Chevron. The collusive practices denounced included the conduct of surveys about past and current salary information and future salary budgets, exchanges of large amounts of detailed information between the firms and frequent meetings between the human resource departments to discuss current and future wage budgets. And even though the lower court initially declined the claim, the court of appeals confirmed latter that this was, in fact, a violation of the first section of the Sherman Act.

In 2006 the two registered nurses Pat Cason-Merenda and Jeffrey A. Suhre brought a lawsuit on behalf of all registered nurses employed between 2002 and 2006 in several hospitals and medical centers in the Detroit Metropolitan Statistical Area. Those hospitals were accused of conspiring to depress the wage levels of registered nurses in the context of a national nurse shortage, by exchanging detailed and non-public information about remunerations through meetings, telephone conversations and written surveys. In 2009 a settlement agreement was reached with St. John’s Health System, who has agreed to pay a compensation of over 13.5 million dollars.

In September 24, 2010, the Department of Justice of the United States enforced the high technology companies Google, Apple, Adobe, Intel, Intuit and Pixar to stop entering into no-solicitation agreements, in which they compromised not to steal workers from each other. Such contracts were responsible for restraining the wages of high skilled workers and for reducing access to better job opportunities and they constituted thereby an anti-competitive conduct. Unfortunately, no-solicitation agreements appear to have been restarted in 2011, when some high skilled employees claimed that the “cold calls” offering better payments and working conditions have ceased. This led the software engineer Siddharth Hariharan to fill a lawsuit against the previously mentioned companies plus Lucasfilm, in which he accuses the companies for conspiring against free competition and demands a compensation exceeding 25 thousand dollars.
Although these three cases alone provide strong evidence of the temptation of firms to reduce competition in the labor market, some other examples could be given. For instance, in 2012 it was not for the first time that the union of American football players sued the National Football League for fixing a secret salary cap, claiming damages of about one billion dollars.

Besides, collusion in labor market is not a new phenomenon and can be even found in the middle age, as Margaret Peters of Stanford University shows in her recent paper about the reactions of labor markets to the Black Death in the fourteenth century (Peters, 2010). She found that while in the Western Europe the fall in labor supply increased the wages, living conditions and political rights of the peasantry, the opposite occurred in Eastern Europe and in the Middle East, where landlords succeeded to collude and to force peasants to supply more unpaid work. The paper discusses further the economic reasons that enabled the two last geographic areas to sustain collusion.

The ability of employers to cooperatively fix wages below the competitive level was also mentioned by Adam Smith in the *Inquiry into the Nature and Causes of the Wealth of Nations* published in 1776:

> “We rarely hear, it has been said, of the combinations of masters, though frequently of those of workmen. But whoever imagines, upon this account, that masters rarely combine, is as ignorant of the world as of the subject. Masters are always and everywhere in a sort of tacit, but constant and uniform combination, not to raise the wages of labor above their actual price.”

In short, collusion in the labor market has existed for a long time and yet little has been done to prevent it. In part, the lack of intervention by the competition authority may result from the absence of a strong economic theory that studies the economic effects of collusion in the labor market, with particular concern to consumer welfare.

Indeed, almost all the existing literature on the subject focuses on collusion in the supply side of the labor market, that is, on the cooperative interactions between employees, agents (in principal-agent contracts), as well on the economic effects of labor unions. As regards to collusion in the demand side of the labor market, which is the one we are interested in, the literature is extremely scarce and is spread over too specific subjects. For example, in the paper *Star Wars: Exclusive talent and collusive outcomes in labor markets* (Mukherjee, Selvaggi, & Vasconcelos, 2012) a principal-agent setting is used to study how exclusive employment contracts may increase the
welfare of highly productive workers (the so called “stars”), by avoiding collusion between the principals. And in *Low-Wage Labor Markets and the Power of Suggestion* (Shelkova, 2008) it is proposed that a non-binding minimum wage can be a focal point that coordinates tacit collusion between low-wages employers. These two articles not only fall on very particular issues as exclusive employment contracts and non binding minimum wages, but they also rely in very particular scenarios as two-principals-two agents contracts in the first case and a perfectly competitive product market in the second case. A more general model was presented by Fabian Bergès and Stéphane Caprice, who investigated how collusion in prices affects the wage and employment levels of qualified and unqualified workers (Bergès & Caprice, 2008). However this paper investigates collusion in the product market, whilst our subject-matter is collusion in the labor market.

Therefore the main purpose of this article is to contribute to the economic literature with a more general and strong theory of collusion in the labor market that investigates the economic effects of setting wages below the competitive level, given an oligopolistic product market and an oligopsonistic labor market. In order to build a powerful theoretical model, no specific functional forms are considered and main assumptions are kept as general as possible.

In section 2 we present the firm maximization problem and the competitive equilibrium in a very simple model with competition in quantities, where the connection between the product market and the labor market can be easily illustrated. In section 3 we present again the maximization problem and competitive equilibrium, but in a more robust model of price competition with differentiated product. In section 4 we investigate the collusive outcome and prove that, under the one input assumption, collusion in the labor market and collusion in the product market have exactly the same results, which include the rise in prices and the fall in output, employment and wages. The higher prices and lower wages in cartelized industries are not only associated with the elimination of the well known business stealing effect, but also with the elimination of the labor force stealing effect. In section 5 we explain how collusion in the labor market may correspond to partial collusion in the product market and we analyze the effects of the collusive behavior on the firms outside the cartel, as well on other labor markets and industries. In section 6 we provide some notes about how the theory in this paper can be applied to formal and informal cartels. At last, section 7 concludes.
2. A simple model of competition in quantities

2.1 Firm optimization problem

Consider an industry where there are a limited number of firms producing the final good and hiring specialized workers that are specific to this industry. The firms observe the final good’s demand function \( P = f(Q) \), that gives an inverse relation between the market price and the total quantity demanded, as well as a labor supply function\(^1\) \( W = g(L) \), according to which the wage increases with the total amount of labor offered. The total quantity of the final good and the total labor force are respectively equal to the sum of the quantity produced and labor used per firm (\( Q = \sum Q_i \) and \( L = \sum L_i \)). Each firm has also a production function that uses labor as the only input, \( Q_i = h_i(L_i) \). At last, assume further that the cost function, \( g(\sum L_i)L_i \), is convex.

