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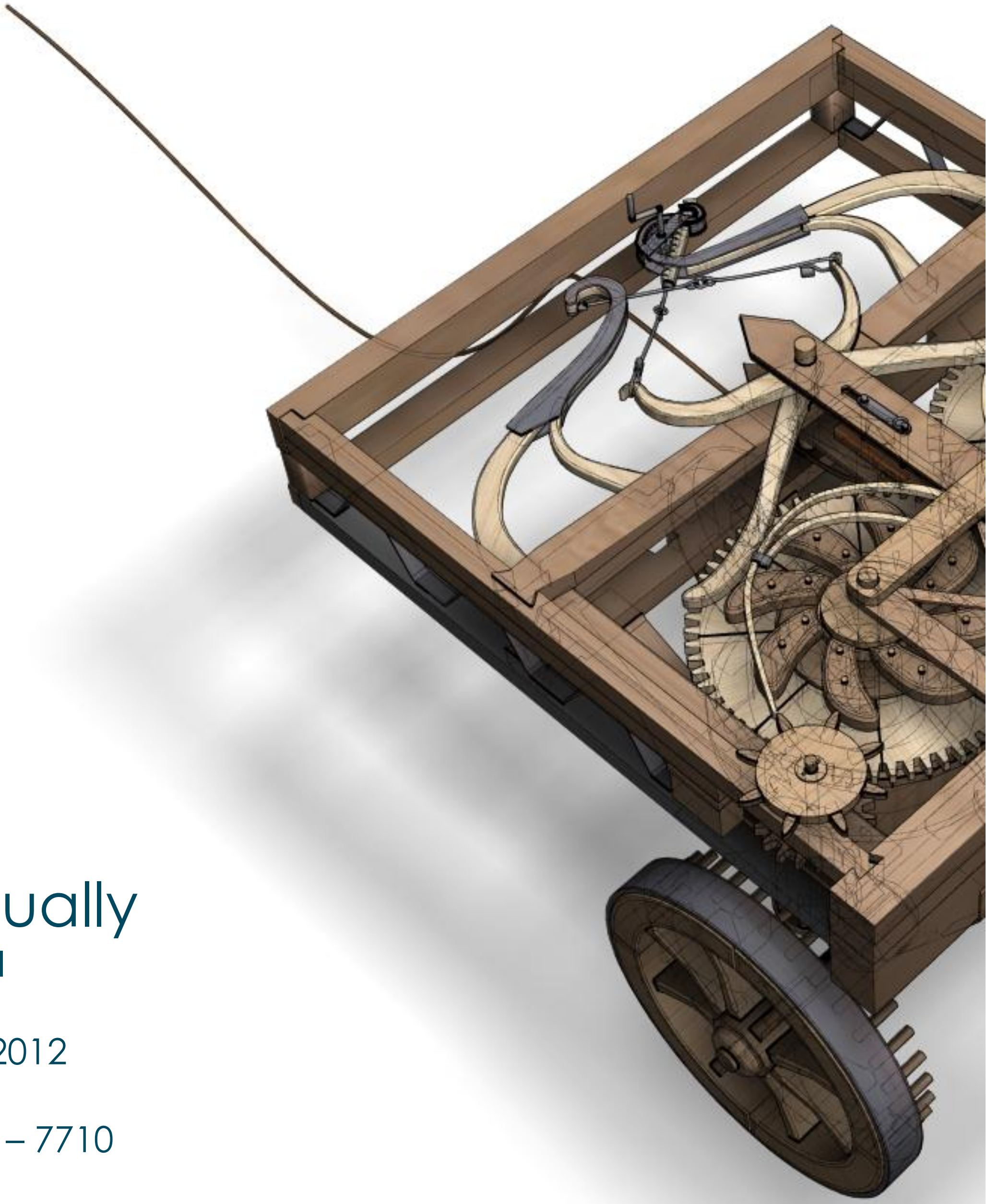

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A CLOSED FORM SOLUTION FOR A GROWTH MODEL WITH EXTERNALITIES AND PUBLIC SPENDING

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Abstract:

This paper studies the equilibrium dynamics of a growth model with public spending. The model considers negative production externalities by explicitly including them as unfavorable effects in the production function. Differently from conventional analysis here government spending along with private production, also generate negative externalities. The model simultaneously determines the optimal shares of consumption, capital accumulation, taxes and composition of the two different public allocations, which maximize the representative household's lifetime utilities in a centralized economy. Moreover, with one restriction on the parameters we fully determine the solutions path for all variables of the model and determine the conditions for balanced growth. Given the active role the government has in determining the level of production, the higher the externalities compared to the optimum, the lower the tax rate.

Keywords: growth models, fiscal policy, public spending composition, externalities.

JEL classification: O40, H50, E13, H20, D62.

1. Introduction

The relation between fiscal policy and economic growth is a central and controversial issue in the growth literature. Within this debate academics and policy makers have been particularly concerned about the potential negative effects deriving from industrialization. On the one hand it is stated that the economic benefits of improving production are related to more employment, more consumption and potential high tax revenue. On the other hand it is stressed that, while economic growth improves quality of life through produced goods, it also reduces welfare since it generates substantial negative externalities, such as congestion and environmental degradation.

The list of negative externalities associated with production may be considerably long. They mainly concern effects on residents' welfare such as: crowding and congestion cities, roads and public transportation and cities, noise, litter, air contamination and global warming effects, degradation of nature, increased urbanization, and increased crime rate. Congestion and environmental degradation caused by an expansion of manufacturing are essentially effects that are not taken into account by individual firms. Hence, production expansion is more desirable to an individual firm than it is to society. In this case competitive equilibria are not Pareto optimal. To correct this distortion, the government's fiscal policy should internalize such adverse effects. Among the public policies affecting the productive sector, taxation and government spending play an especially important role.

The logic behind the congestion effects of average capital stock is commonly recognized in the existing literature. Barro and Sala-i-Martin (1992), for instance, suggest that almost all public services are characterized by a certain degree of congestion and Eicher and Turnowski (2000) argue that congestion adversely affects the equilibrium growth rate. There are two main approaches to deal with environment externalities: government interventions (pigovian taxes, subsidies and direct regulation) and public abatement policies.

It is commonly recognized that tightening environmental policies generally has an adverse effect on economic growth because it crowds out private expenditure, including investment (Haung, and Cai, 1994; Ligthart, and van der Ploeg, 1994). Conversely, several studies propose that environmental tax policies may support economic growth. Ewijk, and Wijnbergen (1995), Bovenberg, and Smulders (1995), and Bovenberg, and de Mooij (1997), show that environmental taxes improve the quality of the environment, which in turn ameliorates the efficiency of other productive inputs, thereby promoting economic growth (see also Ricci, 2002 and Nakada, 2004 on similar positions).

Concerning the public abatement policy it should be mentioned that there are essentially two positions in the economics literature. The first assumes that private firms deal with abatement (Bovenberg, and de Moiij, 1997; Bovenberg, and Smulders, 1995). The second presumes that abatement spending is financed by the government. Within the latter, Gruver (1976) investigates the optimal division of investment between pollution control capital and directly productive capital. The model considers pollution as a flow positively related to aggregate output, negatively related to the stock of pollution control capital, and having a negative impact on utility. Greiner (2005) analyzes a growth model where pollution affects only the utility of a representative household but does not affect production possibilities directly by entering the aggregate production function. However, there is an indirect effect of pollution on output, because it is supposed that resources are used for abatement activities.

Economides and Philippopoulos (2008) investigate Ramsey second-best optimal policy in a general equilibrium model of growth augmented with renewable natural resources. Natural resources are depleted by private economic activity but they can also be maintained by public policy. The government uses tax revenues to finance infrastructure services and cleanup policy. Policy instruments (the tax rate on polluting activities and the allocation of tax revenue between infrastructure and cleanup policy) are chosen optimally. Gupta and Barman (2009) analyze the properties of optimal fiscal policy in the presence of productive public expenditure and environmental degradation. They consider the level of consumption as the source of pollution. Government allocates its tax revenue between pollution abatement expenditure and productive public expenditure. Degradation of environmental quality reduces the effective benefit of public investment expenditure. One common feature of all these models is that they treat externalities as being generated by private production while the government acts as a "cleaner up" and subtracts the required resources from the private sector.

Finally, a more recent line of research in economic growth models, has focused on the role played by negative externalities and has established the existence of indeterminate equilibrium paths. Chen and Lee (2007) consider a social constant returns economy where a congestion effect generates negative aggregate externalities. Itaya (2008) shows how pollution may affect indeterminacy results in a one-sector growth model with social increasing returns. In Meng, and Yip (2008) indeterminacy derives from negative capital externalities. In Antoci *et al.* (2005) and in Antoci, and Sodini (2009) negative externalities may generate indeterminacy in an economy where private goods can be consumed as substitutes for free access environmental goods.

Starting from the above discussion, the aim of this work is to study the equilibrium dynamics of a growth model with public spending where negative aggregate production externalities are explicitly included in the production function as unfavorable effects. The model simultaneously determines the optimal shares of consumption, capital accumulation, taxes and composition of the two different public expenditures which maximize a representative household's lifetime utilities in a centralized economy. Optimality is determined by deriving the first best optimum of the social planner in the presence of adverse effects deriving from aggregate production. Moreover, under the condition $\sigma=\alpha$ (Uzawa, 1965; Smith, 2006; Chilarescu, 2008; Hiraguchi, 2009) the model supplies a closed form solution and determines the conditions for a balanced growth (Carboni, and Russu, 2012).

The paper has the following structure: section 2 contains the model background, section 3 outlines the analytical model, section 4 describes the dynamics and section 5 concludes.

2. Model Background

In the last decades, a vast literature has emerged on the relationship between fiscal policy and long-run economic growth, and the composition of public expenditure has become a central question in growth studies. For instance, Lee (1992), Devarajan *et al.* (1996) expand on Barro's model, allowing different kinds of government expenditure to have different impacts on growth. Devarajan *et al.* (1996) consider two productive services (expressed as flow variables) with two different productivities and derive the conditions under which a change in the composition of expenditure leads to a higher steady-state growth rate of the decentralized economy. By using the distinction between productive and non-productive spending (Glomm and Ravikumar, 1997; Kneller *et al.*, 1999), they are able to determine the optimal composition of different kinds of expenditures, based on their relative elasticities. Following a similar line, Chen (2006) investigates the optimal composition of public spending in an endogenous growth model with a benevolent government. He establishes the optimal productive public service share of the total government budget and the optimal public consumption share, determined by policy and structural parameters.

Also within an endogenous growth framework, Ghosh, and Roy (2004) introduce public capital and public services as inputs in the production of the final good. They show that optimal fiscal policy in an economy depends on the tax rate and on the share of spending for the accumulation of public capital and the provision of public services. Finally, employing a neoclassical framework Carboni, and Medda (2011, a, b) consider two different kinds of public capital through accumulation and determine the government size and the mix of government expenditures which maximize the rate of growth and the long-run level of per capita income.

Following this strand of literature this paper analyzes the equilibrium dynamics of a growth model with public finance, where two different allocations of public resources are considered. We consider the fiscal policy as a part of the aggregate economy by explicitly including the public sector in the production function. This generates a potential relationship between government and production.

In line with Devarajan *et al.* (1996) and Ghosh, and Gregoriu (2008) we consider the two types of public expenditure entering as flows in the production function. All government activities are considered to be production-enhancing according to their respective elasticities. Hence, the government can influence private production through spending for different types of public investment such as roads and highways, telecommunication systems, RandD capital stock, other infrastructures (Aschauer, 1989; Kneller *et al.*, 1999) or for simple services, such as the maintenance of infrastructure networks and keeping law and order. The different impact of each type of government spending on production makes is all the more necessary to disaggregate the public budget into its various components.

The model considers negative production externalities by explicitly including them as unfavorable effects in the production function. Unlike conventional analysis, here government spending, along with private production, is also assumed to generate negative externalities. This is supposed to have an effect on optimal public spending and tax decision. We analyze the case where the social planner internalizes the externalities in Ghosh, and Gregoriu (2008). Differently from their work which considers four control variables (c, τ, g_1, g_2 in their terminology), we endogenize y so that the social planner directly accounts for, τ and φ in the maximization decision while taking into consideration the negative aggregate externalities coming from production. Moreover, employing a Cobb-Douglas production function our model ends up with three equations. Hence, the complexity of the dynamic system is reduced.

It worth highlighting that Zhang (2011) supplies an analytical expression of the balanced growth solution in a multi-sector model. He calculates the optimal distribution coefficient of fixed capital investment and of labor hour, the proportion of production, the economic growth rate, the rate of change of the price index, and rental rates of different fixed capital. However, differently from our work his analysis does not consider optimal fiscal policy.

3. Model Set Up

In this section we model the government expenditure composition as a part of the aggregate economy. We explicitly include the public sector in the production function as a distinct input based on the rationale that government services are not a substitute for private factors, and resources cannot be easily transferred from one sector to another. Public capital provides flows of rival, non-excludable public services, which would not be provided by the market. Flows are proportional to the relative stocks and enter the production function together with private capital.

The model considers two different categories of public spending. The first (G_1) is traditional core productive spending. The second (G_2) is a broad concept of capital, namely "institutional" spending embracing all the activities which are designed to improve the environment in which firms can effectively operate (Glaeser *et al*, 2004). Both components of government expenditure are complementary with private production (e.g. private vehicles can be used more productively when the quality of the road network increases). Following Barro (1990) and most of the recent work in growth studies, in our specification productive government expenditure is introduced as a flow (Glomm, and Ravikumar, 1994; Turnowski, and Fischer, 1995; Devarajan *et al.*, 1996; Eicher, and Turnovsky, 2000; Ghosh, and Gregoriu, 2008).[1]

[1] An alternative method is to allow the government also to accumulate stocks of durable consumption goods and physical infrastructure capital (Arrow, and Kurz, 1969; Futagami *et al*. (1993); Fisher, and Turnovsky, 1998; Carboni, and Medda, 2011a, b, among others). Although attractive in terms of realism, this approach would substantially increase the dimensionality of the dynamic system. The introduction of two public capital stocks along with private capital would imply a macro dynamic equilibrium with three state variables which considerably complicates the formal analysis (Turnovsky, and Fisher, 1995).

We assume that there is a large number of infinitely lived households and firms that is normalized to one, that population growth is zero and that there is no entry or exit of firms. The representative firm produces a single composite good using private capital (*k*) which is broadly defined to encompass physical and human capital, and two public inputs, G_1 and G_2, based on CES technology:[2]

$$y = k^{\varepsilon} G_1^{\beta_1} G_2^{\beta_2} \overline{y}^{-\psi} \tag{1}$$

where $\varepsilon = 1 - \beta_1 - \beta_2$, $\overline{y}^{-\psi}$ represents the negative externalities deriving from aggregate production ($\overline{y}$) (Chang *et al.*, 2011).

The government finances total public expenditure, $G_1 + G_2$, by levying a flat tax, τ, on income. In line with the main literature, we assume a permanent balanced government budget and rule out debt-financing of government spending (Barro, 1990; Futugami, Morita, and Shibata, 1993; Fisher, and Turnovsky, 1998). Public spending is financed by levying an average flat-rate tax on incomeτ $(0 < \tau < 1)$:

$$G_1 + G_2 = \tau y \tag{2}$$

$\phi(\text{or } 1 - \phi)$ denotes the share of public revenue allocated to $G_1(\text{or } G_2)$ so that

$$G_1 = \phi \tau y \tag{3}$$
$$G_2 = (1 - \phi)\tau y \tag{4}$$

The households own the firms and therefore receive all their output net of taxation which they either reinvest in the firms to increase their capital stock or use for consumption, depending on their preferences and the returns on private capital. Private investment by the representative household equals

$$\dot{k} = (1 - \tau)y - c \tag{5}$$

The central planner maximizes lifetime utility U given by

$$U(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \tag{6}$$

where c represents per capita consumption, and σ is the inter-temporal elasticity of substitution. Replacing (3) and (4) in (1), we obtain

$$y = k^{\alpha} \Lambda(\tau, \phi) \tag{7}$$

where $\Lambda(\tau, \phi) := (\tau\phi)^{\gamma_1}(\tau(1 - \phi))^{\gamma_2}$ and

$$\alpha = \frac{\varepsilon}{1 - \beta_1 - \beta_2 + \psi}, \gamma_1 = \frac{\beta_1}{1 - \beta_1 - \beta_2 + \psi}, \gamma_2 = \frac{\beta_2}{1 - \beta_1 - \beta_2 + \psi}.$$

We assume that the central planner chooses the functions$c$, τ and ϕ in order to solve the following problem

$$\underset{c,\tau,\phi}{MAX} \int_0^{\infty} \frac{c^{1-\sigma} - 1}{1 - \sigma} e^{-rt} dt \tag{8}$$

[2] This specific production function exhibits constant returns to scale at a disaggregate level because each firm takes $\overline{y}$ as given. On the contrary, the social planner can internalize the externality, thus obtaining decreasing returns.

subject to

$$\dot{k} = (1-\tau)k^{\alpha}(\tau\phi)^{\gamma_1}(\tau(1-\phi))^{\gamma_2} - c$$
$$k(0) > 0; \quad t \in 0, +\infty)$$

where $r > 0$ is the discount rate.

4. Dynamics

The current value of the Hamiltonian function associated to problem (8) is

$$H = \frac{c^{1-\sigma}-1}{1-\sigma} + \lambda((1-\tau)k^{\alpha}\Lambda(\tau,\phi) - c) \quad (9)$$

where λ is the co-state variable associated to k. By applying the Maximum Principle, the dynamics of the economy is described by the system

$$\dot{k} = \frac{\partial H}{\partial \lambda} = (1-\tau)k^{\alpha}\Lambda(\tau,\phi) - c \quad (10)$$
$$\dot{\lambda} = r\lambda - \frac{\partial H}{\partial k} = \lambda(r - \alpha(1-\tau)k^{\alpha-1}\Lambda(\tau,\phi)) \quad (11)$$

with the constraint

$$H_c = c^{-\sigma} - \lambda = 0 \quad (12)$$
$$H_{\tau} = (-k^{\alpha}\Lambda + k^{\alpha}(1-\tau)\Lambda\Lambda_{\tau})\lambda = 0 \quad (13)$$
$$H_{\phi} = (1-\tau)k^{\alpha}\Lambda_{\phi}\lambda = 0 \quad (14)$$

with $\Lambda_{\tau} = \frac{\partial\Lambda}{\partial\tau} = \frac{\Lambda}{\tau}(\gamma_1+\gamma_2)$ and $\Lambda_{\phi} = \frac{\partial\Lambda}{\partial\phi} = \frac{\Lambda}{\phi}(\gamma_1-\gamma_2)$.

