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Abstract

The present paper uses the "growth accounting" methodology to estimate technological change, in an attempt to formulate an explanation of Russia's economic decline and signs of recovery in the 1992-1999 time span, in relation to technological change. Also, the potential output and output gap is estimated using a Cobb Douglas production function and a Hodrick-Prescott filter for the Russian Economy before 2000. The results do show that, despite the general economic collapse during the 1990s, rooted in the Soviet economy's very structure, the level of technology has, practically, remained unchanged which, in turn, prevented the Russian Economy from further deteriorating. Meanwhile, the relationship between output gap and inflation is briefly examined and the results suggest that output gap is sufficient to explain the largest part of inflation in the Russian economy. As a final conclusion, technological progress and, consequently, long-term economic growth is linked to Russia's political and structural development.

J.E.L. Classification: P26, O10

Keywords: growth accounting, output gap, Cobb-Douglas, HP filter, technology, Russia

1. Introduction

Russia's transition from a centrally planned to a Western type capitalist economy was marked, as known, by a rapid decline in nearly all economic indices, during most of the 1990s. Also, contrary to most former "socialist" countries in Europe, where the negative rates of change of G.D.P. and of industrial output were reversed to positive since 1994, in Russia the deterioration of the economic situation continued (Campos and Coricelli 2002, Blanchard 1997, Millios 2001, I.M.F. 2001, 2002) for a few more years until the end of the decade.

The purpose of the present paper is dual: on one hand, the estimation of change in the technological level of the Russian Economy, which constitutes a very important determinant of long-term economic growth, and, on the other hand, an attempt to better understand the supply side of the Russian economy by examining the concept of potential output and output gap.

According to Mokyr the economic importance of technology and innovation is great: "The difference between rich nations and poor nations is not […] that the rich have more money than the poor, but that rich nations produce more goods and services. One reason they can do so is because their technology is better; that is, their ability to control and manipulate nature and people for productive ends is superior" (Mokyr 1990: preface). However, although technology can be viewed from an "econometric" point of view as an (e.g. exogenous) independent variable determining the output, it is also country specific, that is it depends on the overall complex socio-economic framework of the historically specific social formation under investigation. Our study refers to the Russian economy, as a whole, for the time period 1992-1999, which, practically, marks the end of the crisis period (Stikuts 2003) and is based on the *Growth Accounting* methodology.

On the other hand, potential output is an unobservable variable, which is related to the changes in technology. It cannot be estimated directly, but it can be estimated with the aid of several statistical and theoretical methods. Statistical methods eliminate cyclical fluctuations from the actual output time series. The statistical methods include the time trend approach and the Hodrick-Prescott (HP) filter approach. To apply statistical methods, no other additional variables than actual output are needed. This is the reason why statistical methods are widespread. On the other hand, statistical methods have several drawbacks, such as low estimation and forecasting efficiency, particularly when made over longer horizons (Stikuts 2003). The application of these methods requires relatively extensive time series.

The most essential drawback of this approach, however, is that substantial changes in the economic structure due to which the level of potential output may change – and therefore be inconsistent with the forecast –, are not taken into account (Stikuts 2003). This drawback is particularly noteworthy for the case of Russia and other transition economies, as with the advance of market economy in the early 1990s a great number of changes in the economic structure took place, and the level of Russia's potential output changed alongside with them.

Because of the several drawbacks of the statistical methods, the analysis based on the production function is used as an alternative method for measuring potential output. The most widely applied structural method is the estimation of the production function in the form of the Cobb-Douglas (CD) production function. Potential output thus estimated takes into account the changes in the economic structure.

The paper is structured as follows: section 2 analyses the performance of the Russian economy during the last decade; section 3 presents the methodological framework; section 4 sets out the data and the variables used; section 5 presents and analyses the empirical results; in section 6 a further discussion of the paper's findings is set forth; finally, section 7 concludes the paper.