The optimizing problem of the firm is to choose the quantity produced and the amount of labor that maximize the profit function \( \pi_i = PQ_i - WL_i \) (Cournot, 1838). Due to the one input assumption, the production function establishes an exact relation between the quantity of good and the quantity of labor and so profits can be expressed in terms of one of the variables only. In first place consider profits as a function of the quantity produced:

\[
\pi_i = f\left(\sum Q_i\right)Q_i - g\left[\sum h_i^{-1}(Q_i)\right]h_i^{-1}(Q_i)
\]

(1)

Given that the market price is a decreasing function of the quantity produced and that the cost function is convex, the profit function is concave and first order conditions can be used to obtain the maximum.

\[
\frac{d\pi_i}{dQ_i} = 0 \quad \leftrightarrow \quad f(.) + f'(.)Q_i = g(.)h_i^{-1}(Q_i) + g'(.)h_i^{-1}(Q_i)h_i^{-1}(Q_i) \quad \leftrightarrow \\
\leftrightarrow \quad P + \frac{dP}{dQ}Q_i = W\frac{dL_i}{dQ_i} + \frac{dW}{dL} \frac{dL_i}{dQ_i}L_i
\]

(2)

This optimal condition states that the firm produces up to the point where the marginal revenue is equal to the marginal cost. Because firms must reduce the price to sell more, the marginal gain from producing an extra unit of product is equal to the price earned with that unit minus the price reduction undertaken multiplied by the quantity that the

\(^1\) In order to include unemployment in our model one could consider instead a social labor supply function that accounts for the effects of labor unions and minimum wage policies.
Collusion in the labor market

firm was already able to sell at a greater price (also called the infra-marginal units). As regards to the marginal cost, producing an extra unit implies using a greater amount of workers that the firm must attract with a wage increase. Thus the cost of producing an extra unit of the final good is the wage paid to the new workers hired plus the wage variation times the number of workers that the firm already had before.

From equation (2) we obtain the best reply function $Q_i^{FOC}(Q_{-i})$ and the profit is given by $\max(\pi_i^{FOC}, 0)$, once the firm can always choose to leave the market to avoid any losses. Finally, the optimal quantity produced by each firm is $Q_i^* = \arg\max(\max(\pi_i^{FOC}, 0))$.

Because the labor market has an oligopsony structure every firm takes into account its power to partially control the wage level and so they choose to produce a lower quantity and to hire fewer workers in order to prevent the wage from growing too much, as we can see from the second term of the right-handed side of equation (2). In contrast, if the labor market was perfectly competitive this term would be equal to zero and the quantity produced would be larger.

The profit function can be also rewritten as a function of labor only:

$$\pi_i = f \left( \sum h_i(L_i) \right) h_i(L_i) - g \left( \sum L_i \right) L_i$$

This time the first order condition can be obtained by setting the derivative of the profit relative to the number of workers equal to zero:

$$\frac{d\pi_i}{dL_i} = 0 \quad \leftrightarrow \quad f(.) h_i'(L_i) + f'(.) h_i'(L_i) h_i(L_i) = g(.) + g'(.) L_i \quad \leftrightarrow$$

$$\leftrightarrow \quad P \frac{dQ_i}{dL_i} + \frac{dP}{dQ} \frac{dQ_i}{dL_i} Q_i = W + \frac{dW}{dL} L_i$$

Therefore, each firm is optimizing profits when the gain of an extra worker equals its additional cost. Because the extra worker raises the production capacity of the firm, its marginal gain corresponds to the market value of the new units produced minus the necessary price reduction multiplied by the quantity that the firm was already able to sell with a smaller labor force. The marginal cost of labor is the wage that must be paid to the additional worker plus the product of the number of workers already hired times the necessary wage variation to attract an extra worker.
From the optimal condition we obtain the best reply function $L_i^{FOC}(L_{-i})$, the profit is given by $\max(\pi_i^{FOC}, 0)$ and the optimal amount of labor is $L_i^* = \arg\max(\max(\pi_i^{FOC}, 0))$. Once again, when deciding how many workers to hire in the labor market, the firm takes into account its power to influence the price of the final good. In fact, as long as the product market is not perfectly competitive, the second term of the left-handed side of equation (4) is not null and the firm measures the impact of hiring more workers in the production level and, thereby, in the final price.

The optimal conditions previously obtained can also be used to get the final good supply and the labor demand functions. Separating the price from the other terms of equation (2) gives the inverse supply function of the firm, $P = \phi_i(Q_i)$, and the market goods supply is equal to the sum of the quantities produced by all firms together: $Q = \sum \phi_i^{-1}(P)$. In turn, separating the wage from the other terms of equation (4) gives the inverse labor demand of the firm, $W = \theta_i(L_i)$, and the market labor demand is equal to the sum of the labor demanded by all firms: $L = \sum \theta_i^{-1}(W)$.

2.2. Oligopoly equilibrium

The competitive equilibrium of the model correspond to the market price, wage, individual quantities produced and number of workers hired by firm for which the product market and the labor market are in equilibrium. Solving the system of $n$ best reply functions expressed in quantities gives the quantity produced by firm. Replacing these quantities in the production functions or solving the system of $n$ best reply functions in terms of labor gives the number of worker hired by firm. Finally the market price and wage can be directly obtained from the final good demand and labor supply functions.
3. A price competition model with product differentiation

3.1. Firm optimization problem

Although there are some industries where it is conceivable that the market price of the good is well defined and firms compete through the quantities produced (example: automobile, housing and heavy industries), in most cases it is more realistic to assume that each firm sets the best possible price to compete with its rivals.