By straight calculation, we can write the values of the control variables τ, ϕ which

$$\phi^{\text{å}} = \frac{\gamma_1}{\gamma_1+\gamma_2} \quad (15)$$
$$\tau^{\text{å}} = \frac{\gamma_1+\gamma_2}{1+\gamma_1+\gamma_2} \quad (16)$$

which in terms of the initial exponents become

$$\phi^{\text{å}} = \frac{\beta_1}{\beta_1+\beta_2} \quad (17)$$
$$\tau^{\text{å}} = \frac{\beta_1+\beta_2}{1+\psi} \quad (18)$$

It is worth noting that ψ (the unfavorable effect) has only effects on $\tau^{\text{å}}$ and that the optimal rate of taxation will be smaller than the case with no externalities ($\psi = 0$). This comes from the very assumption of the model which assumes government spending, along with private production, to be a source of negative undesired effects. This clearly affects optimal public spending and tax decision. More in detail, in order to reduce (increase) the externalities to the optimal level the central planner ought to reduce (increase) taxes and public spending.

By replacing equations (17) and (18) in (8) and noting that from equation (12)$\frac{\dot{c}}{c} = -\frac{1}{\sigma}\frac{\dot{\lambda}}{\lambda}$, one can write the following system, equivalent to (10)-(11)

$$\dot{k} = \Lambda^{\dot{a}} k^{\alpha} - c \quad (19)$$

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}(\alpha \Lambda^{\dot{a}} k^{\alpha-1} - r) \quad (20)$$

where

$$\Lambda^{\dot{a}} := \frac{\Lambda(\tau^{\dot{a}}, \phi^{\dot{a}})}{1+\gamma_1+\gamma_2} = \beta_1^{\gamma_1} \gamma_2^{\gamma_2} (1+\gamma_1+\gamma_2)^{1-\gamma_1-\gamma_2} \quad (21)$$

This condition is required in order to obtain a closed form solution and has been applied in Uzawa (1965) two-sector growth model, Smith (2006) while describing the Ramsey model, Chilarescu (2008) and Hiraguchi (2009) while describing the Lucas (1988) model.

Lemma 1 *If $\alpha = \sigma$ then the solution of equation (20) is given by*

$$c(t) = \frac{\omega c_0}{c_0 + (\omega k_0 - c_0) e^{rt}} k(t) \quad (22)$$

Proof. If we consider the variable defined as $x = \frac{c}{k}$, we can write the following differential equation

$$\frac{\dot{x}}{x} = \frac{\dot{c}}{c} - \frac{\dot{k}}{k},$$

replacing (19) and (20), we obtain

$$\frac{\dot{x}}{x} = \frac{\alpha}{\sigma} \Lambda^{\dot{a}} k^{\alpha-1} - \frac{r}{\sigma} - \Lambda^{\dot{a}} k^{\alpha-1} + \frac{c}{k} \quad (23)$$

under the hypothesis $\frac{\alpha}{\sigma} = 1$, we get $\frac{\dot{x}}{x} = -\frac{r}{\sigma} + x$, where for some $x(0) = x_0$ the solution is $x(t) = \frac{\omega}{1 + (\frac{\omega}{x_0} - 1) e^{\omega t}}$, where $\omega := \frac{r}{\sigma}$. But for some $x_0 = \frac{c_0}{k_0}$ the solution is given by (22).

Theorem 1 *Under the assumptions of the above lemma, the following statements are valid:*

- If $\omega k_0 - c_0 = 0$, then consumption per labor unit is always proportional to the capital per labor unit

$$c(t) = \omega k(t) \quad (24)$$

- If $\omega k_0 - c_0 > 0$, then

$$\frac{\dot{k}(t)}{k(t)} > \frac{\dot{c}(t)}{c(t)}, \qquad \forall t \quad (25)$$

- If $\omega k_0 - c_0 < 0$, then

$$\begin{cases} \frac{\dot{k}(t)}{k(t)} < \frac{\dot{c}(t)}{c(t)}, & \forall t \in (0, \bar{t}) \\ \frac{\dot{k}(t)}{k(t)} > \frac{\dot{c}(t)}{c(t)}, & \forall t > \bar{t} \end{cases} \quad (26)$$

where $\bar{t} := \frac{1}{\omega} ln(\frac{c_0}{|\omega k_0 - c_0|})$

For $c_0 \neq \omega k_0$

$$\lim_{t\to\infty}\left(\frac{\dot{c}}{c}-\frac{\dot{k}}{k}\right) = -\omega \tag{27}$$

that is, there exists a t^*, such that $\frac{\dot{k}}{k} \approx \frac{\dot{c}}{c} + \omega \Leftrightarrow c(t) = \omega k(t)e^{-\omega(t-t^*)}, \forall\, t > t^*$.

Proof. From 22, the first statement is obviously true. Differentiating $x(t)$, we obtain $\frac{\dot{x}}{x} = \frac{\dot{c}}{c} - \frac{\dot{k}}{k} = -\frac{r(\omega k_0 - c_0)}{c_0 e^{-\omega t} + (\omega k_0 - c_0)}$. Thus the next three statements follow as consequence.

As it is well known, a macroeconomics model exhibits balanced growth if consumption and capital grow at a constant rate while hours of work per time period stay constant that is if and only if $c_t = \omega k_t$.

Theorem 2 *If model exhibits balanced growth, the dynamic of the state variable $k(t)$ is given by*

$$k(t) = \left(\frac{\omega}{\Lambda^* + e^{\omega(\alpha-1)t}(k_0^{\alpha-1}\omega - \Lambda^*)}\right)^{\frac{1}{\alpha-1}} \tag{28}$$

Proof. To prove the theorem, observe that, in the case $c_0 = \omega k_0$, $\dot{k}(t) = \Lambda^* k^\alpha - \omega k$ is a Bernoulli differential equation.

Theorem 1 shows the relation between growth and the variables c and k when varying the initial conditions (c_0, k_0).

- *Case 1* realizes balanced growth.
- *Case 2* tells us that if the ratio between initial conditions $\left(\frac{c_0}{k_0}\right)$ is smaller than $\omega = \frac{r}{\sigma}$ (i.e. constant rate of time preference and constant elasticity of intertemporal substitution ratio) then the capital stock growth ratio $\left(\frac{\dot{k}}{k}\right)$ is greater than the growth rate of consumption $\left(\frac{\dot{c}}{c}\right)$ at any point in time.
- *Case 3* implies that if the ratio between initial conditions $\left(\frac{c_0}{k_0}\right)$ is larger than $\omega = \frac{r}{\sigma}$ then for a given initial period $(0;\bar{t})$ the growth rate of capital stock is larger than that of consumption, while for the remaining time the opposite occurs.
- *Case 4* if $c_0 \neq \omega k_0$ then for a significantly large period of time ($t \to \infty$) consumption goes to zero given $c(t) = \omega k(t)e^{-\omega(t-t^*)}$.

Concluding Remarks

This work addresses the issue of optimal policy with externalities caused by aggregate production and analyzes the equilibrium dynamics of a growth model with public finance and two different allocations of public spending. Fiscal policy is part of the aggregate economy. This generates a potential relationship between government and production. In order to better capture reality, the model considers negative production externalities by explicitly including them as unfavorable effects in the production function. However, differently from the conventional paradigm, government spending, along with private production, also generates undesired effect.

In the ideal world represented in economic models, agents interact exclusively through the market as a function of their choices and actions. In the real world, the actions of an agent may alter the environment where other economic agents operate, regardless of, and in addition to, the effects generated by the price system. Hence, we emphasize the role played by taxation and public expenditures in the internalization of external effects aiming at achieving a socially desirable outcome. This is an important issue, because if such public intervention is optimally done, overall welfare in the economy improves.

The model analyzes the equilibrium dynamics and derives a closed form solution for the optimal shares of consumption, capital accumulation, taxes and composition of the two different public expenditures which maximize a representative household's lifetime utilities for a centralized economy. With one restriction on the parameters $(\alpha = \sigma)$ we fully determine the solutions path for all variables of the model and determine the conditions for a balanced growth. Finally, given the active role the government has in determining the level of aggregate production, the model suggests that the higher (lower) the externalities, the lower (higher) the tax rate and public spending ought to be.

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THE GOVERNMENT-TAXPAYER GAME

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Abstract:

In this paper, we model - quantitatively – a possible realistic interaction between a taxpayer and his Government. We formalize, in a general setting, this strategic interaction. Moreover, we analyze completely a particular realistic sample of the general model. We determine the entire payoff space of the sample game; we find the unique Nash equilibrium of the interaction; we determine the payoff Pareto maximal boundary, the conservative payoff zone and the conservative core of the game (part of Pareto boundary greater than the conservative payoff of the game). Finally, we suggest possible compromise solutions between the two players. From an economic point of view, the sample chosen gives an example of normative settings, for which, there is no reason (convenience), for the taxpayer, to evade the taxes or to declare less than his real income, when his behavior is conservative (defensive, risk-averse). Moreover, the two proposed compromise solutions (which realize the maximum collective gain) could be significantly applied to distinguished taxpayer (big companies and so on).

Keywords*:* Government; taxpayer; tax; fiscal policy; tax evasion.

JEL Classification: E62; H21; E42; G38; G18; G28; H26.

1. The Model

We shall consider a two-player normal form gain game, G = (f, >), representing the rational interaction between the **Government (first player 1)** and a **Taxpayer (second player 2)**, in a country. The payoff function f from the product E × F into IR^2 of our game shall be defined upon the bi-strategy space of the game, Cartesian product of the respective strategy spaces of the two players, and with values into the payoff universe IR^2. The two components f_1 and f_2 of the function f are the respective payoff function of the two players.

1.1. Strategy spaces

Government**.** The unit interval **U** = [0,1] is the strategy set of the Government, a probabilistic interval: each element x of the unit interval **U** is the probability that the Government checks the real (true) income of the Taxpayer.

Taxpayer**.** The compact interval F = [0,V] is the range of possible income declarations of the Taxpayer, each element y in F is a possible income that the Taxpayer may decide to declare to the Government, V is the true income of the taxpayer.

1.2. Payoff function of the Government

We consider, firstly, the payoff function of the Government, in his interaction with the Taxpayer 2; it is, as usual, a real function f_1: [0,1] × [0,V] ⟶ **R**. To construct the payoff function f_1 (that is, to define its "correspondence law") we shall proceed step by step.

First step. Firstly, we consider the case in which the Government checks the Taxpayer declaration, that is, the strategy 1 of the Government. In this case, we have

$f_1(1, y) = tV + g(t)(V - y) - C$, for every strategy y in F, where:

a) the fixed real number t, belonging to IU, is the percentage (the unit interval U is now interpreted in a different way), due by the Taxpayer to the Government, upon his real income V. Hence, a first income of the Government, in this case, is the discounted cash flow tV;
b) the real number g(t) > t is the fixed percentage due, by the taxpayer, to the Government upon his own non-declared income (V – y); so that, the Government receives also the discounted cash flow g(t)(V - y);

c) at last, the real number C is the cost afforded by the Government to check the tax evasion.

Second step. Secondly, we consider the case in which the Government does not check (at all) the taxpayer declaration and accept the strategy y of the Tax-payer as his true income, so that, we have:

$f_1(0,y) = ty$,

for every strategy y of the second player.

Third step. To obtain the values of the function f_1, on the remaining part of the bi-strategy space, we shall use the von Neumann mixed-extension method, but only with respect to the first finite strategy space {0,1} of the Government. In other terms, we shall consider – for every strategy y of the Taxpayer - the mixed extension of the finite stochastic variable $L(y): \{0,1\} \to \mathbf{R}$, defined by

$L(y)(0) = f_1(0,y) = ty$ and $L(y)(1) = f_1(1, y) = tV + g(t)(V - y) - C$,

by using the probabilistic scenarios **only for the actions of the Government** (see later for a robust justification of this probabilistic choice and its applicability). We so have:

$$\begin{aligned} f_1(x, y) &= \mathbf{E}_{(1-x,\, x)}(L(y)) = \\ &= \mathbf{E}_{(1-x,\, x)}(ty,\ tV + g(t)(V - y) - C) = \\ &= (1- x)\, ty + x\,[tV+ g(t)(V- y) - xC] = \\ &= x\,[tV + g(t)(V- y) - C - ty] + ty . \end{aligned}$$

1.3. Payoff function of the second player, the Taxpayer

In general, for the payoff function of the second player, we have:

$f_2(0,y) = (V- y) + (1 - t)y$, for every y in F; indeed, when the government does not check the possible evasion, the Taxpayer net income is:

1) the non-declared income $(V- y)$ (considered as it is, since there are no taxes on it);
2) plus the declared income y minus the tax ty , which player 2 has to pay because of the declaration y.

When the Government decides to check the declaration of the Taxpayer, we obtain:

$f_2(1, y) =(1-t)V - g(t)(V- y)$,

for every y in F, indeed, when the Government checks the possible evasion, the Taxpayer net income is:

1) the non-declared income $(V- y)$ minus a higher tax $g(t)(V- y)$ - with respect to the usual taxation $t(V- y)$ - because of the evasion;
2) plus the real income V minus the tax tV on the real income V, which player 2 has to pay because the Government, after the check, knows the real income V of the Taxpayer.

Mixed extension. By adopting the von Neumann mixed extension method, as before only on the Government strategies, we obtain:

$$\begin{aligned} f_2(x,y) &= \mathbf{E}_{(1-x,\, x)}((V - y)+(1 - t)y,\ (1- t)V - g(t)(V- y)) = \\ &= (1- x)\,((V - y) + (1 - t)y)+ x((1- t)V - g(t)(V- y)), \end{aligned}$$

for every pair (x,y) in the bi-strategy space.

Payoff Function of Government - Taxpayer Game. Resuming the above results, we can finally give the definition of the payoff vector function of our entire game G; it is defined by

$$f(x,y) = (x\,[tV + g(t)(V- y) - C - ty] + ty,\ (1- x)\,[(V - y)+ (1 - t)y] + x[(1- t)V - g(t)(V- y)]),$$

for every (x,y) in the strategic square S.

2. Numerical Example

To build up a computable and realistic example, we shall put:

$t = 25\% = ¼$, $g(t) = ½ = 50\%$, $C = ¼$ and $V = 1$.

Remark (on the strategy sets).

(1) In the above example, we are normalizing the real income V; so that, also the declaration strategy y belongs to the compact unit interval **U** = [0,1], 0 means total Tax Evasion (declaration 0), 1 means No Tax Evasion (the declaration y equals the real income V).

(2) Any strategy x of the first player belongs to [0,1], but the meaning is completely different, as it is emphasized in the following remark.

Remark (interpretation of strategy spaces). The interpretations of our strategy spaces are obvious and recalled below:

a) the strategy space E is a probabilistic strategy space;
b) the strategy space F (of the second player) is a "money" strategy space;
c) any strategy x of E has a probabilistic meaning: probability 0 means "No check the possible tax evasion of the Taxpayer"; probability 1 means "to check the possible tax evasion of the player 2";
d) from a *frequency* point of view, the probabilistic strategy x is realizable by checking n = x m taxpayer declarations, where m is the total number of taxpayers.

2.1. Payoff functions

Let us see the form of our particular payoff functions.

Payoff function of the Government

In our numerical example, we have:

$$f_1(x, y) = x((1/4) V + (1/2) (V- y) - (1/4) - (1/4)y)+ (1/4)y =$$
$$= x ((3/4) – (1/2) y – (1/4) – (1/4) y)) + (1/4)y =$$
$$= x ((1/2) – (3/4) y)) + (1/4) y =$$
$$= x/2 - (3/4)xy + y/4,$$

for every pair (x,y) in the square $\mathbf{U}^2$.

Payoff function of the taxpayer

In our numerical example, we have:

$$f_2(x, y) = (1- x) (1- y +(3/4)y + x((3/4) –(1/2)(1- y))=$$
$$= (1- x) (1- (1/4)y) + x(1/4)+(y/2)) =$$
$$= (1- (y/4)) - x + (x/4) y + (x/4) + (x/2) y =$$
$$= 1- (3/4) x + (3/4) xy - y/4,$$

for every pair (x,y) in $\mathbf{U}^2$.

Payoff function of the sample game

Concluding, in our numerical example, the payoff function of the entire game is defined by

$$f (x, y) = (x/2 + y/4 – (3/4) xy, 1 - (3/4) x + (3/4) xy – y/4) =$$
$$= (1/4) (2x + y - 3xy, -3x – y + 3xy) + (0,1),$$

for every strategy profile (x,y) of the game G.

Tridimensional representation of the game (f,>). Here, we present a 3D representation of the game (f,>). This representation consists in the union of the graphs of the payoff functions. The mostly higher surface is the graph of the Government payoff function, the mostly lower surface is the graph of the Tax-payer payoff function.

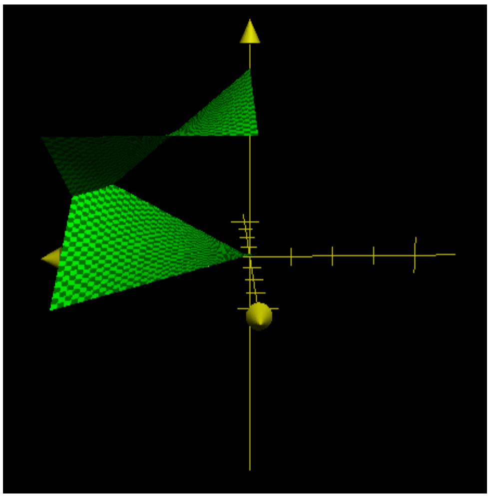

Figure 1. 3D representation of f

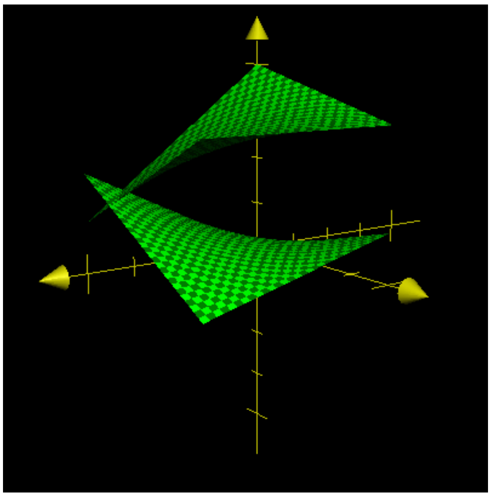

Figure 2. 3D representation of f

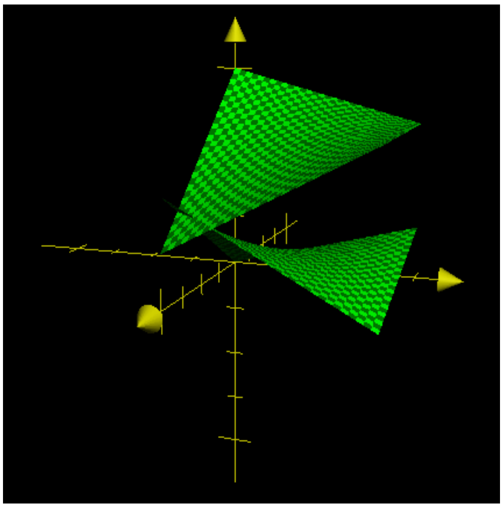

Figure 3. 3D representation of f

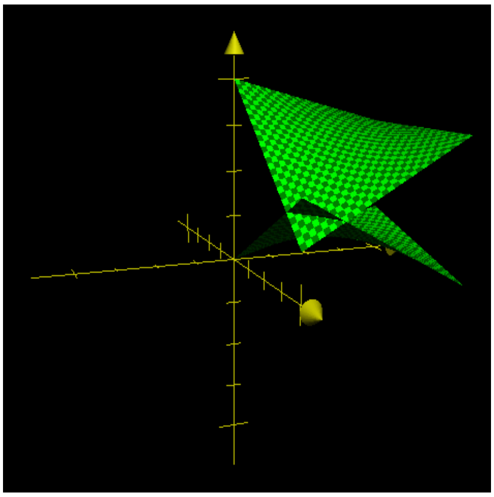

Figure 4. 3D representation of f

Note that, there is a connected part of the bi-strategy square on which the Tax-payer function is greater than the Government function. We represent it in the following figure.