If the products sold and the jobs offered by firms are homogeneous, we have a Bertrand competition in the product market and in the labor market (Bertrand, 1883). In that case the strategic interaction between firms becomes complex and it is possible that no pure strategies Nash equilibrium exists, due to the capacity constrains that result from the Bertrand competition in the labor market. Besides empiric evidence strongly suggests that products are not completely homogeneous, as consumers are willing to pay higher prices for the goods that have the characteristics they most value. Similarly, jobs in the industry are usually seen by workers as heterogeneous, either because of different working conditions, company values, work colleagues and distance from home.

For these two reasons our model assumes price competition in the goods market with product differentiation and wage competition in the labor market with job differentiation. It is not important if the product or job differentiation arises from an endogenous mechanism as it is described in the Hotelling model (Hotelling, 1929) or in the circle model (Salop, 1979). All it matters is that each firm faces an individual demand function that is decreasing with respect to its own price and increasing with respect to other firms prices, \( Q_i = f_i(P_i, P_{-i}) \), and an individual labor supply that increases with the own wage and decreases with other firms wages, \( L_i = g_i(W_i, W_{-i}) \).

Naturally market total demand, \( Q = \sum f_i(P_i, P_{-i}) \), is decreasing with respect to any price and total labor supply, \( L = \sum g_i(W_i, W_{-i}) \), is increasing with respect to any wage. Once again, each firm faces a production function that uses labor as the only input, \( Q_i = h_i(L_i) \), and the cost function given by \( W_i g_i(W_i, W_{-i}) \) is convex.

At the competitive equilibrium each firm chooses the price and the wage that maximize profits, assuming that all the other firms are not going to change their decisions. Despite the fact that there isn’t a direct relation between the price and the wage, the profit function \( \pi_i = P_i Q_i - L_i W_i \) can still be rewritten as a function of one of the variables only. Consider first the profit function in terms of prices:
Collusion in the labor market

\[ \pi_i = P_i \times f_i(P_i, P_{-i}) - h_i^{-1}(f_i(P_i, P_{-i})) \times g_i^{-1}(h_i^{-1}(f_i(P_i, P_{-i})), W_{-i}) \]

Since the profit function is concave, its maximum is attained at the point where the derivative of profits in order to the price is equal to zero.

\[ \frac{d\pi_i}{dP_i} = 0 \iff f_i(\cdot) + P_i \frac{\partial f_i(\cdot)}{\partial P_i} - h_i^{-1}(\cdot) \frac{\partial f_i(\cdot)}{\partial P_i} g_i^{-1}(\cdot) - h_i^{-1}(\cdot) g_i^{-1}(\cdot) \frac{\partial h_i^{-1}(\cdot)}{\partial f_i(\cdot)} \frac{\partial f_i(\cdot)}{\partial P_i} = 0 \]

\[ \iff Q_i + P_i \frac{\partial Q_i}{\partial P_i} - \frac{\partial L_i}{\partial Q_i} \frac{\partial Q_i}{\partial P_i} W_i - L_i \frac{\partial W_i}{\partial L_i} \frac{\partial Q_i}{\partial P_i} = 0 \] (5)

According to equation (5), when the firm is maximizing a small change in the price should not have any effect on profits. Indeed, if the derivative was positive it would be profitable to slightly increase the price and if it was negative the opposite would be also true. The first two terms of the left-handed side of equation (5) are the impact of a price variation in the revenue obtained in the goods market: when the price increases, the firm gains one more unit of money for each unit of product transacted and loses the market value of all the products that are no longer sold due to the price raise. The two last terms of the left-handed side of equation (5) are the effect of a price variation in the total costs incurred from hiring workers in the labor market. On the one hand, when the price is increased less workers are required to satisfy the falling demand, allowing the firm to save the wages paid to those workers. On the other hand, once the firm hires fewer workers, it is now able to hold all the necessary labor force at a lower wage level.

The best response function that comes from equation (5), \( P_{i}^{FOC}(P_{-i}, W_{-i}) \), defines the optimal price for firm \( i \) as a function of a vector of prices and wages from the other firms. The actual profit obtained will be as usual equal to \( \max(\pi_i^{FOC}, 0) \). Analogously to the last section, when the firm sets the optimal price in the product market it takes into account its power to constraint the wage paid to the workers. Therefore the firm sets a greater price than it would if the labor market was perfectly competitive, case in which the fourth term the left handed side of equation (5) would be null.

Now consider the profit function expressed in terms of wages:

\[ \pi_i = f_i^{-1}(h_i(g_i(W_i, W_{-i})), P_{-i}) \times h_i(g_i(W_i, W_{-i})) - g_i(W_i, W_{-i})W_i \]

When the firm is optimizing, a very small change in the wage should not have any effect on profits and so the first order condition can be stated as:
Collusion in the labor market

\[ \frac{d\pi_i}{dW_i} = 0 \leftrightarrow f_i^{-1}(\cdot)h_i + \frac{\partial f_i^{-1}(\cdot)}{\partial h_i}g_i - g_i(\cdot) - \frac{\partial g_i(\cdot)}{\partial W_i}W_i \]

\[ \leftrightarrow P_i dQ_i \frac{dQ_i}{dL_i} P_i dL_i + \frac{\partial P_i}{\partial Q_i} dL_i Q_i - L_i - \frac{\partial L_i}{\partial W_i}W_i = 0 \]  

(6)

The two first terms of equation (6) describe the revenue gain obtained in the goods market when the firm raises the wage level in one unit: on the one hand, a greater wage attracts more workers that are able to produce more and the firm earns the market value of the extra production; on the other hand, a raise in production also implies a fall in the price, which decreases the revenue of all the units of the good that were already sold before. The two last terms of equation (6) correspond to the additional cost incurred in the labor market: when the wage increases in one unit, not only the firm has to pay an extra unit of money for every worker in the company, but it also attracts more employees to whom must be paid the whole wage.