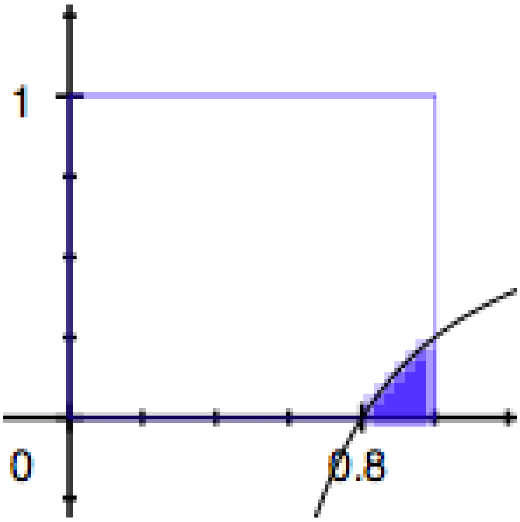

Figure 5. Tax-payer function is greater than the Government function

3. Digression: Why the taxpayer should pay the taxes?

Note that our game (f,>) is a non-zero and non-constant sum game: the aggregate payoff function s of our game G is the real function defined on the bi-strategy space by

$s(x, y) = - ¼ x + 1$, for every probability strategy x of the Government. The interpretation is quite clear:

a) 1 is the total income of the tax payer, which is in this context the only effective income of the game;
b) and ¼ x is the expense of the Government for checking the evasion, when it decides to employ the strategy x.

Observe, moreover, that the maximum, on the strategy space **U,** of this social sum s is attained at any bi-strategy point (0,y), with y in **U**, and this maximum is 1 (the Taxpayer real income). So that, the maximum collective gain $1 = \max_U (s)$, corresponds to the situation in which the Government does not check the declaration of the Taxpayer (0 expenses for checking it). Of course, in this case, the Taxpayer (if he is aware of the Government strategy) will choose to declare nothing (his strategy 0) and *the total collective payoff remains only in the Taxpayer's hands*. Obviously this last situation is a selfish bad scenario for the human society: but this is also the reason at the root of the tax evasion.

The *key-solution for the collectivity* is that the tax tV (or ty or g(t)(V-y), and so on…) should be used by the Government "much better" than how much the taxpayer itself can do! In other terms, *to convince the Taxpayer to pay the taxes*, the Government should employ the capitals deriving from taxes at an income rate i_G such that, for any reasonable tax payer individual income rate i_T, one has (for instance in the case of truthful declaration)

$$(1+ i_G) tV + (1+ i_T)(1- t)V > (1+ i_T)V,$$

i.e., a rate of income that makes the social sum $(1+ i_G) tV + (1+ i_T)(1- t)V$ greater than the potential future income $(1+ i_T)V$, of the Taxpayer.

4. The Complete Analysis of Our Sample Game

In this section we conduct the complete analysis of the game (f, >). At this aim, we observe that the payoff function f, of our numerical example, is viewable as 0.25 g + (0,1), where we have considered the "payoff kernel" g, defined by

$$g(x,y)= (2x + y - 3xy, -3x – y + 3xy),$$

for every bi-strategy (x,y). We shall study only this kernel g, since any information on the game (f, >) is deductible from the game (g, >), by a 0.25 rigid contraction and then by a (0, 1) translation.

4.1. The bi-strategy space

As we already saw, the bi-strategy space of our game is the square $\mathbf{U}^2$ it is represented in the following figure.

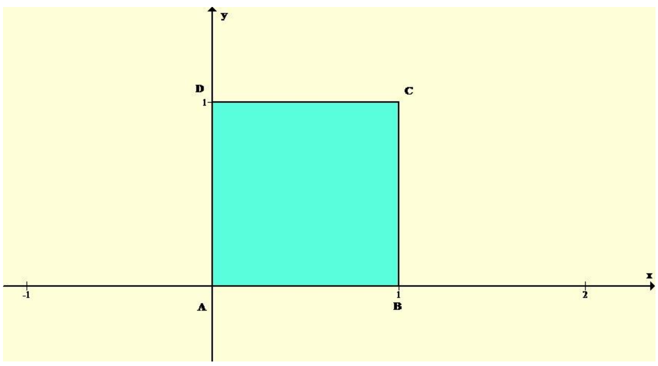

Figure 6. The bi-strategy space (square) S

4.2. The Payoff space

Our first significant aim is to find the payoff space of the game (g, >), that is the image g(S) of the vector payoff function g (the image of the bi-strategy square S under g). At this aim, we transform the topological boundary fr(S) of the square S, that is the union of the 4 edges of the square; and moreover, we have also to transform the critical zone cr(g) of the vector function g (set of bi-strategies at which the Jacobian matrix of g is not-invertible): the boundary of the image of g, is contained into the union of the two images g(fr(S)) and g(cr(g)):

$fr(g(S)) \subseteq g(fr(S)) \cup g(cr(g))$.

So let's go to study the Critical zone of g.

Critical zone. The critical zone of the function g is the set of all bi-strategies (x,y) at which the Jacobian matrix (family) is not invertible. The Jacobian family of the function g - defined by

$g(x,y)= (2x + y - 3xy, -3x – y + 3xy)$,

for every bi-strategy (x,y) - is the pair of gradients

$J(g)(x,y) = (grad(g_1), grad(g_2)) =$

$= ((2 - 3y, 1 - 3x), (3y - 3, 3x - 1))$.

The Jacobian determinant of the function g at the point (x, y) is the determinant of the vector family J(g)(x, y), that is the real number:

$det J(g)(x,y) = (2 - 3y)(3x - 1) + (3y - 3)(3x - 1) =$

$= 6x - 2 - 9xy + 3y + 9xy - 3y - 9x + 3 =$

$= -3x + 1$.

So the Jacobian family is not invertible at the point (x, y) if and only the abscissa x is equal to 1/3. Concluding the critical zone of the function g is the segment cr(g) = **U**(0,1) + (1/3,0), or, if you prefer, the segment cr(g) = [(1/3,0), (1/3,1)].

Recapitulating: the critical zone is the subset of points (x,y) of the plane with x = 1/3 and y in **U**, it is the segment [P, Q] represented in the following figure 2. Note that the payoff critical zone is the unique point P' = (2/3,-1) (see Appendix 3).

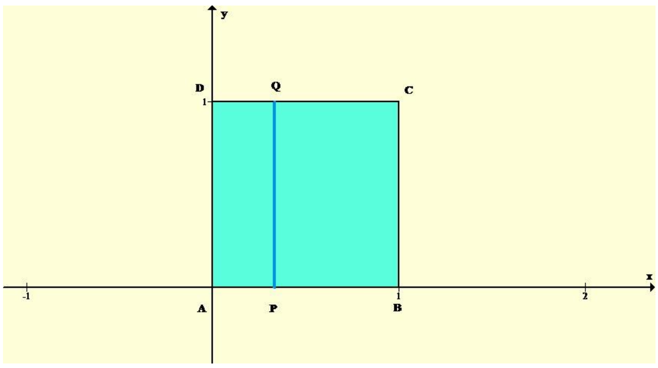

Figure 7. The Critical zone [P,Q] in bi-strategy space

Payoff space. Since the boundary of the payoff space is contained into the union of the transformation of the boundary of the square S and since the critical zone in the payoff space in reduced to the single point P' = (2/3, -1), we deduce that the boundary of the payoff space is indeed the transformation of the boundary of the square S. So we have the following Figure 3 (for the calculations see Appendix 3). In Figure 3, it is evident the geometric importance of the knot P'.

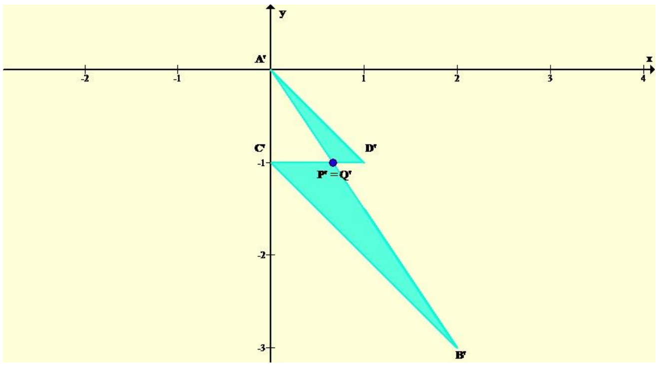

Figure 8. The payoff space of the game

4.3. Nash equilibrium

The **unique Nash equilibrium** is the pair N = (1/3, 2/3), the corresponding Nash payoff N' belongs to the payoff critical zone, so it is the payoff P' = (2/3, -1): this is simple to check and we give the calculations in Appendix 1.

The **Nash payoff of the original game** (f, >) is the payoff (1/6, 3/4). As we'll see, the Nash payoff of the taxpayer is his conservative one.

4.4. Conservative phase

Also the conservative bi-value of the game belongs to the payoff critical zone {P'}, as shown in the following figure 4. We give all the calculations in Appendix 2. The conservative strategies are $x^{\#}$ = 1/3 and $y^{\#}$ =1, respectively. Note that *the unique conservative strategy of the taxpayer is the truthful declaration* 1.

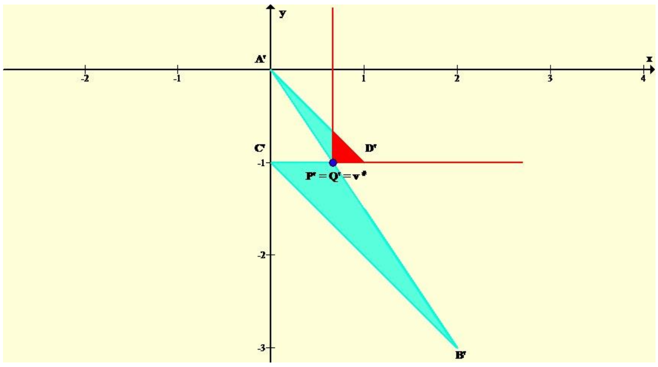

Figure 9. The conservative zone of the game (g, >) in its payoff space

4.5. Pareto boundary

The Pareto maximal boundary is (straightforwardly) the union of segments [A', D'] and [H', B'], shown in the below figure (the point H' - which is not Pareto efficient - is denoted by a little triangle). Note that it is bounded but not compact and (evidently) not connected.

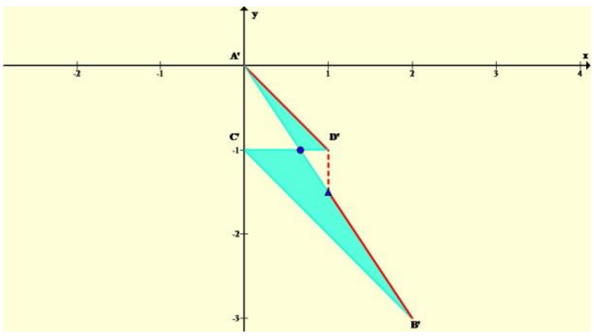

Figure 10. The Pareto boundary in the payoff space (bounded but not closed)

4.6. The conservative core

The core is simply a compact segment, as it is shown in the figure below. It has the important characteristic to be entirely with the maximum collective (aggregate) value of the game.

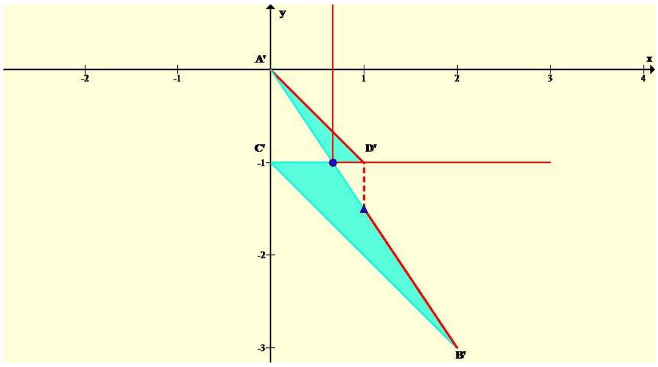

Figure 11. The conservative core (which coincides with the Nash core) in the payoff space

4.7. Compromise solution

We propose two compromise solutions, maximizing the collective payoff of the game. They are almost coincident. We propose Kalai-Smorodisky solutions with threat point the Nash equilibrium and utopia points, the sup of the game or the sup of the core. They are both win-win solutions with respect to the Nash payoff.

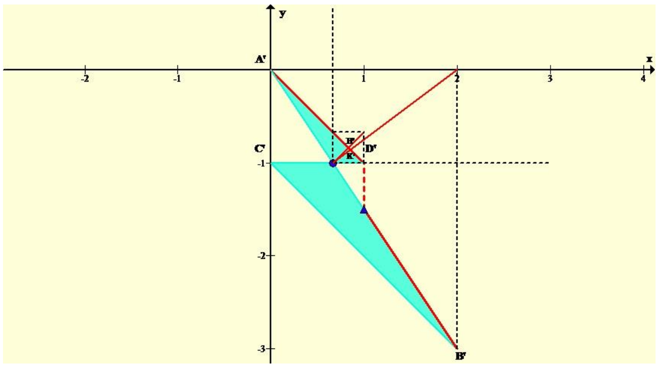

Figure 12. The Kalai-Pareto compromise solution and the core compromise in the payoff space

Important remark 2 (risk neutral solution of the game). To stress more the question, let au study the payoff function of the taxpayer at its Nash equilibrium strategy y = 2/3. We have

$h(x) := g_2(x, 2/3) = - 3x - 2/3 + 2x = - 2/3 - x,$

for every Government strategy x. Assume the taxpayer be risk neutral and without any information about the Government strategy, then we have to consider the mean value of the above function h, it is

$\mu = (½) (- 2/3 - 5/3) = - 7/6 < -1 = v_2^{\#},$

so that, even a risk neutral taxpayer, will decide to defend himself by the conservative strategy 1.

Important remark 3 (Stackelberg behavior). Assume that the taxpayer is aware that the Government is being to use his Nash equilibrium strategy 1/3. Then, the payoff function to be considered is the section g_2 (1/3,), given by $g_2(1/3, y) = -1$, for every y in E: also in this case, we have the conservative payoff -1.

Conclusions

The goals of our paper are resumed in what follows.

- We model, in a *very general and applicable framework*, the interaction between a Government of a country and any possible tax-payer of the country itself, by using a *realistic probability (frequency) approach for the checking evasion strategy* of the Government;
- We propose a *realistic and realizable, by normative actions and laws*, particular sample of the general model. In this sample, the *Nash equilibrium* shows a situation in which the payoff of the taxpayer equals

the *conservative payoff* of the taxpayer himself. Not only this circumstance is, by itself, the worst possible one for a tax evasion, but moreover, *the taxpayer could attain this Nash/conservative payoff by declaring truthfully his real income*, not incurring in any punishment.

- Furthermore, since at least the conservative payoff (and in this case also Nash payoff) of the tax payer is certainly reached by the adoption of his unique conservative strategy 1, for *a risk averse or risk neutral tax payer, there is no reason to declare less than his real income.*
- In our realistic particular example, the *conservative strategy of the tax payer (the most likely one*) shows a situation in which *a tax payer has no convenience to declare an income inferior than the real one;*
- We propose, by the way, a measure of the *collective loss in the above Nash equilibrium*, and we show its position by the *total knowledge of the entire payoff space* of the sample-interaction.
- We show *two (quantitatively close) compromise solutions*, applicable (by binding contracts) in the case of *great distinguished tax-payers*, maximizing the collective gain of the society.

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APPENDIX 1

Nash Equilibrium

We recall that the kernel function g is defined by

$g(x,y)= (2x + y - 3xy, -3x – y + 3xy)$,

for every x,y in the strategy square **U**. Then, for what concern the partial derivative of g_2 in the second argument, note that

$g_2 (x,)'(y) = \partial_2 g_2 (x, y) = -1 + 3 x \geq 0$,

so that the tax-payer section $g_2 (x,.)$ is strictly increasing if x > 1/3, it is constant if x = 1/3 and it is strictly decreasing when x < 1/3. Hence, the reaction correspondence B_2 (from E into F) is defined by $B_2(x) = \{0\}$ if x < 1/3, $B_2(x) = F$ if x = 1/3 and $B_2(x) = \{1\}$ if x > 1/3. Recapitulating, we have

$$B_2 (x) = \begin{cases} \{0\} & \text{if } x \in [0, 1/3[\\ [0,1] & \text{if } x = 1/3. \\ \{1\} & \text{if } x \in]1/3, 1] \end{cases}$$

On the other hand, we have $g_1 (x,y) = 2x + y – xy$, for any x, y in [0,1]. Since we have

$g_1 (.,y)' (x) = \partial_1 g_1 (x,y) = 2 – 3y \geq 0$,

then the section $g_1 (.,y)$ is strictly increasing if y < 2/3, it is constant if y = 2/3, and it is strictly decreasing if y > 2/3. Hence, the reaction correspondence B_1 (of F into E) is defined by $B_1(y) = \{1\}$ if y < 2/3, $B_1(y) = E$ if y = 2/3 and $B_1(y) = \{0\}$, when y > 2/3:

$$B_1 (y) = \begin{cases} \{1\} & \text{if } y \in [0, 2/3[\\ [0,1] & \text{if } y = 2/3. \\ \{0\} & \text{if } y \in]2/3, 1] \end{cases}$$

Nash Equilibria. We have (by intersecting the graph of B_2 with the inverse graph of the correspondence B_1) one unique Nash equilibrium of the game (g,>): the point N = (1/3, 2/3). This Nash equilibrium is also the Nash equilibrium of the original game (f,>). The **Nash payoff of the kernel game** (g,>) is the critical payoff point N' = g(N) = (2/3, – 1), this is obvious also because the entire critical zone (1/3,0) + **U**(0,1) is transformed into the single point P' = (2/3,-1).

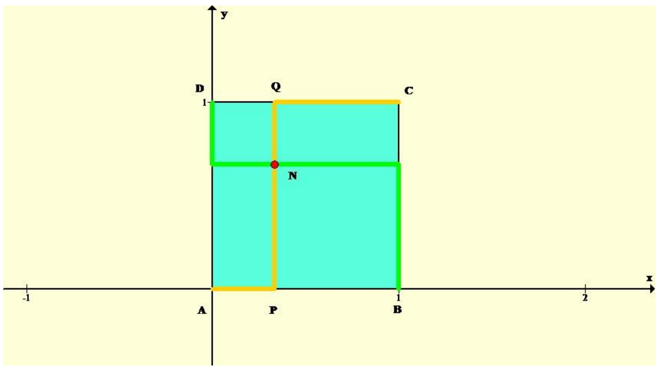

Figure A1. The best reply graphs with Nash equilibrium

The **Nash payoff of the original game** (f,>) is the critical payoff point

(1/4)N' + (0, 1) = (1/4) (2/3, – 1) + (0, 1) = (1/6, ¾).

Note that this point guarantees a collective gain equal to 11/12.

Important remark 1 (risk averse solution of the game). Note that the Nash payoff of the taxpayer (in the original game (f,>)) is ¾, exactly the conservative payoff of the taxpayer in the game (f,>). So that, a rational risk averse taxpayer should prefer the conservative strategy $y^{\#} = 1$ (which guarantees at least this payoff ¾, independently on the Government strategy) to the uncertain scenario shown by the Nash equilibrium strategy 2/3: **a risk averse taxpayer has no reasons to choose other strategies than the conservative truthful declaration** $y^{\#} = 1$, in the conditions of our sample game (f,>).

APPENDIX 2

Conservative phase

The conservative value for the first player is

$v_1^{\#} = \sup_{x \in E} \inf_{y \in F} (2x + y - 3xy) = \sup_{x \in E} g_1^{\#}(x)$,

where $g_1^{\#}(x) = \inf_{y \in F} (2x + y - 3xy)$ is the *worst gain function for the first player*. Now, fixed $x \in [0, 1]$, we have

$g_1(x, .)'(y) = 1 - 3x$,

so the section $g_1(x,.)$ is strictly increasing if $x < 1/3$, it is constant if $x = 1/3$ and it is strictly decreasing if $x > 1/3$. Hence, **the worst offensive correspondence** O_2 of the second player versus the first one is defined, from E into F, by $O_2(x) = \{0\}$ if $x < 1/3$, $O_2(x) = F$ if $x = 1/3$ and $O_2(x) = \{1\}$ if $x > 1/3$.

So that **the worst gain function for the Government** is defined by

$$g_1^{\#}(x) = \begin{cases} g_1(x, 0) = 2x & \text{if } x \leq 1/3 \\ g_1(x, 1) = 1 - x & \text{if } x > 1/3 \end{cases}$$

The unique maximum point of the above function is $x^{\#} = 1/3$, this is the **unique conservative strategy of the first player**. **The conservative value of the first player** is $v_1^{\#} = g_1^{\#}(x^{\#}) = 2/3$.

The conservative value for the second player is

$v_2^{\#} = \sup_{y \in F} \inf_{x \in E} (-3x - y + 3xy) = \sup_{y \in F} g_2^{\#}(y)$,

where

$g_2^{\#}(y) = \inf_{x \in E} (-3x - y + 3xy)$

is the **worst gain function for the second player**. Now, fixed $y \in [0, 1]$, we have

$g_2(.,y)'(x) = -3 + 3y$,

so the section $g_2(., y)$ is strictly decreasing if $y < 1$, it is constant if $y = 1$. Hence, the worst offensive correspondence O_1, form F into E, is defined by $O_1(y) = \{1\}$, if $y < 1$ and by $O_1(y) = E$, if $y = 1$.

So that, **the worst gain function for the Taxpayer** is defined by

$g_2^{\#}(y) = g_2(1, y) = -3 + 2y$,

for every y in F. The unique maximum point of the above function (in F) is the strategy $y^{\#} = 1$, this is the **unique conservative strategy of the second player**.

The conservative value of the second player is $v_2^{\#} = g_2^{\#}(y^{\#}) = -1$.

The payoff at the conservative cross is the Nash Payoff, $g(1/3, 1) = (2/3, -1)$.

APPENDIX 3

Payoff space

We study the image of the function g - defined by
g (x, y) = (2x + y - 3xy, -3x – y + 3xy),
for every bi-strategy (x, y).

Image of side [A, B]. We have
G (x, 0) = (2x, -3x),
for every strategy x in [0, 1], so that the image of the segment [A, B] is the straight line segment [A', B'], *where* A' = (0, 0) and B' = (2,-3).

Image of side [B, C]. We have
g(1,y) = (2 - 2y, - 3 + 2y),
for every strategy y in [0, 1], so that the image of the segment [B, C] is the straight line segment [B', C'], *where* B' = (2,-3) and C' = (0, -1).

Image of side [C, D]. We have
G (x,1) = (1 - x, – 1),
for every strategy x in [0, 1], so that the image of the segment [C, D] is the straight line segment [C', D'], *where* D' = (1, -1) and C' = (0, -1).

Image of side [A, D]. We have
G (0, y) = (y, – y),
for every strategy y in [0, 1], so that the image of the segment [A, D] is the straight line segment [C', D'], *where* D' = (1, -1) and A' = (0, 0).

Image of the critical zone [P,Q]. We have
g(1/3,y) = (2/3 , -1),
for every y in [0, 1], so that the image of the critical strategy segment [P, Q] is the degenerate straight line segment [P',Q'] (it is a unique point), where P' = Q' = (2/3, -1).

MODELING UNEMPLOYMENT AND EMPLOYMENT IN ADVANCED ECONOMIES: OKUN'S LAW WITH A STRUCTURAL BREAK

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Abstract:

Using a modified version of Okun's law, we have modeled the rate of unemployment and the employment/population ratio in several largest developed countries: Australia, Canada, France, Japan, the UK, and the U.S. Our results show that the evolution of the (un)employment rate since the early 1970s can be predicted with a high accuracy by a linear dependence on the logarithm of real GDP per capita. All empirical relationships estimated in this study need a structural break somewhere between 1975 and 1995. We argue that these breaks are of artificial nature and were caused by similar changes in measurement procedures in all studied counties: the deviation between the GDP deflator and CPI and the structural breaks in the modified Okun's law are synchronous. Statistically, the link between measured and predicted rate of (un)employment is characterized by R^2 from 0.84 (Australia) to 0.95 (Japan). The model residuals are likely to be associated with measurement errors.

Keywords: employment, unemployment, real GDP, modeling, Okun's law.

JEL Classification: J65.

1. Introduction

There is an economic problem which is likely felt as superior to all other problems in the socio-economic domain. This problem is employment. At all times, paid jobs are the most important source of income. Unemployment is an issue of the same importance but is rather a complementary part of the employment problem. In the short run, the change in unemployment is practically equal to the change in employment, with the level of labor force, i.e. the net change in unemployment and employment, evolving at a slower pace.

It is instructive to use the trade-off between the rate of unemployment and the employment/population ratio to predict the workforce evolution in developed countries. As we have recently revealed, Okun's law (Okun, 1962) is able to provide a very accurate prediction technique for the rate of unemployment (Kitov, 2011). Therefore, one can test real economic growth, as expressed by the change rate of real GDP per capita, as the driving force behind the employment/population ratio.

2. Modified Okun's Law

Since the quantitative description of unemployment was very successful with only GDP as a predictor, we do not include in our employment model economic, financial, demographic, educational, or any other variables. Hence, we do not use any of the assumptions underlying the dynamic labor market models *introduced and developed by Diamond (2011), Mortensen (2007) and Pissarides (2000) among others. Our model is a parsimonious and purely empirical one.*

*We will seek a theoretical explanation in due course. This is a difficult task since the current understanding of the employment market is poor. One may judge the failure of many theoretical models (Zhu, 2008) by the evolution of employment and unemployment in the OECD countries during the 2008 crisis***.** The OECD (2007) projected the rate of unemployment to fall during 2008 in the OECD area and expected the level of 5.5% in average. Unfortunately for the OECD countries, there was no sign of the approaching failure in any theoretical or empirical model of the labor market.

We start with a modified Okun's law, where real GDP is replaced with per capita GDP. We also extend the modified Okun's law by integration of both sides of the relevant equation. As a result, one obtains a link between the rate of (un)employment and the logarithm of the overall change in real GDP per capita accompanied by a linear time trend with a positive slope. Thus, our model uses levels instead of derivatives.

For our empirical study, we use the most recent data on GDP per capita provided by the Conference Board (2011) and data on the (un)employment rate from the U.S. Bureau of Labor Statistics (2011). For several developed countries, the latter time series are available only from 1970. For the U.S., all variables are available since 1948. We allow for a structural break in the link between the (un)employment rate and real GDP per capita which might manifest artificial changes in definitions of employment and real GDP as well as actual shifts in the linear relationship.

Kitov (2011) has tentatively assessed several quantitative unemployment models based on Okun's law in the biggest developed countries: the United States, the United Kingdom, France, Australia, Canada and Spain. In this article, we enhance these tentative models and the link between employment and real GDP is also studied in the same countries except Spain (BLS does not provide the employment/population ratio). Instead of Spain we included Japan in the list. Our statistical results suggest the presence of a reliable relation between (un)employment and real GDP per capita.

According to the gap version of Okun's law, there exists a negative relation between the output gap, $(Y^p-Y)/Y^p$, where Y^p is potential output at full employment and Y is actual output, and the deviation of actual unemployment rate, u, from its natural rate, u^n. The overall GDP or output includes the change in population as an extensive component which is not necessary dependent on other macroeconomic variables. Econometrically, it is mandatory to use macroeconomic variables of the same origin and dimension. Therefore, we use real GDP per capita, G, and the modified version of Okun's law has the following form:

$$du = a + bdlnG \quad (1)$$

where: du is the change in the rate of unemployment per unit time (say, 1 year);
$dlnG = dG/G$ is the relative change rate of real GDP per capita;
a and b (<0) are empirical coefficients.

The intuition behind Okun's law is very simple. Everybody may feel that the rate unemployment is likely to rise when real economic growth is very low or negative. An economy needs fewer employees to produce the same or smaller real GDP also because of the growth in labor productivity.

When integrated from t_0 to t, equation (1) can be rewritten in the following form:

$$u_t = u_0 + bln\,[G_t/G_0] + a(t-t_0) + c \quad (2)$$

where u_t is the rate of unemployment at time t. The intercept $c\equiv 0$, as is clear for $t=t_0$.

Instead of using the continuous form (2), we calculate a cumulative sum of the annual estimates of $dlnG_i$. As a result, for any time t we need only the initial (G_0) and current (G_t) estimates of real GDP per capita, what ignores the path between these points. By definition, the cumulative sum of the observed du_t (= u_{t+1} -u_t) is the time series of the unemployment rate, u_t: $u_{t+1} = u_t + du_t$. Statistically, the use of levels, i.e. u and G, instead of their differentials is superior due to the effective suppression of uncorrelated measurement errors.

Figure 1 depicts the evolution of annual increments in the rate of unemployment, du, in the U.S. and that of the employment/population ratio, e, with a negative sign, $-de$. Both curves evolve practically in sync from 1949 to 2010 with the du series demonstrating a slightly higher volatility. A linear regression gives for the curves in Figure 1 a slope of 1.24 and R^2=0.88. It is an important observation that du almost coincides with – de in amplitude after 1985. The higher level of correlation between these variables allows formulating quantitatively a modified Okun's law for de:

$$de = \alpha + \beta dlnG \quad (3)$$

where β should be a positive constant. Equation (3) is the sought functional dependence between the first differences of the rate of employment and the growth rate of real GDP per capita.

When integrated, relationship (3) has the following form:

$$e_t = e_0 + \beta ln[G_t/G_0] + \alpha(t-t_0) \quad (4)$$

In this study, we use (2) and (4) for the estimation of all coefficients by a standard *LSQ* method. We seek the best fit between the measured and predicted rate of (un)employment.

Kitov (2011) has shown the necessity of a structural break in (1). Figure 1 also suggests that the link between *de* and *dlnG* might change around 1985 because the relationship between *du* and *de* also changes. Therefore, we introduce a structural break with floating timing in (2) and (4). Due to the difference in characteristics of the measurement noise between employment and unemployment, the years of the sought structural breaks, which have to be estimated by the best fit method, may differ by a few years. The measurement noise also includes all changes in definitions which make the time series of (un)employment quantitatively incompatible in time, as the BLS explicitly reports.

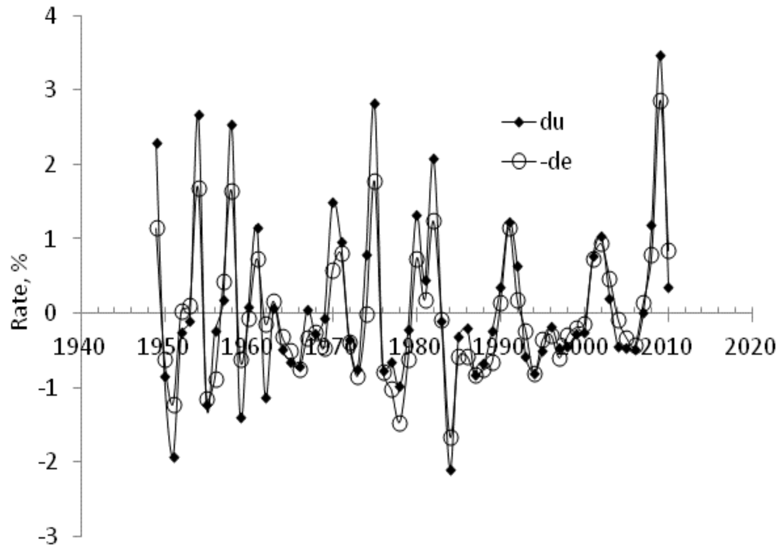


Figure 1. The evolution of *du* and *–de* in the U.S. between 1949 and 2010

For the U.S., we allow the break year to vary between 1975 and 1995. Thus, relationship (4) should be split into two segments:

$$e_t = e_0 + \beta_1 ln[G_t/G_0] + \alpha_1(t-t_0),\ t<t_s$$
$$e_t = e_s + \beta_2 ln[G_t/G_{ts}] + \alpha_2(t-t_s),\ t \geq t_s \quad (5)$$

where e_0 is the measured employment/population ratio at time t_0; e_s is the predicted employment/population ratio at the time of structural break t_s; α_1 and β_1, α_2 and β_2 are empirical coefficients estimated before and after the structural break, respectively. The integral form of the modified Okun's law for unemployment should be also split into two time segments:

$$u_t = u_0 + b_1 ln[G_t/G_0] + a_1(t-t_0),\ t_0<t<t_s$$
$$u_t = u_s + b_2 ln[G_t/G_{ts}] + a_2(t-t_s),\ t \geq t_s \quad (6)$$

In the next Section, we estimate all coefficients and timing of structural breaks in (5) and (6). All time series are obtained from the same sources. Thus, we avoid, in part, the incompatibility of measuring procedures and definitions in different countries. Twenty years ago almost all developed countries had different definitions of unemployment and employment. Moreover, these internal definitions were subject to numerous revisions which made these domestic time series incompatible over time. Apparently, these incompatibility problems in (un) employment time series cannot be resolved at all since the appropriate measurements were not conducted. Therefore, one should not exclude the possibility of structural breaks in some labor force series, which might be synchronized with the breaks in real GDP per capita.

3. Empirical results

We start with the case of the U.S. Since we have already estimated a preliminary empirical relationship for the rate of unemployment using only the best visual fit (Kitov, 2011), it is important to re-estimate Okun's law using a reliable statistical procedure. The method of least squares applied to the integral form of Okun's law (6) results in the following relationship:

$$du_p = -0.406 dlnG + 1.095, \; 1979 > t \geq 1951$$
$$[0.04] \quad [0.07]$$
$$du_p = -0.465 dlnG + 0.895, \; 2010 \geq t \geq 1979 \quad (7)$$
$$[0.04] \quad [0.06]$$

where du_p is the predicted annual increment in the rate of unemployment, *dlnG* is the (measured) relative change rate of real GDP per capita per one year.

There is a structural break in 1979 which divides the whole 60-year interval into two practically equal segments. In 1979, the slope changed from -0.406 to -0.465 and the intercept from 1.095 to 0.895. Instructively, the ratio of the slopes is (0.465/0.406=) 1.15 with the ratio of the respective intercepts (0.895/1.095=) 0.81 ~ 1/1.15.

The deviation between the observed and predicted values is very sensitive to all coefficients since the cumulative sums multiply any static error by the number of samples and an error of 0.01 in the intercept rises to 0.5 in 50 years. Not surprisingly, both intercepts are reliable with the standard error of 0.007 and p-value of 10^{-9}. Both slopes are also reliably estimated with the standard error of 0.04 and p-value of 10^{-11}. Since all models in this study have reliable coefficients we skip the results of significance testing.

Here it's worth emphasizing again that the current rate of unemployment depends on its initial value many years ago and the cumulative change in real GDP per capita. Therefore, the uncertainty of coefficients in (7) is defined by the net growth in *G* over the sixty year period, which is measured much more accurately than its annual change in the original version of Okun's law. This also means that the current rate of unemployment has to remember its initial value in 1951 (the start point of our model for the U.S.) and even earlier. Hence, the difference in the initial rates of unemployment in developed countries may partly explain the current difference. Obviously, this effect is directly implied by Okun's law.

Figure 2 (left panel) displays the measured and predicted rate of unemployment in the U.S. since 1951; the latter is obtained using the integral form of the modified Okun's law with the *G* estimates from 1951 to 2010. The agreement between these curves is excellent with the standard error of 0.55%. The time series of model error is displayed in the right panel of Figure 2. The average rate of unemployment for the same period is 5.75% with the mean (absolute) annual increment of 1.1%. All in all, this is a very accurate model of unemployment with R^2=0.89. Hence, the model (the integral Okun's law) explains 89% of the variability in the rate of unemployment between 1951 and 2010.