From equation (6) we get the best response function that expresses firm \( i \) optimal wage as a function of the wages and prices set by its rivals, \( W_i^{\text{FOC}}(W_{-i},P_{-i}) \). As usual, every firm is free to leave the market to avoid losses and profits are thus given by \( \max(\pi_i^{\text{FOC}},0) \). Finally note that a firm setting the wage in the labor market is aware of its ability to influence the price in the product market, as we can see from the second term of the left handed side of equation (6) (this term is different than zero as long as the product market is not perfectly competitive).

3.2. Oligopoly equilibrium

The competitive equilibrium of this model consist in four vectors of \( n \) variables, the prices, quantities, number of workers and wages, for which every firm in the market optimizes profits given the decisions undertaken by its rivals. In other words, at the competitive equilibrium there are no unilateral profitable deviations.

The \( 4n \) equilibrium variables of the model can be obtained with \( 4n \) equations: \( n \) goods demand functions, \( n \) labor supply functions and \( n \) production functions that are exogenous to the model, as well as \( n \) best reply functions obtained from profit maximization. Although in last section we derived \( n \) best reply functions in terms of prices and \( n \) best reply functions in terms of wages, the firsts are equivalent to the seconds, as they are closely related through the exogenous functions of the model.
4. Collusive outcome

4.1 The cartel optimization problem

So far we have studied how companies that produce or sell a final good using labor as their only input make optimal decisions in a competitive scenario. In this section it is shown how the strategic interaction and main results change when firms build a cartel that optimizes overall profits. The results obtained here are crucial to understand the role of competition authority in the regulation of the labor market.

When firms compete by quantities and the product is homogeneous, the collusive outcome corresponds to all firms producing together the monopoly quantity. If firms have equal and constant marginal costs, it doesn’t matter how the production is distributed between them. If firms have different linear cost technologies, only the most efficient ones should produce. If firms have different non linear cost technologies, the total production should be distributed between them in such way that the marginal cost of producing an extra unit is equal to every firm. Despite the greater simplicity of working with competition by quantities, from now on we will only consider price and wage competition with differentiated products and job posts, for the sake of realism.

In our industry each firm produces a specific differentiated good that, in spite of being a close substitute to the other goods, it has particular characteristics valued by consumers that can only be achieved using the firm’s production technology. Besides, each firm uses the labor force with different degrees of efficiency and the working conditions in some firms may be more attractive than in others. In these circumstances it is no longer possible to define a global market price and wage that maximizes aggregate profits. Instead, the cartel must define a specific price and wage per firm that takes into account how is the product valued by consumers, the efficiency of the cost technology and the attractiveness of the job. Therefore the vector of prices and wages that maximize the profits of the cartel are the solution to the following maximization problem:

\[
\begin{align*}
\max \quad & \pi = \sum_{j=1}^{n} P_j Q_j - L_j W_j \\
\text{s. t.} \quad & Q_j = f_j(P_i, P_{-i}), \quad L_j = g_j(W_i, W_{-i}), \quad Q_j = h_j(L_j), \quad j = 1, \ldots, n
\end{align*}
\]
Collusion in the labor market

Although it is not possible to eliminate all the restrictions and to express profits as a function of either wages or prices, the optimization problem faced by the cartel can still be simplified to have one set of restrictions only:

\[
Max \quad \pi = \sum_{j=1}^{n} P_j \times f_j(P_i, P_{-i}) - g_j(W_i, W_{-i}) \times W_j
\]

\[
s.t. \quad h_j^{-1}(f_j(P_i, P_{-i})) = g_j(W_i, W_{-i}), \quad j = 1, ..., n
\]

This particular specification of the problem allows us to withdraw some previous conclusions. Despite having \(2n\) instruments available to optimize profits (\(n\) prices plus \(n\) wages), the cartel is constrained by \(n\) different restrictions. This means that in reality the cartel has only \(n\) instruments to optimize profits, while the other \(n\) instruments are directly obtained from the firsts. Because the profit function is concave and the solution is unique, it doesn’t matter if:

- The cartel sets the optimal prices and the wages directly result from labor supplies, production functions and final good demanded quantities; or
- The cartel sets the optimal wages and prices are defined by the demand functions given the production levels of the workers attracted by all firms.

In other words, collusion in the goods market and collusion in labor market are completely equivalent when the firms that compete in the two markets are the same.

4.2. Business stealing effect

The optimization problem previously described can be solved using the Lagrange multipliers method, which consists in maximizing the following objective function:

\[
L = \sum_{j=1}^{n} P_j \times f_j(P_i, P_{-i}) - g_j(W_i, W_{-i}) \times W_j + \lambda_j \left[ g_j(W_i, W_{-i}) - h_j^{-1}(f_j(P_i, P_{-i})) \right]
\]

The Lagrangian multipliers \(\lambda_j\) can be interpreted as the shadow price of labor or, in other words, as the value that one worker operating in firm \(j\) has to the total profits of the cartel.
Collusion in the labor market

At the optimal interior solution the derivatives of the Lagrangian function with respect to the decision variables \((P_1, ..., P_n, W_1, ..., W_n, \lambda_1, ..., \lambda_n)\) are equal to zero. Thus, from the first order conditions with respect to price:

\[
\frac{\partial \pi}{\partial P_i} = 0 \iff Q_i + \sum_{j=1}^{n} \left[ P_j \frac{dQ_j}{dP_i} - \lambda_j \frac{\partial L_j}{\partial Q_j} \frac{\partial Q_j}{\partial P_i} \right] = 0 \iff \\
Q_i + \sum_{j=1}^{n} \left( P_j - \lambda_j \frac{\partial L_j}{\partial Q_j} \right) \frac{\partial Q_j}{\partial P_i} = 0 \tag{7}
\]

As usual, optimizing behavior implies that a small change in the price of any firm shouldn’t have any effect on total profits, as the derivatives with respect to prices are null. In the competitive setting, when a firm increases the price in one unit, it earns one extra unit of money for each product sold and it loses the revenue of the amount of goods that consumers are not willing to buy anymore. As we can see from equation (7) not only these effects are still present in the collusive setting, but there is also an additional effect: when one of the firms increases the price in one unit, all the other firms face an increasing demand and the cartel gains the revenue of all the extra units sold. This means that relatively to the competitive setting each firm has an extra incentive to raise the price, as it is aware of the positive effect it has on the production levels of the other firms.