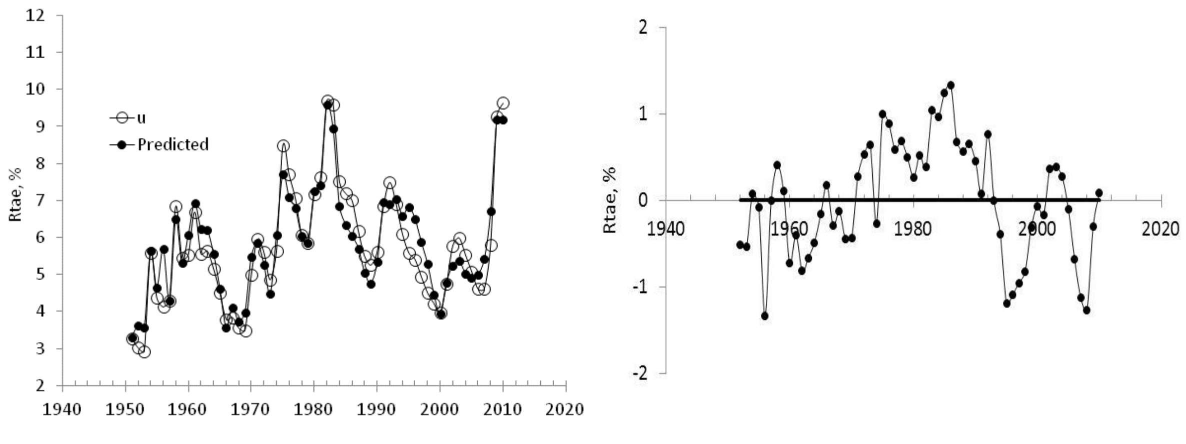


Figure 2. Left panel: The observed and predicted rate of unemployment in the USA between 1951 and 2010. Right panel: the model error with the regression line coinciding with the x-axis

Both variables in (7) are measured with some uncertainty. The rate of unemployment is estimated in the Current Population Surveys which are conducted every month by the Census Bureau for the Bureau of Labor Statistics. The Bureau of Labor Statistics (2006) describes non-sampling and sampling errors associated with unemployment measurements in the CPS and multiple revisions to unemployment definition and procedures (e.g. a major revision in 1978). Considering all these factors, the inherent uncertainty in the (annualized) rate of unemployment might be crudely estimated as 0.2% to 0.4%. The level of real GDP per capita is also subject to measurement uncertainty. The accuracy of annual estimates could be roughly estimated as 0.5 to 1.0 percentage points. With the empirical slope in (7) of ~0.5, the uncertainty in *G* is transformed in the uncertainty of 0.2% to 0.4% in the rate of unemployment. Thus, the model error of 0.55% is likely wholly related to the measurement errors. Statistically, there is almost no room for any other macroeconomic variables to influence the rate of unemployment, except they are affecting the real GDP per capita.

In (7), the rate of real GDP growth has a threshold of (0.895/0.465=) 1.92% per year for the rate of unemployment to be constant. When $dlnG > 0.0192$, the rate of unemployment in the U.S. decreases. Figure 3 displays the evolution of *dlnG* since 1979. On average, the rate of growth was 1.65% per year, i.e. slightly lower than the threshold and the rate of unemployment has been increasing since 1979.

Empirical model (7) suggests a tangible shift in slope and a significant change in intercept around 1978. This is a very important finding. There are two terms in (7) which define the evolution of the unemployment rate: real economic growth counteracts the positive linear time trend. Figure 4 depicts both components. The difference or the distance between $a(t-t_0)$ and $-bln(G_t/G_0)-u_0$ in Figure 4 is the rate of unemployment.

We have mentioned already that the 1979 break is associated with artificial changes in measurement units. Let's, however, assume that the structural break in 1979 was related to a true change in the macroeconomic behavior. The result of this "true" change is obvious when we extend the trend $a_1(t-t_0)$ observed before 1979. The distance would have been much larger with the old trend after 1979, i.e. the rate of unemployment would have been also higher than that actually measured. If to extrapolate the current time trend and the dependence on *G* one can project the rate of unemployment. Figure 4 also depicts such a projection through 2050. Without a new structural break, the rate of unemployment in 2050 will be near 25% (like in Spain). It would be good if the U.S. is currently struggling through a transition to a new relation in (7) which will be able to keep the rate of unemployment below 10%. In any case, the growth rate of real GDP per capita has to be much higher than 2% per year in order to reduce the current rate of unemployment to the level of 5%.

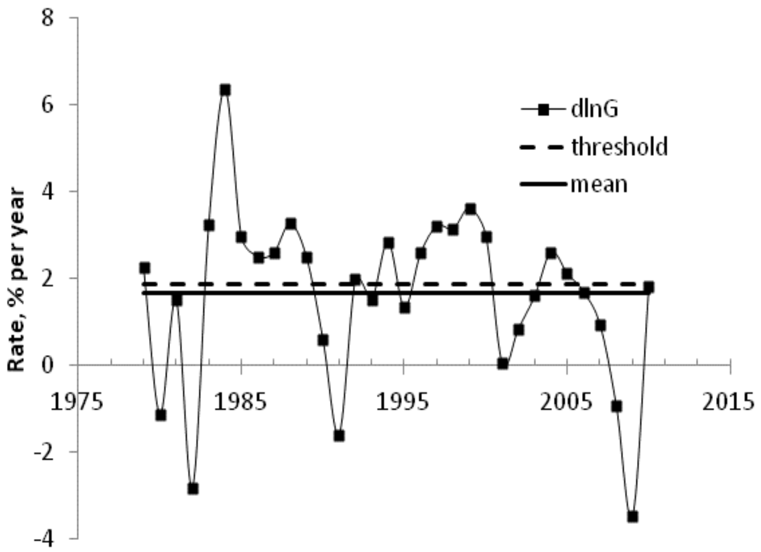


Figure 3. The growth rate of real GDP per capita, *dlnG*, as a function of time
Also shown is the threshold rate of 1.92% per year and the mean growth rate 1.65% per year

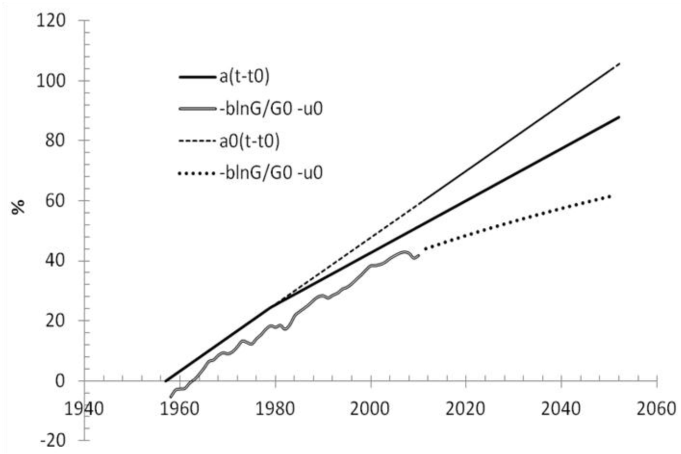


Figure 4. The evolution of two components in (7) defining the unemployment rate

In the above paragraph, we assumed constant increment of real GDP per capita when extrapolating its evolution into the future. For a constant annual increment, one obtains a logarithmic time trend which follows from our model of economic growth (Kitov, 2009). We have introduced an inertial growth component, $(dlnG/dt)_i$, which is inversely proportional to the attained level of real GDP per capita:

$$(dlnG/dt)_i = C/G \tag{8}$$

where C is an empirically estimated constant. The term *C/G* represents the inertial rate of growth. Figure 5 demonstrates the observed evolution of *G* since 1950 and gives two projections: a linear one with an annual increment *C*=\$591.5 (2010 U.S. dollars) and an exponential growth following the trend observed before 2010. The deviation between these projections is fast and the next few years should help to distinguish between them.

After obtaining relationship (7) with a high predictive power for the rate of unemployment we have estimated (using the integral form) a modified Okun's law for the employment/population ratio:

$$de = 0.277dlnG - 0.457,\ 1983 > t \geq 1951$$
$$de = 0.496dlnG - 0.870,\ 2010 > t \geq 1983 \tag{9}$$

Figure 6 compares the observed and predicted change in the employment/population ratio. Figure 7 shows the cumulative curves for both time series in Figure 6. It also provides some hints on the nature of the break near 1983. The difference between 1979 and 1983 as the estimated break years might be related to the effect of measurement noise on the results of the least squares method: even small deviations in noise may affect the RMS error and the break year shifts. In reality, the employment/population ratio jumped from ~57% in 1982 and ~63% in 1989. The change in slope in (7) and (9) is rather similar: both the rate of employment and unemployment is more sensitive to the rate of change in GDP after the break.

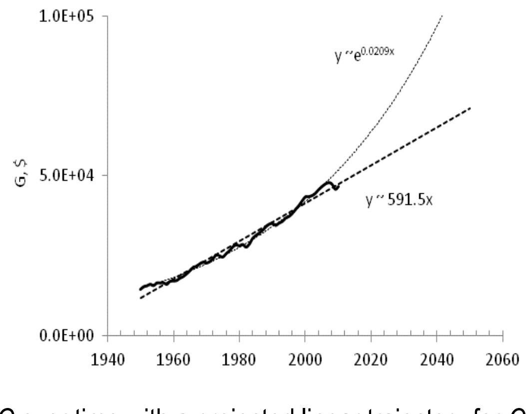


Figure 5. The evolution of *G* over time with a projected linear trajectory for *C*=\$591.5 and an exponential trajectory $G_t=G_0exp(0.0209t)$,
where the exponent corresponds to that obtained for the period between 1950 and 2010

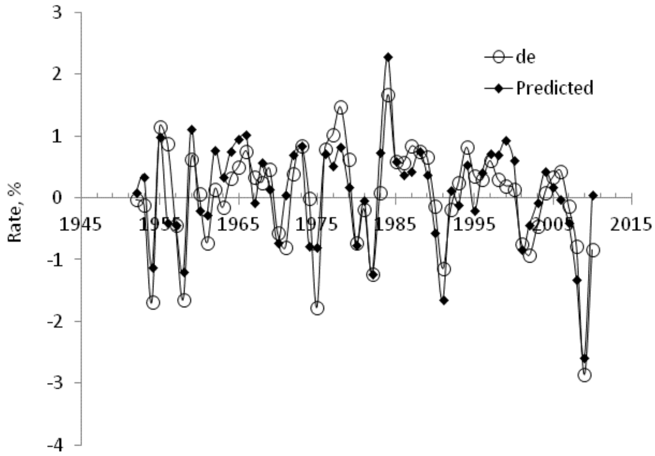


Figure 6. The observed and predicted change in the employment/population ratio, *de*

The next country to model is the United Kingdom. The change in the unemployment rate is also highly correlated with the change in employment/population ratio, R^2=0.79. Figure 8 shows both curves between 1972 (the employment rate estimates are available since 1971) and 2010. As expected, the change in the rate of unemployment is more volatile. The best fit models for the rate of (un)employment in the UK is as follows:

$du_t = -0.63dlnG_{t-1} + 1.35,\ 1987 > t > 1965$
$du_t = -0.39dlnG_{t-1} + 0.63,\ 2010 \geq t \geq 1988$

$de_t = 0.41dlnG_{t-1} - 1.11,\ 1983 > t > 1971$
$de_t = 0.41dlnG_{t-1} - 0.81,\ 2010 \geq t \geq 1983$ (10)

where $dlnG_{t-1}$ is the change rate of real GDP per capita one year before, i.e. the predicted curve leads by one year. Figure 9 shows the cumulative curves for the time series in (10). The agreement between the curves is excellent with R^2=0.89. The standard error is 0.47% between 1972 and 2009. There is a large deviation from the measured employment/population ratio after 2008. This deviation is consistent with the difference between *de* and –*du* in 2009.

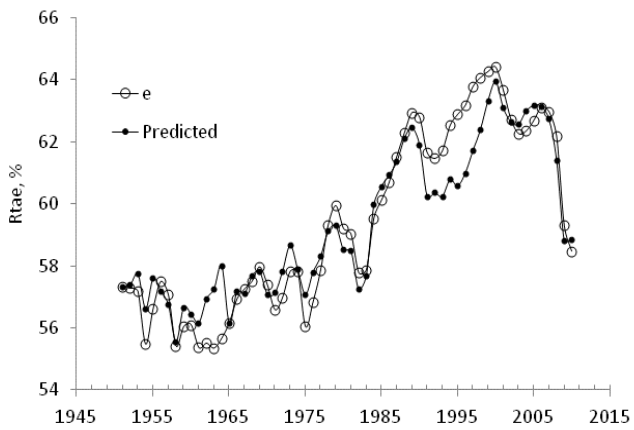


Figure 7. The cumulative curves for the observed and predicted change in the employment/ population ratio in the U.S.

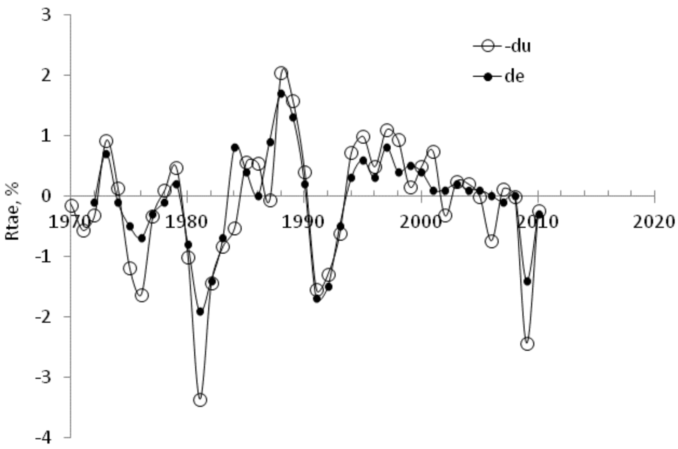


Figure 8. The (negative) change in the rate of unemployment, *-du*, compared to the change in the rate of employment in the UK

There is a structural break near 1983 (1987 for unemployment) which is expressed by a significant shift in intercept without any change in slope. The employment/population ratio varies around 58%; between 54.3% in 1982 and 61% in 1972. After 1983, relationship (10) implies that the UK needs the rate of GDP growth above (0.81/0.41=) 1.97% per year to increase the employment rate. However, the discrepancy between the measured and predicted curves after 2008 may manifest the start of a transition to a new dependence in (10), with a lower sensitivity of the employment rate to the change in GDP. When of artificial nature, this discrepancy also affects all coefficients in (10).

For the rate of unemployment, the threshold is 1.65% per year after 1987. Therefore, the rate of employment is slightly harder to rise with real economic growth. In the U.S., the situation is apposite. Considering the uncertainty in all coefficients, the hypothesis that both thresholds for a given country are equal cannot be rejected.

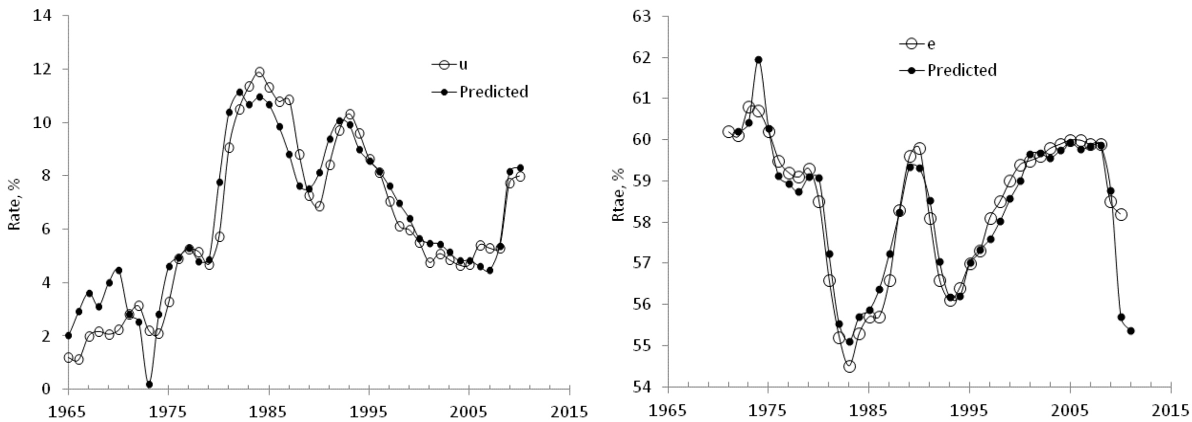


Figure 9. The cumulative curves for the observed and predicted change in the rate of unemployment and employment/ population ratio in the UK

In Canada, the change in the rate of employment, *de*, and the rate of unemployment, *du,* are well correlated (R^2=0.76) as Figure 10 demonstrates. As in other developed countries, the rate of unemployment is more volatile. For Canada, the following best-fit models have been obtained by the least-squares (as applied to the cumulative sums):

$du_t = -0.39 dlnG_t + 1.16, \; 1983 > t > 1970$
$du_t = -0.28 dlnG_t + 0.30, \; 2010 \geq t \geq 1983$

$de_t = 0.40 dlnG_t - 0.67, \; 1984 > t > 1970$
$de_t = 0.44 dlnG_t - 0.56, \; 2010 \geq t \geq 1984$ (11)

Figure 11 shows the cumulative curves for all involved time series in (11). For the rate of employment, the overall fit is very good with R^2=0.84 and the standard error of 0.83% between 1971 and 2010. Before 1984, the predicted curve is likely leading the measured one by 1 year. It is important that the most recent period is well described and the fall in the employment rate in 2009 was completely driven by the drop in real GDP per capita.

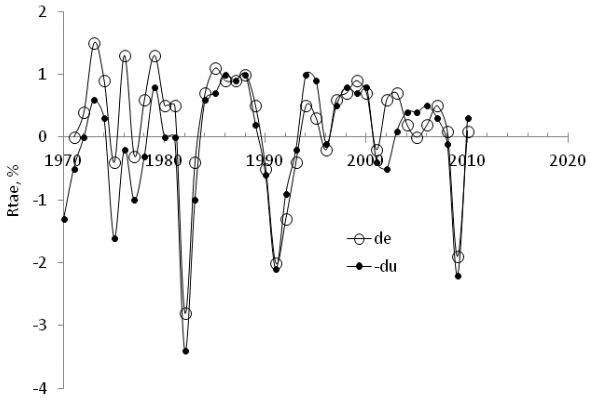


Figure 10. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Canada

There is a structural break near 1984 (1983 for unemployment) which is expressed by a slight shift in the slope and intercept. The employment/population ratio varies between ~54.5% in 1971 and ~64.1% in 2008. For the period after 1984, relationship (11) demands the rate of GDP growth above (0.56/0.44=) 1.27% per year for the employment rate to increase. Otherwise, the employment rate will be falling and the rate of unemployment will be increasing. The rate of unemployment has a threshold of 1.07% per year.

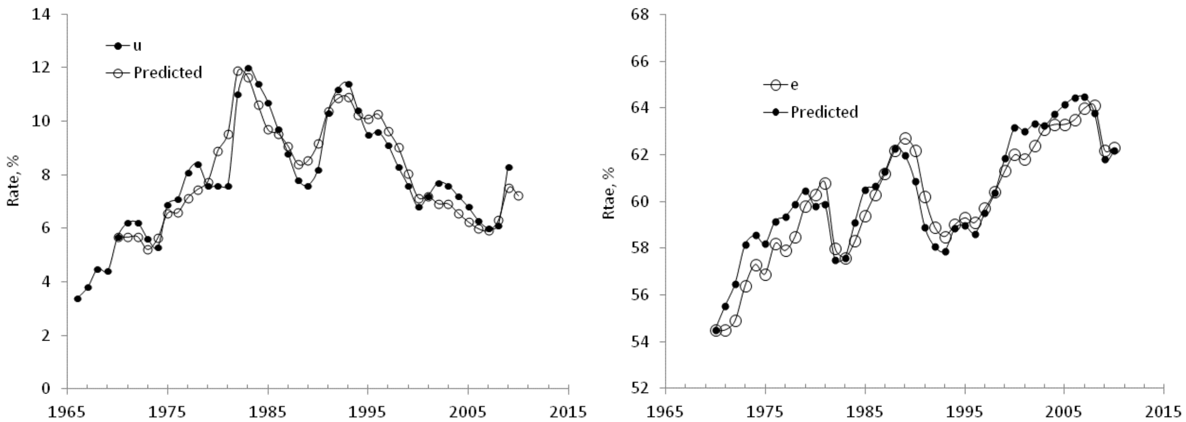


Figure 11. The cumulative curves for the observed and predicted change in the rate of (un)employment in Canada

France gives another example of successful modeling. As expected, the change in the rate of unemployment in Figure 12 is more volatile except the step in the employment rate near 1982. This is a completely artificial break from 53.2% in 1981 to 55.3% in 1982, and we do not need to model it. It is worth noting that *-du* and *de* diverge in 2010. This means that Okun's law for France does not fit observations or the observations are biased.

For France, the best-fit model for the rate of (un)employment is as follows:

du_t = -0.155$dlnG_t$ + 0.805, 1988 > t > 1970
du_t = -0.508$dlnG_t$ + 0.710, 2010 ≥ t ≥ 1988

de_t = 0.155$dlnG_t$ – 0.65, 1994 > t > 1970
de_t = 0.250$dlnG_t$ – 0.30, 2010 ≥ t ≥ 1994 (12)

Figure 13 shows the cumulative curves for the time series in (12). There is a structural break near 1994 which is expressed by significant shifts in the slope and intercept. The employment/population ratio varies between ~56% in 1970 and 50.4% in 1992. The agreement is good with R^2=0.91 and the standard error of 0.39% for the period between 1971 and 2010. The rate of employment grows when the rate of GDP growth exceeds (0.30/0.25=) 1.2% per year.

Figure 14 compares the change in the rate of employment and the rate of unemployment, in Australia. The best-fit models are as follows:

$du_t = -0.69dlnG_t + 1.50,\ 1995 > t > 1975$
$du_t = -0.45dlnG_t + 0.75,\ 2010 \geq t \geq 1995$

$de_t = 0.50dlnG_t - 0.92,\ 1983 > t > 1970$
$de_t = 0.41dlnG_t - 1.08,\ 2010 \geq t \geq 1983$ (13)

Figure 15 shows the cumulative curves for the time series in (13). For the employment rate, there is a structural break near 1983 which is expressed by tangible shifts in slope and intercept. The employment/population ratio varies between 55% in 1983 and 64% in 2008. The agreement is relatively good with R^2=0.84 and the standard error 1.19% for the period between 1971 and 2010. For the rate of unemployment, the break was in 1995 but is accompanied by a smaller shift in coefficients with a higher R^2=0.87. Figure 15 implies that the rate of employment is overestimated since 1995 and thus the structural break after 1995 is likely a better hypothesis.

We finish modeling the evolution of the employment rate in developed countries with Japan. Figure 16 compares the change in the rate of employment, *de*, and the negative rate of unemployment, -*du*. The latter variable is as volatile as former one and they differ drastically (R^2=0.45) compared to the synchronized evolution of these variables in the U.S. That's why we have failed to obtain a reasonable Okun's law for Japan: the measured rate of unemployment is suspicious and most probably is biased down before 1980.

The employment/GDP model for Japan is similar to Okun's law. The best-fit model has been obtained by the least-squares (applied to the cumulative sums):

$de_t = 0.02dlnG_t - 0.53,\ 1978 > t > 1965$
$de_t = 0.14dlnG_t - 0.42,\ 2010 \geq t \geq 1978$ (14)

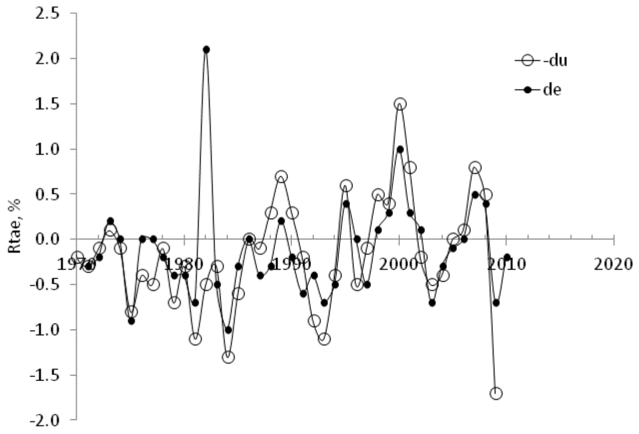


Figure 12. The (negative) change in the rate of unemployment compared to the change in the rate of employment in France

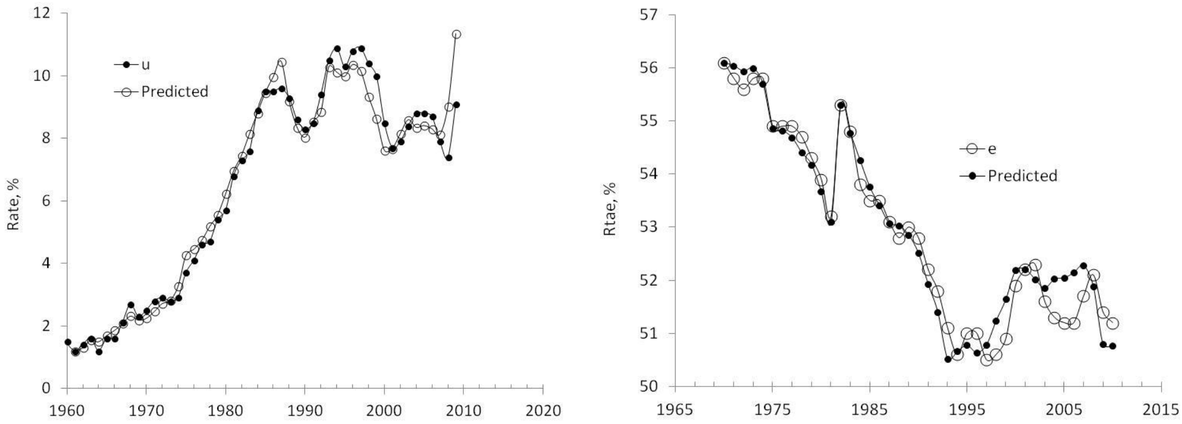


Figure 13. The cumulative curves for the observed and predicted change
in the employment/population ratio in France

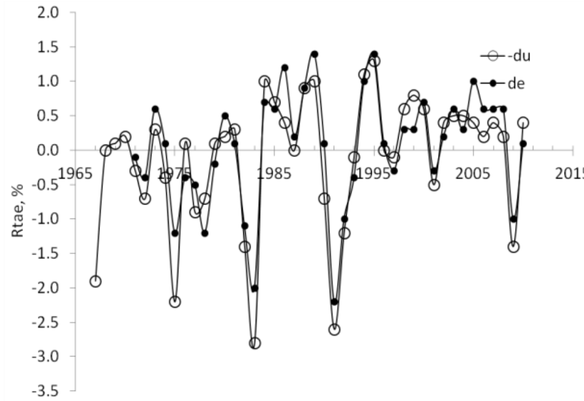


Figure 14. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Australia

Figure 17 shows the cumulative curves for the time series in (14). There is a structural break in 1978 which is expressed by a dramatic shift in slope and a slight break in intercept. The employment/population ratio varies between 64% in 1970 and 56% in 2010. The agreement is excellent with R^2=0.95 and the standard error 0.50% for the period between 1971 and 2010. The coefficient of determination might be biased up when both time series are nonstationary. In the long run, we consider both variables as stationary ones despite the negative trend since 1970.

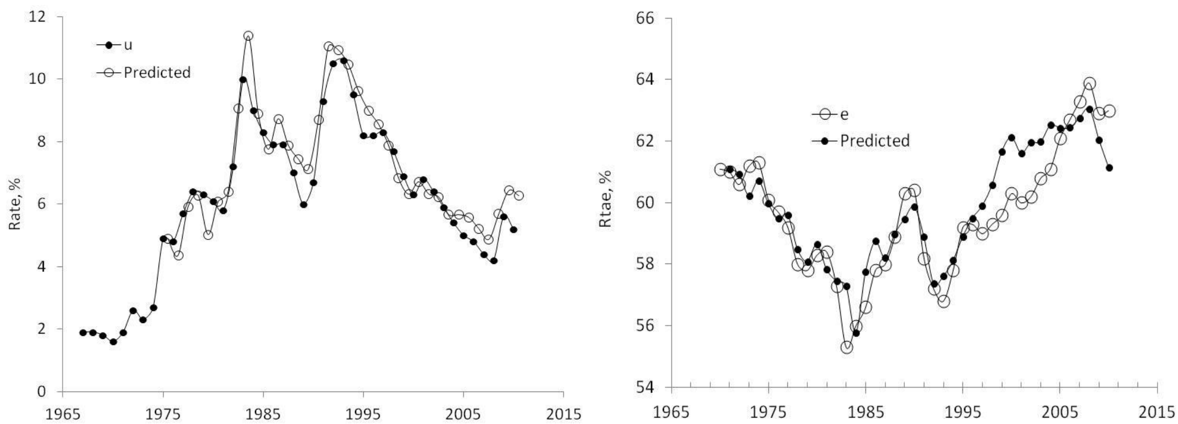


Figure 15. The cumulative curves for the observed and predicted change
in the employment/ population ratio in Australia

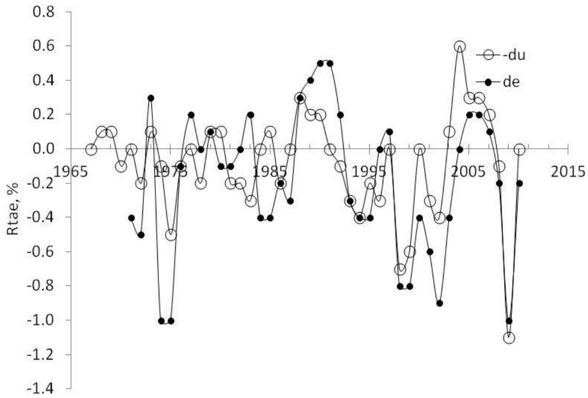


Figure 16. The (negative) change in the rate of unemployment compared to the change in the rate of employment in Japan

In this Section, we have modeled the rate of unemployment and employment in the biggest developed countries. All models include structural breaks, which may differ for unemployment and employment. This difference in timing might be caused by specific properties of measurement noise but the cause of all breaks is likely of the same nature. In the next Section, we present a series of structural breaks in the GDP deflator, which are synchronized with the breaks in the rate of employment.

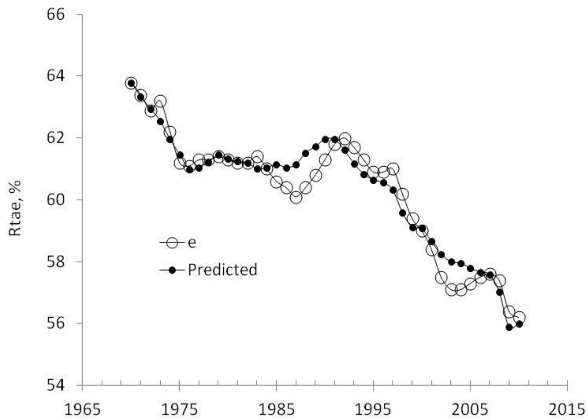


Figure 17. The cumulative curves for the observed and predicted change in the employment/ population ratio in Japan

4. On the Nature of Structural Breaks

We have revealed statistically reliable links between (un)employment and real GDP. However, there is a crucial question on the cause of the structural breaks. There are two possibilities have discussed in Section 2: all structural breaks are of artificial nature (e.g. change in measurement units) or manifests some actual change in the response of employment to GDP. There is a general observation that all breaks coincide in time with the split between the GDP deflator, *dGDP*, and the consumer price index, *CPI*, i.e. with the change in measurement procedures associated with real GDP. Specifically, the GDP deflators and CPIs coincide before the breaks and deviate at different rates after the breaks.

Real GDP is defined as the difference between nominal GDP and the GDP price deflator. The latter is not easy to calculate or even evaluate. Before 1978, there was no practical difference between the cumulative inflation values of the CPI and the GDP deflator in the US, as the left panel of Figure 18 demonstrates. This Figure depicts the cumulative inflation as defined by the GDP deflator (dotted line) and the CPI (solid line). These are the cumulative sums of the annual inflation rates from 1929, which are different from the relevant price indices since they are differently calibrated in the beginning.

Effectively, the *dGDP* and *CPI* curves in Figure 18 coincide before and diverge after 1978. We found no direct statement on the reasons of the change in definitions in the relevant BEA document (2008), but one might guess that this is likely related to the introduction of a new methodology measuring the overall price inflation. This difference has likely affected our analysis of Okun's law and forced the introduction of a structural break in 1978.

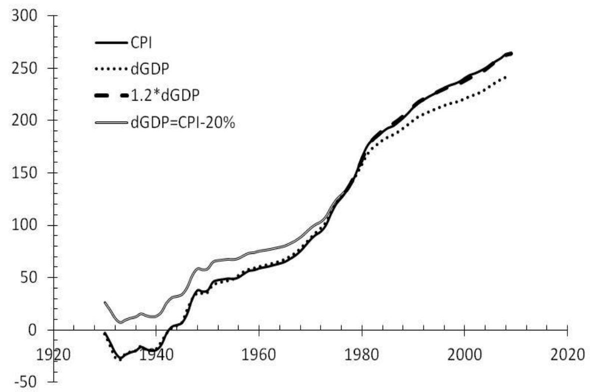
Interestingly, the CPI can be represented is a linear function of the GDP deflator after 1978:

$$CPI_t = 1.2dGDP_t \qquad (15)$$

In Figure 18, the *CPI* cumulative curve practically coincides with the *1.2dGDP* curve.

Apparently, before 1978 the CPI was used to estimate of the overall price inflation. Since 1979, the GDP deflator has been used instead of the CPI. In the right panel of Figure 18, we displayed the difference between the *CPI* and *dGDP* cumulative curves. This difference has a clear break in 1978. One should neglect this break in any quantitative analysis involving real GDP: the cumulative change in inflation between 1978 and 2011 is of 22 percentage points. This implies that, when applied to the estimates before 1978, the new concept of the GDP deflator would result in a bigger change in real GDP estimates.

Figure 19 illustrates another unclear feature of the link between the GDP deflator and CPI. Surprisingly, the difference CPI-1.2dGDP varies not randomly but rather oscillates with a changing period. One may expect this difference to rise above the zero line in 2011 and then reach the level of +3 percentage points during the next five years. We have no explanation of this effect.



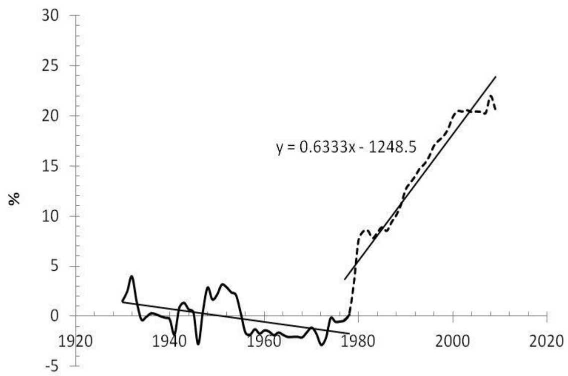


Figure 18. Left panel: Cumulative rates of CPI and dGDP inflation, original and scaled by a factor of 1.2. Right panel: The difference between the original cumulative curves of the CPI and dGDP. The timing of the structural break is obvious

Therefore, we have confirmed the hypothesis that the break in Okun's law is likely of artificial nature and it is associated with the definitions of real GDP rather than with actual process in the U.S. economy. So to say, the U.S. shifted in 1978 from "mph" to "km/h", but still uses the old speed limit as expressed in "mph".

In order to validate this finding we have borrowed data from the OECD and calculated the CPI and dGDP cumulative inflation in Australia, Canada, Japan, France, and the UK, as shown in Figure 20. There are clear breaks in different years. For Australia, the difference is small and starts after 1990. It is worth noting that the slopes in relationship (13) are also close. Apparently, the years of structural breaks in (13) are difficult to estimate due to the measurement noise level.

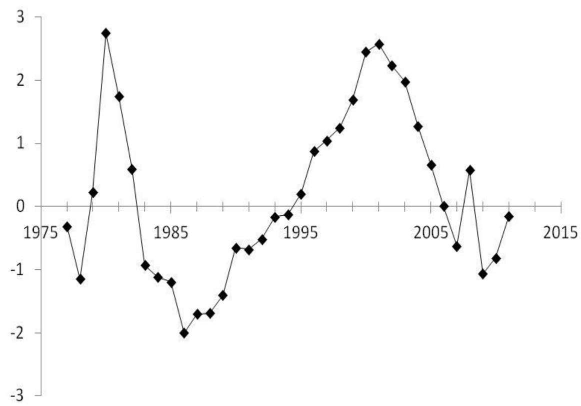


Figure 19. The difference between the cumulative CPI and 1.2dGDP

For Canada, there is a break after 1980 which closely corresponds to the 1983 break in Okun's law (11). The deviation is fast and does not match the small change in the slopes estimated in (11). For the UK, the deviation starts around 1979 (1982 in Okun's law). For some unknown reason, the GDP deflator in the UK rises faster than the CPI. In Japan, the CPI and dGDP diverge since 1974. Considering the accuracy and the length of the initial portion of the time series in Japan since 1971, this year well corresponds to the break in 1978. In France, the discrepancy is marginal and might be dated crudely between 1990 and 1995. This does not contradict the break in 1995, as estimated somewhere between 1988 and 1994 in (12).

Conclusion

We have successfully modeled the evolution of the unemployment rate and employment/ population ratio in a few biggest developed countries using a modified Okun's law with the rate of change of real GDP per capita as the driving force. This model demonstrates an extraordinary predictive power with the coefficient of determination between 0.84 and 0.95. One can accurately describe the dynamics of employment (and thus, unemployment) since 1970. Unfortunately, the OECD does not provide homogenized labor force estimates before 1970 and national data might be biased by severe differences in definitions. The U.S. is the only country we have modeled since 1950. This example shows the accuracy of the model in the past which we could also expect for other developed countries.