Actually, one of the reasons why prices tend to be lower in competitive markets is the existence of a business stealing effect. When firms are free to compete with each other they tend to reduce prices as an attempt to steal valuable market shares from their rivals. Because the cartel eliminates this business stealing effect, companies refrain from lowering prices, as that would injure the total profitability of the cartel.

4.3. Labor force stealing effect

A deeper analysis of equation (7) allows us to observe another effect that contributes to the rising prices of the cartel.

As we can see in equation (7) the net gain of producing an extra unit of good is the price minus the marginal cost of production, which corresponds to the additional amount of labor used multiplied by the value that each unit of labor has to the cartel given its best
alternative use ($\lambda$). To comprehend what is indeed the value or shadow price of labor, we must take a look to optimal conditions with respect to wages.

$$\frac{\partial \pi}{\partial W_i} = 0 \iff -L_i + \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_i} W_j + \lambda_i \frac{\partial L_i}{\partial W_i} = 0 \iff$$

$$\iff \sum_{j=1}^{n} \lambda_j \frac{\partial L_j}{\partial W_i} = L_i + \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_i} W_j \quad (8)$$

Equation (8) alone tells us that the wage of any firm must be set at the level where the marginal gain – the increase in the entire labor force times the value that each worker has to the cartel – is equal to the marginal cost – the extra unit of money that must be paid per worker plus the entire wages that must be paid to the new workers hired. It is important to remark that once again the firm takes into account the effect of changing the wage not only on the workers it hires, but on the cartel’s entire labor force.

Unfortunately, finding the shadow price of the workers operating in firm $i$ ($\lambda_i$) imply solving the following system of $n$ equations:

$$\begin{aligned}
\sum_{j=1}^{n} \lambda_j \frac{\partial L_j}{\partial W_1} &= L_1 + \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_1} W_j \\
\sum_{j=1}^{n} \lambda_j \frac{\partial L_j}{\partial W_2} &= L_2 + \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_2} W_j \\
&\vdots \\
\sum_{j=1}^{n} \lambda_j \frac{\partial L_j}{\partial W_n} &= L_n + \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_n} W_j
\end{aligned}$$

Because such system can be quite complex to solve, in order to find the economic interpretation of the shadow price of labor we will assume for now that the cartel is symmetric, that is, all the firms have the same cost technology and face symmetric goods demand and labor supply functions. In this case, the price, wage and shadow price is equal for every firm and equation (8) can be simplified as follows:

$$\lambda_i \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_i} = L_i + W_i \sum_{j=1}^{n} \frac{\partial L_j}{\partial W_i} \iff \lambda_i = W_i + \frac{L_i}{\sum_{j=1}^{n} \frac{\partial L_j}{\partial W_i}} \iff \lambda_i = W_i + \frac{L_i}{\partial L} \iff$$

$$\iff \lambda_i = W_i + L_i \frac{\partial W_i}{\partial L} \quad (9)$$
From equation (9) we conclude that if the cartel is maximizing joint profits, the value of the last worker employed by firm \( i \) must be equal to the cost of hiring him \( W_i \) plus the necessary wage variation to increase the labor force of the firm in one unit \( \partial W_i / \partial L_i \) multiplied by the total number of workers \( L_i \), at the collusive setting the cost of the additional worker is the wage \( W_i \) plus the necessary wage variation to increase the labor force of the cartel \( \partial W_i / \partial L \) times the number of workers of the firm \( L_i \). To understand this crucial difference note that when firms are competing they only care about their own labor force and so hiring an additional worker may imply stealing individuals employed in other firms of the industry. But when firms are engaged in a cartel, a worker stolen from other firm has absolutely no additional value, since the total labor force of the cartel remains constant and the value of the worker is the same regardless of the company he is employed in (due to the symmetry assumption). Hence the shadow price \( \lambda_i \) refers to the value of hiring an additional worker that was not operating in the industry yet. And the cost of such worker includes the necessary wage variation to increase the total labor force in one unit \( \partial W_i / \partial L \).

Now that we are aware of what the shadow price of labor is when the cartel is optimizing profits, we can apply the symmetry assumption to equation (7) and replace \( \lambda_i \) by equation (9):

\[
Q_i + n \left( P_j - \lambda_j \frac{\partial Q_j}{\partial P_i} \right) \frac{\partial Q_j}{\partial P_i} = 0 \leftrightarrow Q_i + \left( P_i - \lambda_i \frac{\partial L_i}{\partial Q_i} \right) \sum_{j=1}^{n} \frac{\partial Q_j}{\partial P_i} = 0 \leftrightarrow Q_i + \left( P_i - \left( W_i + L_i \frac{\partial W_i}{\partial L} \right) \frac{\partial L_i}{\partial Q} \right) \frac{\partial Q}{\partial P_i} = 0
\]

(10)

Given that \( \partial W_i / \partial L \) is greater than \( \partial W_i / \partial L_i \) (see proof at the end of the section), it is possible to conclude that when compared to the competitive setting, the marginal cost of production is larger, which also encourages firms in the cartel to rise prices. Indeed, when firms compete with each other there is a “labor force stealing effect” that motivates them to increase wages in order to attract workers employed in rival companies, causing production levels to rise and prices to fall. Because the cartel eliminates the labor force stealing effect, companies become more reluctant in declining prices as they know that producing more involves hiring workers from outside the industry.
Collusion in the labor market

It is important to highlight that the last conclusions crucially depend on the assumption of symmetry. For that reason, in the case of an asymmetric cartel the elimination of the labor force stealing effect only means that prices increase on average, not being possible to guarantee that the price of each particular company of the cartel does so.