Okun's law has been estimated many times for all the studied countries (e.g. Tilleman, 2010; Knotek, 2007; Malley and Molana, 2010; Pierdzioch *et al.*, 2011) but has failed to give more statistically reliable results than those obtained in this study. There are two reasons behind this failure. The original version of Okun's law uses real GDP instead of GDP per capita. This notion has no justification because the rate of unemployment is defined as a portion of the labor force level, i.e. in relative terms independent on the overall population. At the same time, real GDP includes the extensive population growth as a bigger (1% per year in the U.S.) and permanent part of output. In a quantitative model, the extensive part of real GDP introduces a bias proportional to its portion. For the periods of slow growth (e.g. in 2008 and 2009), this portion can be a larger one. As a result, no reliable statistical inference is possible. The use of real GDP per capita removes this bias and all statistical results become reliable.

The second reason is associated with data quality and compatibility over time. The necessity of structural breaks in Okun's law was stressed in many studies (e.g. Huang and Chang, 2005; Marinkov and Geldenhuys, 2007). However, these breaks were considered as related to actual changes in economic behavior. We have shown that all structural breaks in the estimated models of the rate of employment (Okun's law) and the employment/population ratio for the U.S., Japan, Australia, Canada, France, and the United Kingdom are artificial and were forced by the change in real GDP definition in the years of these breaks. Hence, the real GDP estimates are incompatible over the break years and thus biased.

From the side of (un)employment, there were several significant revisions to the relevant definitions. The BLS (2006) provides a short description of major changes and warns about the overall incompatibility of the labor force data. The OECD (2008) provides the same estimates for other developed countries and also states the overall incompatibility due to revisions to definitions and methodology of estimates. The issue of labor force revisions should be taken into account in quantitative modeling of (un)employment as well. Potentially, these revisions introduce small-amplitude level shifts in the related time series which harm the statistical inferences and the model reliability.

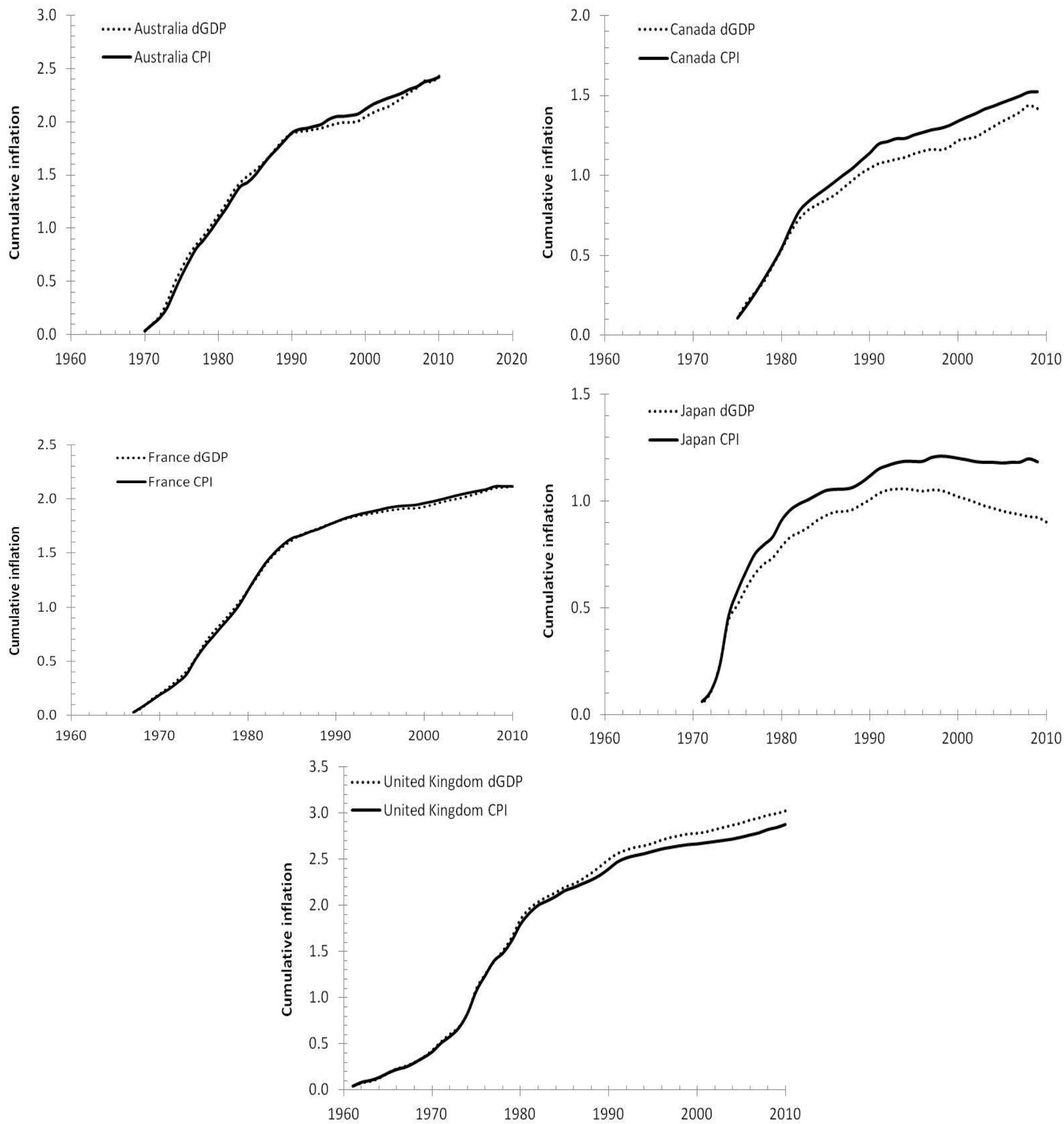


Figure 20. Cumulative values of the GDP deflator and CPI for the studied countries
The years of deviation coincide with structural breaks in Okun's law for the same countries

We have removed both problems in Okun's law and obtained robust quantitative models estimating the evolution of unemployment and employment in the biggest advanced economies. Initially, we revealed modified and integral versions of Okun's law for the United States and then validated the original model by data in Australia, Canada, France, Japan, and the UK. The whole set of modified models should be further validated by new data in the studied economies and data from other developed countries.

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KNOWLEDGE-BASED ECONOMIES AND THE INSTITUTIONAL ENVIRONMENT

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Abstract:

Modern economies are increasingly based on knowledge and, more generally, on the intangible assets that favor the economic development. Knowledge-based economies are founded on increasing specialization, research, innovation and learning. The change towards a knowledge-based economy is happening on a global scale, a transformation is taking place in all advanced industrialized economies and many developing economies are also aspiring to reach this target. Knowledge-based economies require some critical requisites to become real and efficient economies. These are the four pillars: education and training, innovation, information infrastructure, institutional regime.

This contribution will focus mainly on one of those pillars: the institutional environment. Thus, after examining the definition and the characteristics of a knowledge-based economy, it focuses on the relationship between knowledge-based economies and the role of institutions. Institutions and the institutional environment play a key role in the development of a knowledge economy, so they do matter.

The paper argues that various institutional changes must be introduced and these institutional changes that need to be made will involve the public and private sector, as it has been in the case of the Finland's economy. In addition, because of the difficulties for the institutions to build and establish itself over time, it is necessary a certain degree of flexibility in the institutional regime and, hence, the ability to respond to uncertainties.

Keywords: knowledge-based economy, institutional environment, institutions, innovation, development.

JEL Classification: O30, O32, D02, D20.

1. Introduction[3]

Modern economies are increasingly based on knowledge and, more generally, on the intangible assets that promote the economic development in the present day.

Knowledge-based economies are founded on increasing specialization, research, innovation and learning. One of the main features of knowledge-based economies is their reliance in the new information technologies, like ICT, which are general purpose technologies.

The change towards a knowledge-based economy is happening on a global scale, a transformation is taking place in all advanced industrialized economies and many developing economies are also aspiring to reach this target. It is a deep and general process which operates across all sectors of the economy: manufacturing and services, high tech and low tech, domestic and internationally traded, public and private, large corporation and small enterprise.

Knowledge-based economies require some critical requisites to become real and efficient economies. These are, according to the approach followed by the World Bank, the four pillars: education and training, innovation, information infrastructure, institutional regime.

The transformation towards knowledge-based economies will necessarily determine a shift in the proportion of national income derived from knowledge-based industries, in the percentage of the workforce employed in knowledge-based jobs and in the ratio of firms using new technologies to innovate, but it is also crucial the institutional setting.

[3] I like to thank David Carfì and Mario Graziano for their helpful discussions and observations. The author remains the only responsible for the opinions expressed and any errors contained in the essay.

This contribution will focus mainly on one of those pillars: the institutional environment. Thus, after examining the definition and the characteristics of a knowledge-based economy, it focuses on the relationship between knowledge-based economies and the role of institutions.

Institutions and the institutional environment play a key role in developing a knowledge economy, so they do matter. Thus conscious efforts must be made to establish new and appropriate institutions and to change and strengthen existing institutions to support the process towards a knowledge-based economy, as it has been in the case of the Finland's economy. The paper argues that various institutional changes must be introduced and these institutional changes that need to be made will involve the public and private sectors. In addition, because of the difficulties for the institutions to build and establish itself over time, it is necessary a certain degree of flexibility in the institutional regime and, hence, the ability to respond to uncertainties.

2. Knowledge-Based Economy: definition and characteristics

The notion of knowledge-based economy (KBE) has been widely used in the literature in recent years, although its meaning is sometimes found to be vague because of the different object to which it refers and also to the difficulties of measurement.

The process towards a KBE, started in the early 1970s, has gradually spread across the economies, mainly with the evolution of high technologies and the development of information and communication service sectors. Thus a KBE has been typically characterized by a scenario of structural transformations[4]. In this scenario, following a Schumpeterian view (Schilirò, 2009, 2010), knowledge becomes the central source of innovation and, hence, of growth[5]. However, the current development of a KBE should be understood in the context of the globalization and the evolution of capitalism that has occurred since the changes in the 1990s, this is why it is so important to analyze the role of institutions and their changes to better understand the KBE. Last but not least important, KBE is driven by the demand for higher value added goods and services created by more sophisticated and better educated consumers and businesses.

The OECD, which have generated abundant research on this topic following the approach proposed by Machlup (1962)[6], has suggested the following definition: «A knowledge-based economy is an economy where the role of knowledge as compared with natural resources, physical capital and low skill labor has taken on greater importance» (OECD, 1996). According to this view, OECD maintained that although the pace may differ, all OECD economies are moving towards a knowledge-based economy.

Historically, the development of the KBE, in which knowledge creation and easy access to knowledge generate greater efficiency, has benefited from technological and institutional conditions, like the rising relative share of GDP due to intangible capital (Abramovitz, and David, 1996), the significant growth of educational institutions, the development of large research laboratories, the expansion of knowledge-intensive activities (Foray, 2004). Moreover, the ITC revolution has been crucial in this development process, as it involves technologies aimed to the production and dissemination of knowledge and information. So the production and the diffusion of ITC (general purpose technologies), interacting with the knowledge-intensive activities, have determined important effects on the economy (Helpman, 1998, Steinmueller, 2002). The diffusion of ITC permits productivity gains in the processing, storage and exchange of information, which is an important area of the KBE. ITC favor the creation and growth of new industries (i.e., multimedia, software, e-commerce). They constitute an incentive to adopt new and original organizational models in the distribution and dissemination of knowledge.

Globalization has also been an important factor for the KBE. The opening up of markets and the internationalization of trade in knowledge sectors exposed the economies to international competition. The creation of global labor markets for highly skilled workers, the provision of investment capital and access to new technology, information, ideas and knowledge flows from around the world have accelerated the transition to a knowledge-based economy. Moreover, globalization and the liberalization of the economy have transmitted and accelerated the forces of change into the economies. These have put pressures on the institutions and the way

[4] Schilirò, 2010.

[5] For Schumpeter (1942) the production and diffusion of knowledge are processes that have a strong influence on economic growth and development. Innovation and the capacity of entrepreneurs to innovate are knowledge-driven processes and thus are basic features of the KBE. In the Schumpeterian vision destruction and disorder are inevitable and positive effects of the innovative activity.

[6] Machlup is considered by many scholars the founder of the studies of the KBE. He identified the KBE a specialized sector consisting primarily of activities relating to communication, education, the media, computing and information-related services.

governments work. So institutions have to gear themselves up to respond to these changes in the market, and governments must also devise new and appropriate policies. At the same time organizational changes need to be introduced, processes have to be improved and strengthened to cope with increasing competition, while this increasing competition, in turn, call for improved co-ordination between institutions.

UNESCO (2005) has drawn a report which describes a knowledge society as one which is nurtured by its diversity and its capacities. A number of studies have been done in the area of knowledge societies and economies, in which the decisive factor to build a KBE is learning, but also the system of education and the capacity of knowledge sharing have their importance.

Powell and Snellman (2004), in their overview of the scholarly literature on the knowledge-based economy, offer another definition of KBE which focuses on the production of novel ideas that subsequently lead to new or improved goods and services. They define the knowledge economy «as production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance as well as equally rapid obsolescence. The key components of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process, from the RandD lab to the factory floor to the interface with customers. These changes are reflected in the increasing relative share of the gross domestic product that is attributable to "intangible" capital (Powell, and Snellman, 2004, p.201).

In practice, the intangible capital is made of intangible assets, which are non-material and non-physical assets, such as RandD, patents, trademarks, copyrights, brands, employee skills, discoveries of new products or processes, software programs, new ideas and new processes used in the organization[7].

Economists like Shapiro and Varian (1999) have already noted that changes in production are part of a broader shift from tangible goods to intangible o information goods. So there is a wide recognition that knowledge and intangible capital determine economic and social change and foster growth. Unfortunately, these 'intangibles' are often very difficult to measure.

A developed line of research focused on patent-based measures to quantify both RandD activity and stocks of knowledge (Powell, and Snellman, 2004), since the term 'knowledge-based economy' has been used to refer to economic shifts in industrialized nations from industrial manufacturing to production that relies primarily on intellectual property[8]. In this picture, knowledge is a commodity to be traded in private markets. Obviously, this approach is not shared by economists like Dasgupta, and David (1994), who, in their seminal paper on the economic analysis of open knowledge, maintained that knowledge is a public good, even if it is a peculiar good[9] .

Powell, and Snellman (2004) argued that the upsurge in overall patenting activity in the U.S. and Europe has been driven by the emergence of new industries (i.e. biotechnology industry and semiconductor industry), which were highly fertile in terms of generation of novel ideas and new products. In turn, this upsurge of new industries was associated with a decline of traditional sectors. In particular, Finland's economy, a small European country, was largely based on forestry and paper production, but since the mid of 1990s it became a global producer of mobiles and wireless communication goods through its big corporation Nokia. Thus, telecommunications patens replaced paper patents as the leading patenting sector. Although Powell and Snellman have recognized the role of the legal and regulatory environment in pushing up process of patenting, they did not give too much weight to the institutional environment, preferring instead to emphasize the role of technology.

The literature, however, has shown that it is important to follow a strategy regarding the institutional framework of intellectual property, by altering the legal conditions and terms of property rights, and then changing the institutional setting. The results obtained are effective for producers as regards, for example, the policy incentives. The U.S. patent policy, in particular, has been strengthened in terms of protection since the early 1980s by a more appropriate institutional regime.

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[7] The role of intangible capital and intangible investments for the growth in the U.S. economy has been highlighted by Abramovitz, and David (1996).

[8] Since the main motivation of R&D activity is the production of knowledge and although knowledge is considered a commodity traded in private markets, R&D is subjected to different kinds of economic constraint as those characterizing the production of goods and services. The uncertainty embodied in the research activities creates a protected world for R&D, which become less dependent on cost-effectiveness and timely delivery outputs than are other economic activities (Foray, 2004).

[9] According to Foray (2004, p.5) knowledge is a particular good different from conventional tangible goods, and it is an "ambiguous good"

Another important point regarding the KBE is that is essentially a learning economy (Lundvall, 2004), where learning processes enhancing competence are fundamental for the economic performance of organizations and the whole economy. A knowledge-driven economy demands a larger proportion of the workforce with a university education and with access to lifelong learning opportunities. This has inevitably determined a major impact on participation rates in tertiary education not only in all OECD countries, but also in the developing ones (TLRP, 2008). China has already more students in tertiary education than the United States. This is leading to a massive increase in the global supply of highly educated workers, able to compete on price as well as knowledge. Thus, knowledge has become a vital commodity to countries, businesses and individuals in the 21st century, which can be considered the age of the knowledge-based economies (Kefala, 2010).

Since a country's most important resource is its human capital, another indicator of the development of the KBE is the growth in human capital. This growth can be captured, according to OECD (2009), by university graduates that furnish an indicator of a country's potential for assimilating, developing and diffusing advanced knowledge and supplying the labor market with highly skilled workers. In 2006, more than one young person in three graduated at the first-stage university level in the OECD area. This represents 7.1 million degrees awarded. Iceland, Australia and New Zealand had the highest graduation rates. Japan with 39 per cent ranks slightly above the OECD average (37 per cent), the United States with 36 per cent rank just below. In Europe almost twice as many degrees per age cohort were awarded in the Nordic countries, Poland, the Netherlands, Belgium, Germany and Austria (OECD, 2009, 5.1). Doctoral graduates are also important for the diffusion of knowledge in the society. They are key players in research and innovation. In 2006, OECD universities awarded 200.000 doctorates to 1.3 per cent of the population at the typical age of graduation. In many OECD countries doctoral degrees have multiplied faster than other university degrees. Since 2000 the number of OECD-area doctorates has increased by 5 per cent a year and the number of first-stage university degrees has grown by 4.6 per cent. Doctoral programs have also progressed in emerging countries. In 2006, Brazil, the Russian Federation, India and China trained half as many doctoral graduates as OECD countries, taken together. Most doctorates are in science and engineering (SandE), followed by the social sciences. 40 per cent of OECD doctoral students graduate in scientific fields. There are proportionally twice as many SandE graduates at doctoral level than at the first-stage university level. The SandE orientation of doctoral programs is even more pronounced in emerging countries (OECD, 2009, 52).

An important aspect of the expansion of the knowledge-based workforce is the development of occupational communities that consist of individuals, often working for different, sometimes rival organizations, who are in the forefront of producing and distributing novel ideas. RandD collaborations among competing organizations have grown in such fields as IT, nanotechnology, biotechnology where knowledge is developing rapidly and the sources of knowledge are widely dispersed (Mowery, 1999). Therefore, in the knowledge-based economies there are knowledge communities, which are networks of individuals involved in the production, reproduction and circulation of knowledge through an intensive use of ITCs that strongly reduce cost of transmitting and sharing knowledge (David, Foray, 2003). These networks also bring about spillovers and feedback mechanisms. A positive virtue that comes from them is that learning productivity is increased by the fact that an individual can «learn to learn» through reproducing the knowledge of others. So these knowledge communities become agents of economic change and of innovation, because they cut across the boundaries of firms and other non-firm organizations and exchange knowledge within a framework of a network operating by the rules of disclosure and reciprocity[10].