Finally, to prove that it takes a greater wage variation to raise the entire labor force of the cartel in one unit \((\partial W_i/\partial L)\) than to raise the labor force of the firm in one unit \((\partial W_i/\partial L_i)\) is straightforward, taking into account that the labor supplied to any firm is increasing with its own wage and decreasing with the wages set by its rivals and given that the total labor supply is equal to the sum of each firm labor supply.

\[
\frac{\partial L}{\partial W_i} = \frac{\partial L_i}{\partial W_i} + \sum_{k=1}^{n-1} \frac{\partial L_k}{\partial W_i}, \quad k = 1, ..., i-1, i+1, ..., n
\]

\[
\sum_{k=1}^{n-1} \frac{\partial L_k}{\partial W_i} < 0 \quad \rightarrow \quad \frac{\partial L}{\partial W_i} < \frac{\partial L_i}{\partial W_i} \quad \leftrightarrow \quad \frac{\partial W_i}{\partial L_i} < \frac{\partial W_i}{\partial L}
\]

5. Partial collusion

The previous analysis of collusion focused on industries where the firms in the supply side of the product market coincide with the firms in the demand side of the labor market. But in reality this perfect match is not common, either because different firms of the same industry have access to different labor markets (case in which collusion in the labor market causes partial collusion in the product market) or because the same labor market supplies workers to different industries (case in which collusion in the product market leads to partial collusion in the labor market). The following section covers the former case.

5.1. Collusion in the labor market and partial collusion in the product market

Consider an industry where \(n + m\) firms produce and sell a differentiated product in the final product market, competing with each other by prices. As usual, each firm faces an individual good demand function that decreases with its price and increases with the price of the rivals, \(Q_i = f_i(P_i, P_{-i})\), as well as a production function that uses one type of labor as the only input, \(Q_i = h_i(L_i)\). Suppose farther that the industry can be
decomposed in two sets of firms that set wages and hire workers at two distinct labor markets, $n$ firms at labor market $A$ and the remaining $m$ firms at labor market $B$. The reason why different firms have access to different labor markets may either be their concentrated location at different industrial zones or because their production functions require different types of specialized workers. The labor supplied to each firm is increasing with respect to the own wage and decreasing with respect to the wages of the rivals located at the same labor market, $L_i^A = g_i(W_i^A, W_{-i}^A)$ and $L_i^B = g_i(W_i^B, W_{-i}^B)$.

It is now our concern to study the economic effects of collusion in one of the labor markets. Suppose that the $n$ firms located at labor market $A$ decide to set wages cooperatively, which as we already know directly determines their price levels. When colluding, the optimizing behavior of the $n$ firms is characterized by equation (10):

$$Q_i^A + \left[ P_i^A - \left( W_i^A + L_i^A \frac{\partial W_i^A}{\partial Q_i^A} \right) \frac{\partial Q_i^A}{\partial P_i^A} \right] = 0$$

(10)

As always the $n$ firms of the cartel refrain from stealing business and labor force from each other and the result is that they all fix greater prices and smaller wages. Notwithstanding the industry is not composed only by the $n$ firms involved in the cartel, but also by other $m$ firms competing in the final product market who are going to react to the rise in prices. Because the later firms are not colluding, their non cooperative optimizing behavior is characterized by equation (5):

$$Q_i^B + \left[ P_i^B - \left( W_i^B + L_i^B \frac{\partial W_i^B}{\partial Q_i^B} \right) \frac{\partial Q_i^B}{\partial P_i^B} \right] = 0$$

$$\iff P_i^B = \left( W_i^B + L_i^B \frac{\partial W_i^B}{\partial Q_i^B} \right) \frac{\partial Q_i^B}{\partial P_i^B} - \frac{Q_i^B}{\partial Q_i^B / \partial P_i^B}$$

$$\iff P_i^B = \frac{\partial \text{Total Cost}_i^B}{\partial Q_i^B} - \frac{Q_i^B}{\partial Q_i^B / \partial P_i^B}$$

(11)

Equation (11) is the best reply function for any of the $m$ firms at labor market $B$, which depends on the prices of the firms of the cartel through the quantity produced $Q_i^B$. Using equation (11) it is possible to prove that under convex cost functions and concave and additive demand functions, the best reply to the non cooperative firms is to produce more at a higher price (see proof in annex).
Collusion in the labor market

Intuitively when the prices of the firms of the cartel go up, the other firms in the industry face a greater demand and sell more, which encourages them to increase prices for two reasons: in first place, producing more implies a greater marginal cost that must be offset by a greater price; secondly the marginal gain of increasing the price is now multiplied by a larger number of units of the final good.

In addition, since all the \( m \) non cooperative firms face now a greater demand, they have to increase the wages paid in order to attract more workers at the labor market \( B \), in order to meet the new production levels. Note that the wage defined by each firm is indeed an increasing function of the quantity produced, \( W_i^B = g_i^{-1}(h_i^{-1}(Q_i^B), W_{-i}^B) \).

In conclusion the effects of the creation of a cartel in labor market \( A \) go far beyond the fall in wages and employment at that market. The most important effect is probably the increase in prices not only of the cooperative firms, but also of the whole industry. Once total demand falls with prices, the total quantity transacted is reduced to the detriment of consumer welfare. But more interestingly, collusion in labor market \( A \) has a positive effect on wages and employment in labor market \( B \), once these two are connected by the same industry. Indeed when the firms at labor market \( A \) collude, some of their production level is transferred to the other firms of the industry, who must hire more workers at greater wages.

Finally the analysis in this section could be prosecuted by considering that labor market \( B \) also supplied workers to other industries, who would be able to attract fewer workers and who would be forced to produce less at higher prices. Thus the general conclusion is that collusion in a specific labor market may have negative effects on prices and quantities on several industries and positive effects on wages and employment on other labor markets.
5. Final notes on the cooperative nature of collusion

In the previous sections we have studied the effects of the creation of a cartel that maximizes joint profits by fixing the optimal wages in the labor market or, equivalently, by setting the optimal prices in the final product market. In this section we wonder if the assumption of joint profit maximization is reasonable, which may depend on whether the firms are playing a cooperative or a non-cooperative game.

Suppose firstly that firms play a cooperative game, by which we mean that they are able to communicate with each other, negotiate enforceable agreements and make side payments. In this case, if joint profits are not being optimized, firms can always negotiate a better deal and use side payments to guarantee that everyone gains. And because the new contract is enforceable, they are willing to do such deal until joint profits are at its maximum. Although cooperative behavior is harder when formal cartels are illegal, it is always possible to communicate and to make side payments “off record”, while credible threats can be used to enforce the negotiated agreements. Therefore it is extremely important to regulate and to investigate collusion in the labor market, in order to avoid cooperative behaviors that lead to the maximization of joint profits along with the negatives consequences on social welfare.

Unfortunately, even if the competition authority is able to compel firms not to cooperate, an informal cartel can still be sustained using, for example, trigger strategies (Friedman, 1971) or optimal penal codes (Abreu, 1984). In the particular case of trigger strategies it can be shown that, as long as every firm is strictly better off when colluding, there are discount rates lower than one for which collusion can be sustained in equilibrium at every stage of an infinite super game (see annex 2). However, because the game is now non-cooperative and side payments are not possible anymore, at least some symmetry is required to guarantee that joint profit maximization improves the profits of all firms. Hence the theory presented in this paper can also be applied to non-cooperative games when the firms of the informal cartel are not too heterogeneous. Finally it is important to recall that joint profit maximization is not the only non-cooperative equilibrium, as it is proved in the Folk theorem.
6. Conclusions

Throughout this article we created a general theoretical model to investigate the strategic interaction between firms that produce a substitute good in an oligopolistic product market, using as the only input the workers hired in an oligopsonistic labor market. The model was used to compare the competitive solution (in which firms set prices and wages without cooperating with each other) with the collusive outcome (in which joint profits are maximized).

Under the one input assumption we found that collusion in the labor market and collusion in the product market have exactly the same results, that is, there are no substantial differences whether the firms of the cartel choose to cooperatively fix prices or wages. Indeed, fixing prices directly determines the quantity of output that firms are able to sell, the labor force required and, thereby, the wages that must be paid. Similarly, fixing wages determines the workers hired, the output produced and the prices that must be defined to sell the whole output. It was also discovered that when compared to the competitive solution, the creation of a cartel causes prices to rise and output, employment and wages to fall, due to two different economic effects: on the one hand collusion eliminates the well known business stealing effects, as firms do not attempt anymore to steal costumers from each other by decreasing prices; on the other hand, collusion eliminates the labor force stealing effect, once firms avoid to increase wages in order not to steal workers from each other.

Furthermore we analyzed industries where different sets of firms have access to different labor markets, in order to investigate how collusion in one of the labor markets affects the firms not involved in the cartel. We concluded that when a cartel is created in one labor market, all the firms of the industry reduce prices and the total quantity produced falls, although some of the production level is transferred from the cartelized firms to the non-cartelized firms.

At last it is important to remark that main conclusions in this paper could be easily generalized to industries that use production functions with more than one input, as long as firms were able to collude relatively to the price of all inputs. A more interesting case that shall be investigated in a future paper is when the production function uses several inputs (for example specialized and non-specialized workers), while firms are able to fix the wage of one of the inputs only.
7. Annex

7.1. Annex 1

Theorem: under convex cost functions and concave and additive demand functions, the price of any firm at labor market $B$ is increasing with the price of any firm at labor market $A$.

Proof: the best reply function in equation (11) expresses the optimal price of any firm at labor market $B$ as a function of the quantity produced, which in turn is a function of the prices of the whole industry.

$$p_i^B = \frac{\partial \text{Total Cost}_i^B}{\partial Q_i^B} - \frac{Q_i^B}{\partial Q_i^B / \partial P_i^B}$$  \hspace{1cm} (11)

Define $BRF_i$ as the following function:

$$BRF_i = p_i^B - \frac{\partial \text{Total Cost}_i^B}{\partial Q_i^B} + \frac{Q_i^B}{\partial Q_i^B / \partial P_i^B} = 0$$

Using the implicit function theorem:

$$\frac{dp_i^B}{dp_j^A} = -\frac{\partial BRF_i}{\partial P_j^A} = -\frac{-\partial^2 \text{Total Cost}_i^B \partial Q_i^B}{\partial P_i^A \partial Q_i^B} + \frac{\partial Q_i^B \partial Q_j^B}{\partial P_i^A \partial P_j^B} - Q_i^B \frac{\partial^2 Q_i^B}{\partial P_i^B \partial P_j^B} \left(\frac{\partial Q_i^B / \partial P_i^B}{\partial P_j^B}\right)^2$$

$$1 - \frac{\partial^2 \text{Total Cost}_i^B \partial Q_i^B}{\partial P_i^A \partial Q_i^B} + \frac{\partial Q_i^B \partial Q_j^B}{\partial P_i^A \partial P_j^B} - Q_i^B \frac{\partial^2 Q_i^B}{\partial P_i^B \partial P_j^B} \left(\frac{\partial Q_i^B / \partial P_i^B}{\partial P_j^B}\right)^2$$

Because the demand function is additive, $\frac{\partial^2 Q_i^B}{\partial P_i^B \partial P_j^B}$ is null and the convexity of the cost function and the concavity of the demand function imply that

$$\frac{dp_i^B}{dp_j^A} = \frac{\partial^2 \text{Total Cost}_i^B \partial Q_i^B}{\partial P_i^A \partial Q_i^B} - \frac{\partial Q_i^B \partial Q_j^B}{\partial P_i^A \partial P_j^B} - Q_i^B \frac{\partial^2 Q_i^B}{\partial P_i^B \partial P_j^B} \left(\frac{\partial Q_i^B / \partial P_i^B}{\partial P_j^B}\right)^2 > 0$$

and the assertion is complete.
From equation (11) it can be also concluded that the raise in $P_j^A$ causes $Q_i^B$ to rise as well. Once a higher $P_i^B$ increases the left handed side and decreases the right handed side of equation (11), the equality must be restored at a higher $Q_i^B$.