If we want to sum up the defining characteristics of a knowledge-based economy (Steinmueller, 2002, Smith, 2002, Foray, 2004, Powell and Snellman, 2004, Lundvall, 2004, Leydesdorff, 2006, Schilirò, 2005, 2009) we can include: i) a fundamental shift in investment towards the creation and exploitation of knowledge and other intangible assets such as RandD, software, design, development, human and organizational capital as the basis of competitive advantage; ii) the presence of cheap, powerful and pervasive general purpose information and communication technologies; iii) the establishment of knowledge-based industries and knowledge related occupations; iv) the key role of innovation, that comes from both the successful exploitation of RandD undertaken and from wider forms of innovation as design and development, marketing and organizational change; v) a KBE is a learning economy, where interactive learning is a key to economic performance of firms, regions and nations; vi) the need to align public investments more closely with the demands of a knowledge-based economy, especially in support of RandD, science and technology, higher education, business and enterprise policies; vii) Universities and the higher education sector have an extremely important role as

[10] David and Foray (2003, p. 8).

economic actors in attracting and retaining RandD and as agents of diffusion and regeneration of knowledge, so in the KBE it is more important than ever the role of knowledge institutions and the higher education sector as providers of human capital and drivers of innovation.

In conclusion, to understand and describe a KBE is not question of labels or of defining the knowledge work, rather the KBE describes a change in economic structures, and the way in which firms and people operate across all sectors potentially affecting a very wide range of occupations. But it is also important to analyze the institutional regime within which the KBE operates.

3. The role of institutions

The knowledge-based economy is an economy that favors the development of those sectors where the technological knowledge spreads more quickly and effectively, this necessarily leads to the unfolding of processes of structural change. In this context the role of institutions is crucial, because it is by the interactions between actors and institutions and, therefore, through the relationships that exist between the production system, public authorities, universities and the education sector as a whole – addressed to developing scientific knowledge and technology – which is affected the innovation performance of firms, organizations and economies (OECD, 1996; Mokyr, 2002). Hence technological and institutional aspects are intertwined in the knowledge-based economy. However, the problems that concern the institutional determinants (which must be distinguished from technological ones) are not easy to solve. At the same, technologies and institutions usually tend to adapt to one another, following a coevolutionary process (Powell, and Snellman, 2004).

Douglas North (1995) pointed out that competition forces the organizations to continually invest in skills and knowledge to survive. Hence, the stock of knowledge the individuals in a society possess is the deep underlying determinant of the performance of economies and societies. Changes in that stock of knowledge are the key to the evolution of economies. Whether it is learning by doing on-the-job or the acquisition of formal knowledge, the most important thing to survive is improving the efficiency of the organization relative to the of rivals. The key point, according to North, is that learning by individuals and organizations is the major influence on the evolution of institutions.

Moreover, it must be accepted the idea that the whole process of knowledge creation and diffusion in a knowledge-based economy heavily depends on appropriate government policies that are usually the outcome of economic incentives and institutional regimes. Thus governments play a crucial role, because knowledge creation and diffusion cannot simply depend on market mechanisms alone. An appropriate framework of economic incentives and institutional regimes is necessary for facilitating the interaction among different sectors in a knowledge-based economy (Schilirò, 2010).

Empirical evidence has sufficiently demonstrated that the institutions help to generate and use new technologies. The institutions that facilitate this task were especially those designed to protect and promote the competition within an industry, the existence of agencies that coordinate set the standards and the evolution of new techniques, the existence of military orders that reduce the uncertainty of demand for a new product or a new technique, the communication between the industries and organizations that specialize in generating new technological knowledge, such as the Universities and research institutes, the intellectual property (Mokyr, 2002, Schilirò, 2010).

To promote a knowledge-based economy not only is required the existence of institutions, but it is equally necessary that these institutions must be strong and credible and that give stability[11]. The creation of credible institutions becomes a precondition, since the development of a knowledge-based community is particularly based on the institutional framework and human capital resources (David, Foray, 2003). Knowledge and institutions are strongly interconnected with each other and their relation is very complex. Institutions typically offer a framework of reference they constitute “the environment”, an autonomous reality that exists independently from the consideration of individuals. They nevertheless reduce uncertainty and create stability for organizations and individuals, and also guide the behavior and the process of knowledge creation.

North (1990) argued, in this regard, that institutions form a rescue anchor for individuals they can greatly simplify the choice between the options, narrowing the number of possible alternatives. Institutions also offer a stable equilibrium and the knowledge of routine within which the problem of the choices appears regular, repetitive and evident. A basic role of institutions in a society and an economy is, therefore, to reduce uncertainty by establishing a stable structure of human interaction, although not necessarily efficient.

[11] Kostiainen, and Sotarauta (2003, p. 431).

To better understand the importance of the institutional environment and the role of institutions in the affirmation of the knowledge-based economy we take into consideration the case of Finland and, then, as a specific local case the city-region of Tampere in Finland.

The Finnish experience in the 1990s is an example of how knowledge can become the driving force in economic transformation and growth. Although in the 1970s Finland was relying mainly on resource-intensive industries – it was in fact an economy largely based on forestry and paper production –, the country has become later the most ICT specialized economy in the world, with a narrow set of leading industries producing new products strictly connected with telecommunications (Powell, and Snellman, 2004, Dahlman *et al.*, 2006). The evolution of Finland's economy was marked by the development of Nokia, a successful enterprise, which have become the global leading company of mobiles and wireless communications. Although there were also other firms in the country operating in the engineering and telecommunications, Nokia has been the industrial engine for developments in the ICT industries in Finland. Nokia, thereby to a significant extent, influenced the rapid industrial restructuring in the 1990s toward electronics and electrical engineering[12]. At the same time a large number of smaller high technology firms also have been established, and many of them have become world leaders in their niche markets.

Noteworthy is the focus of industrial policies in the 1990s of Finnish government toward microeconomic policies that "provide conditions". These microeconomic policies put RandD and innovation at the center stage. Since 1980, research and development (RandD) investments by the government have more than doubled to reach levels equivalent to 3.5 percent of GDP in 2004, which was above the EU average. The Finnish innovation system also has been successful in converting its RandD investments and educational capacity into industrial and export strengths in the high - technology sectors. This change is demonstrated by the fact that Finland is among top performers in patenting (Dahlman *et al.*, 2006). In addition, the governance of the economy in Finland was characterized by a strong focus on coordination of policies among key government agencies and between them and the productive sector, which created a cohesive environment.

The experience of Finland shows that it is possible to make significant structural changes in a relatively short time. It also shows that long-term decisions that shape research and education are possible and must be implemented by suitable institutions (Sahlberg, 2007). Finland in 2007 was the top OECD country for the number of researchers employed (per 1000 employees) and also the top for researches employed in business enterprises: 10 per 1000 employees against an OECD average of 6 per 1000 employees (OECD, 2009, 1.10).

So the specialization in high-tech and RandD intensive production needed to be preceded by important changes in economic and social structures. These decisions are indeed necessary, since they provide guidelines for longer-run growth and help create a sustainable competitive edge. Institutions, in fact, form the reference framework for the action of individuals, and in the present case they have played an important role. First of all the transformation of the Finland's economy has been influenced by various favorable changes in the regulatory framework and in market structures. So there have been changes in the institutional regime. The major changes relate to market liberalization and internationalization of business; these changes are interlinked and mutually supportive. The internationalization and the aim of competing in a context of global markets in the 1990s have given a decisive push towards a structural renewal of the economy (Dahlman *et al.*, 2006).

This deep transformation of the economy of Finland has also affected its local economies as is the case of Tampere city-region. In Tampere, there has been a virtuous combination of integration, based on networks, between tangible and intangible resources, local institutions and actors, where the major characteristics of the knowledge-based economy are strongly tied to those of globalization. In addition, a key element has been the presence of a strong and dynamic central government that has been promoting national systems of innovation, interacting with the endogenous factors of the development, oriented at the local level. It was created, therefore, a dynamic relationship among the various levels of government: local, national and global, where learning, seen primarily as a means to renew and increase the resources, has been the basis for success[13].

Regarding the institutional environment in Tampere, Kostiainen and Sotarauta (2003) point out that the creation of knowledge-based economy was largely made possible by the increasing role of knowledge institutions: first, the establishment of the University of Tampere in the early 1960s after the important institution of Polytechnic in the 1970s and thirdly, the creation of the Science and Technology Park and Agency for

[12] Nokia is by far the largest company in Finland, and it has a considerable impact on the small economy. In 2003 Nokia accounted for 3.7 percent of GDP, one-fifth of exports, 1 percent of total employment, and 35 percent of total national R&D expenditure Dahlman *et al.* (2006).

[13] On the relevance of learning in the knowledge-based economy see Lundvall (2004), Schilirò (2009).

Technology Transfer in the 1980s. In fact, the close ties between universities and industry and the major role of Polytechnic in transferring knowledge and technological expertise to the system production and, more generally, to provide a set of services to firms, were certainly crucial for the economic development of Tampere. Moreover, the regulatory framework in terms of laws and statutes has induced the Polytechnic to invest in product development, contributing favorably to the university-industry relationship, through the Agency for Technology Transfer, and, at the same time, the renewal of the legislation on the Research Technology Center of Finland has allowed the transfer of a number of research laboratories in strategic areas in Tampere. Nokia, the large company which has become global leader in manufacturing mobile phones, also had a considerable impact on the economy of Tampere, in particular through the growth of activities related to information technology. So in the span of 40 years, Tampere has transformed into one of the foremost Finnish cities of the knowledge economy.

In the relationship between institutions, knowledge-based economy and development, the path dependence plays an important role, since it represents an element of persistence of structure over historical time (David, 1994). The central point of the question is whether this path dependence blocks the economic system in the previous path, or is able, through mechanisms of feedback and adjustment processes, to change and evolve towards more advanced scientific and technological knowledge and thereby implement economic development of the territory and its economy. The path dependence could, in effect, lock the system in the previous path, so two alternatives may occur: or is a structural change that occurs through a deep crisis of the previous system, or the local production system remains locked in an increasingly slow vicious circle. In the case of Tampere the first of the two alternatives has occurred, because from an economic reality already industrialized, but declining, a new knowledge-based economy arose, through a self-reinforcing evolutionary process (Kostiainen, and Sotarauta, 2003). Tampere is a paradigmatic example of the Finnish model, based on the application of a system's view of industrial policy. This model based on system's view could be described as an acknowledgement of the importance of interdependencies among the knowledge institutions (research organizations and universities), firms and industries due to the increasing importance of knowledge as a competitive asset. This institutional regime enables the improvement of the general framework conditions for firms and industries, especially in knowledge development and diffusion, innovation, and clustering of industrial activities. Tampere has characterized by an high percentage of educated population, 64,5 per cent of adult population has a secondary level degree, and by an high RandD intensity, equal to 14 per cent of RandD national spending. Therefore, if we look at the factors that have determined the success Tampere we find basically three constants: first, the close ties between universities and firms, secondly, the creation of institutions of research, and thirdly, the creation of Scientific Parks or incubators. There are so new organizations created specifically, which are to operate in an innovative institutional framework, to be the protagonists of the development of the knowledge-based economy. Naturally, there are other factors that have almost always had a positive effect, particularly research policy, direct government support and even the historical and economic context.

In conclusion, for economic success certain institutional innovations are as important as the technological ones. Because of the difficulties for the institutions to build and establish itself over time, the pressure of competition due to the effect of globalization and the evolution of technology, it is necessary a certain degree of flexibility in the institutional regime and, hence, the ability of the institutional environment to respond to uncertainties. Tampere was a case in point.

Conclusions

The present contribution has analyzed the important role of the institutional environment in a knowledge-based economy. Knowledge-based economies are economies founded on increasing specialization, research, innovation and learning and on their reliance in the new information technologies. This work outlined a knowledge-based economy and its features, so it discussed the problems regarding its definition. But it also analyzed the proposed solutions in the literature to measure this peculiar economy in which knowledge is the main driver.

Since knowledge-based economies require some critical requisites to become real and efficient economies, which are the four pillars: education and training, innovation, information infrastructure, the institutional regime, – this contribution has focused on the relationship between a knowledge-based economy and the institutional environment, highlighting the role of the institutions.

The work argues that various institutional changes must be introduced to achieve a knowledge-based economy in a world characterized by processes of globalization, of harsh competition and continuous innovation. The institutional changes that need to be made will involve the government with its economic policies and the private sector, as it has been in the case of the Finland's economy. To deepen the relation between knowledge-based economy and the institutional environment for the development the Finnish experience has been examined briefly. But this work has also shown the peculiar case of the city-region of Tampere in Finland in order to show the important role of the institutions, and, in particular, of the knowledge institutions (university, polytechnic, institute of research, Scientific Parks), since learning, the transmission of knowledge and the communities of researchers are crucial factors for a knowledge-based economy.

In addition, since the institutions need time to build and establish itself and the globalization and the innovation are changing the competitive scenario rapidly and continuously, it is necessary a certain degree of flexibility in the institutional regime and, hence, a capability to respond to uncertainties.

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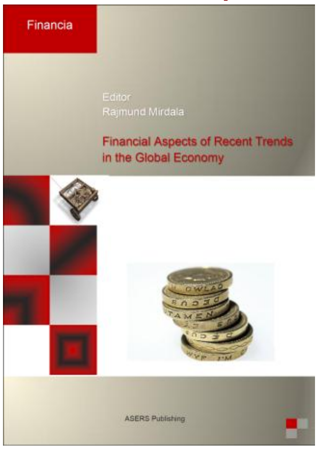

Book title:
“Financial Aspects of Recent Trends in the Global Economy”

A book edited by PhD Rajmund Mirdala
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http://www.asers.eu/asers-publishing/books

To be published by ASERS Publishing in CD-ROM format with ISBN.

Introduction

The current global financial crisis represents one of the key areas of policy makers as well as academics discussions. Together with debt crisis they may be considered as one of the biggest challenge official authorities are facing in last few decades. Both crises focused attention of economists to various aspects of the financial aspects of recent trends in the world economy in the new global era.

Financial liberalization together with the process of growing financial integration among countries in global content significantly contributed to rapid increase in financial dependence of national financial markets. Intensification and internationalization of financial transactions, financial innovations and rising strength of financial institutions accelerated growing potential of the financial sector. It is not surprising that nowadays daily turnover in financial transactions significantly exceeds daily turnover in trade all over the world. As a result overall impact of financial sector activities on the real economy markedly increased over last few decades. Finally, a rising demand for more effective regulation of national financial sectors and international financial transactions seems to be a convenient way that policymakers suggest as the appropriate solution for current global financial challenges. Within this context we also point to an increasing relevancy of voices calling for new arrangement of international monetary system.

Increased uncertainty considerably reduced allocation effectiveness of the financial markets during the crisis period. While the interest rates during the recession period generally decreased, costs of lending increased mostly for highly indebted countries. Economic crisis emphasized another crucial aspect of the current development in the world economy generally known as debt financing of economic growth and related negative trend in public debt development. Particular problems in the most indebted Eurozone countries affected not only stability of the euro exchange rate but also became the main reason for accelerating the process of fiscal unification, banking union formation and key adjustments in Eurozone stabilization mechanisms. As a result the pressures to strengthen financial discipline of the Eurozone member countries increased while the alternative scenarios of Eurozone reconstruction remained still alive (i.e. national bankruptcy, fiscal union).

Another problem partially related to the current debt crisis represents a significant growth of corporate debt, also known as corporate funding crisis. Accumulation of corporate debt during last few decades together with slow post crisis recovery in the main world economy centers raises the risk of upcoming corporate insolvency wave as a result of the huge wall of maturing debt signalizing refinancing difficulties in credit markets in United States, Europe and Asia.

The last problem we emphasize as a direct consequence of negative aspects of the current crisis period is related to the rising indebtedness of households. In many countries an individual insolvency still deserves not sufficient attention of official authorities. Personal bankruptcy as a complex consolidation procedure is also not adequately implemented in the national legislation especially in the less developed countries considering wide aspects of this process.

Book Objectives

In the global era soundness financial sector and financial discipline of agents (governments, investors, households) represents of the key aspect of generally expected positive outcomes of economic and financial globalization. Sustainable economic growth of global economy is necessarily conditional to positive contribution of the financial sector development as well as the financial discipline of agents to the real performance of economies.

Thus, the goal of this book is to encourage the exchange of new ideas about challenges in global trends in finance in the view of wide aspects of current financial and (public, corporate, households) debt crisis. The target audience for this publication is academics, researchers, and policy makers engaged in various disciplines such as international finance, international monetary arrangements, economic prognosis, international capital flows liberalization and regulation, bank asset and liability management, fiscal deficit, public debt, fiscal federalism, fiscal unification, corporate debt, household debt, etc.

Recommended topics of the book include, but are not limited to, the following: financial crisis, global imbalances, challenges to new international monetary arrangements, moral hazard, risk sharing and diversification, bank supervision and revitalization, financial integration, financial deepening, exchange rate regimes, debt crisis, fiscal unification, post crisis economic recovery, corporate indebtedness, personnel bankruptcy, etc.

Submission Procedure

Potential contributors are invited to submit on or before November 20, 2012 a chapter proposal clearly explaining the mission and concerns of their proposed chapter. Book contributions will pass double-blind review process. Book will be subsequently reviewed by two reviewers - experts in the field of macroeconomics. Electronic version of the book will be also reviewed by Thomson Reuters in order to get indexed in the Thomson Reuters' Book Citation Index accessible at the Web of Knowledge (WoK).

Contributors of accepted proposals will be notified by 30 November, 2012 regarding the status of their proposals. For keeping a reasonable trade-off between theoretical and practical issues, a careful selection of the chapters will be done, on the one hand, to cover a broad spectrum of formal and practical aspects and, on the other hand, to achieve as much as possible a self-contained book. Final Camera Ready Manuscript is expected to be December 20, 2012. Contributors may also be requested to serve as reviewers for this book project.

This will facilitate the planning of the review process. Careful preparation of the manuscripts will help keep production time short and ensure satisfactory appearance of the finished book. Please prepare the manuscript using the author guidelines as follows:

- Each chapter must be self-contained and not exceed 30 pages;
- Please centralize all tables and figures with appropriate legends;
- Please carefully check for typos inside the text, figures, legends, etc;
- All equations must be numbered and please try to use standard fonts.

Important Dates:

Full Manuscript/Chapter Due:	20 November, 2012
Acceptance of Chapter Notification:	30 November, 2012
Final Camera Ready Manuscript/Chapter Due:	20 December, 2012
Publication Date:	20 February, 2013.

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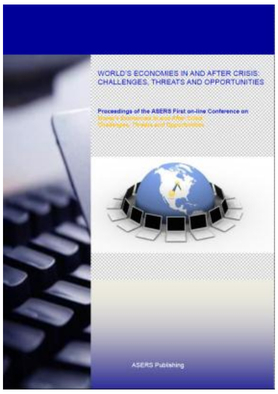

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