### 7.2. Annex 2

Theorem: under trigger strategies, as long as every firm is strictly better off when colluding, there are discount rates lower than one for which collusion can be sustained in equilibrium at every stage of an infinite super game.

Proof: According to trigger strategies, each firm sets the collusive price or wage as long as all the other firms did so in the past stages and whether one of the firms deviates from the collusive path the whole industry reverts to the competitive equilibrium forever. Therefore collusion is only sustained in equilibrium if the long run gains of the cartel exceed the one shot gain from deviation, that is, if the following incentive compatibility constrain (ICC) is verified:

$$
\pi_i^C - \pi_i^P \geq \pi_i^D - \pi_i^C,
$$

where $\pi_i^C$ is the share of the profit of the cartel received by firm $i$, $\pi_i^P$ is the profit of the punishment phase (equal to the competitive profit), $\pi_i^D$ is the profit earned by firm $i$ when it is the only one deviating from the collusive path and $\delta$ is the discount factor. The left handed side of the ICC is the present value of all future gains of the cartel and the right handed side of the equation is the one shot gain from deviation. Isolating the discount factor in equation (11) allows us to rewrite the incentive compatibility constraint as:

$$
\delta \geq \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^P}, \quad i = 1, ..., n
$$

From equation (12) it is possible to conclude that if every firm earns strictly more under collusion than under competition ($\pi_i^C > \pi_i^P$), there are discount factors lower than one for which informal collusion can be sustained in equilibrium.

Theorem: under optimal penal codes there are always discount rates lower than one for which collusion can be sustained in equilibrium at every stage of an infinite super game.
Collusion in the labor market

Proof: In order to be a subgame-perfect equilibrium, optimal penal codes must verify two incentive compatibility constraints. One the one hand, in the collusive subgames all firms must prefer to collude rather than to deviate and being punished afterwards:

\[ \frac{\pi_i^C}{1 - \delta} \geq \pi_i^D + \delta V, \]  \hspace{1cm} (14)

where V is the present discounted value of the profits received in the punishment phase. On the other hand, all firms must prefer to accept the punishment rather than to deviate and have the punishment restarted. The ICC of the punishment subgames is thus given by:

\[ V \geq \pi_i^{DP} + \delta V, \]  \hspace{1cm} (15)

\( \pi_i^{DP} \) is the profit earned when firm \( i \) deviates from the punishment phase. Equation (14) holds when the punishment is extremely severe in the first stage ("stick") while in the following stages firms are rewarded by returning to the collusive path ("carrot").

The penal code is optimal when the present value of the profits earned in the punishment phase is as low as possible. Because firms can leave the market to avoid future losses, at the optimal penal code V is equal to zero and equation (14) is equivalent to:

\[ \delta \geq \frac{\pi_i^D - \pi_i^C}{\pi_i^D} \]  \hspace{1cm} (16)

At last from equation (15) we conclude that under optimal penal codes there are discount factors lower than one for which collusion can be sustained.

We can farther conclude by comparing equations (12) and (15) that the use of an optimal penal code instead of a trigger strategy also increases the set of discount rates for which collusion is possible.
8. Bibliography


Class Action, Case nº 06-15601 (United States District Court Eastern District of Michigan Southern Division June 15, 2007).

Class Action, Case nº 11574066 (Superior Court of the State of California May 4, 2011).


Settlement Agreement, Case nº 2:06-cv-15601 (United States District Court Eastern District of Michigan Southern Division August 31, 2009).


# Recent FEP Working Papers

<table>
<thead>
<tr>
<th>#</th>
<th>Authors</th>
<th>Title</th>
<th>Month 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>476</td>
<td>Mário Graça Moura and António Almodovar</td>
<td>Political Economy and the 'Modern View' as reflected in the History of Economic Thought</td>
<td>December</td>
</tr>
<tr>
<td>475</td>
<td>Marta S.R. Monteiro, Dalila B.M.M. Fontes and Fernando A.C.C. Fontes</td>
<td>Solving Concave Network Flow Problems</td>
<td>December</td>
</tr>
<tr>
<td>474</td>
<td>Marta S.R. Monteiro, Dalila B.M.M. Fontes and Fernando A.C.C. Fontes</td>
<td>Ant Colony Optimization: a literature survey</td>
<td>December</td>
</tr>
<tr>
<td>473</td>
<td>João Correia-da-Silva and Carlos Hervés-Beloso</td>
<td>Irrelevance of private information in two-period economies with more goods than states of nature</td>
<td>December</td>
</tr>
<tr>
<td>472</td>
<td>Gonçalo Faria and João Correia-da-Silva</td>
<td>Is Stochastic Volatility relevant for Dynamic Portfolio Choice under Ambiguity?</td>
<td>October</td>
</tr>
<tr>
<td>471</td>
<td>Helena Martins and Teresa Proença</td>
<td>Minnesota Satisfaction Questionnaire - Psychometric Properties and Validation in a Population of Portuguese Hospital Workers</td>
<td>October</td>
</tr>
<tr>
<td>470</td>
<td>Pedro Mazeda Gil, Oscar Afonso and Paulo Brito</td>
<td>Skill Structure and Technology Structure: Innovation and Growth Implications</td>
<td>September</td>
</tr>
<tr>
<td>469</td>
<td>Abel L. Costa Fernandes and Paulo R. Mota</td>
<td>Triffin’s Dilemma Again and the Efficient Level of U.S. Government Debt</td>
<td>September</td>
</tr>
<tr>
<td>468</td>
<td>Mariana Cunha and Vera Rocha</td>
<td>On the Efficiency of Public Higher Education Institutions in Portugal: An Exploratory Study</td>
<td>September</td>
</tr>
</tbody>
</table>

*Editorial Board* (wps@fep.up.pt)  
also in [http://ideas.repec.org/PaperSeries.html](http://ideas.repec.org/PaperSeries.html)