2. The Russian Economy in the 1990s: An Overview

The decentralization of the enterprise decision-making mechanisms and accountability, the price liberalization and, finally, the largest enterprise privatization in history (Boycko, Shleifer and Vishny 1995) constituted the key elements of the economic reform in the process of Russia's transition form a centrally planned economy to a Western type economy.

After the break-up of the Union, the state revenues were drastically cut. Accordingly were reduced the social benefits, which were provided directly by the state and the large state enterprises to their employees (e.g. health services, education, etc). Also, the commercial transactions among the F.S.U. countries became "foreign trade", and the COMECON collapsed. Furthermore, income taxation from non-state activities constituted a significant cost factor and drove to tax evasion and to delays in tax payments from certain large enterprises (O.C.D.E. 1997). Therefore, the (money) economy was partly replaced during the 1990s by non-monetary transactions[1], which favored the spreading of tax evasion (O.C.D.E. 1997, Kaitila 2003). Meanwhile, the state was unable to control many other fundamental economic and social variables, while the quality of state education, health and transport services deteriorated significantly.

The first apparent result of the "transition" process was the dramatic output decline until 1998, combined with the very high inflation rates. As illustrated in *Table 1*, according to the official Russian statistics (Goskomstat), Russia's G.D.P decreased in the time period 1989-1994 by more than 50% of its 1989 value (which means the middle of the crisis period), and approximately by 30% during the last decade, given the recent recovery of economic activity.

However, we should, at this point, note the following fact: The official Russian statistics overestimated the prior to 1991 values of the macroeconomic data (O.E.C.D. 1995). Thus, based on the most resent studies of Gavrilenkov and Koen (1995), Kubowina (1996), Kubowina and Gavrilenkov (1997) and O.C.D.E. (1997), aggregate output decline in Russia in the 1989-1994 time span is, approximately, 35%. In these studies, an effort was made to account for various factors, which might have affected the estimations (Haaparanta and Kerkela 2000), e.g. the extent of tax evasion. Finally, under the new conditions, the small enterprises "hide" part of their income and, consequently, the aggregate output of the economy is underestimated (Milios 2001). In this framework, the extensive diffusion of non-monetary transactions should also be taken into account. The opposite is in force during the period of the recovery, i.e. after 1998. The reported increase in output is partly deceptive, because of the recession of the non-monetary transactions (Broadman 2001). This situation sets limitations to the estimations of the present paper, as far as both, the extent of the crisis of the Russian economy and the observed recovery are concerned.

[1] For the significance of "the widespread use of money substitutes" in Russian economy see Maroudas and Rizopoulos (2002) and Aukutsiovek (1998).

Table 1: Main Economic Indicators of the Russian Federation (1990-2000)

Έτος	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00
Real GDP (%change)	-2.1	-12.9	-18.5	-12	-15	-4	-7.7	-1.3	3.6	6.0	5.7
Cons.Prices (%change)	5	93	1354	915	320	200	48	15	28	86	21
Investment (% change)	n.a.	n.a.	n.a.	-26.4	-12.8	-7.7	-8.2	-9.3	-6.6	-1.4	18.8
Exports (bn$)	48.8	53.2	42.4	43.7	67.8	82.9	90.6	89.0	74.9	75.7	105.6
Imports (bn $)	50.2	44.5	35	34.1	50.5	62,6	68.1	79.1	63.8	43.6	49.1
Tr.Balance (bn $)	-1.4	8.7	7.4	9.6	17.4	20.3	22.5	22.5	11.1	32.1	56.5
Unemp/ment (%)	n.a.	0.1	0.8	5.7	7.5	8.9	9.9	11.3	13.3	14	n.a.

Sources: I.M.F (1994, 2001, 2002a), OECD 1995, United Nations 1996, Express 1996

Given our reservations concerning the accuracy of the data, there was a much greater decline in industrial output (as to the total output – G.D.P.), while investments practically collapsed (Kaitila 2003, I.M.F. 2002a,b, O.E.C.D. 1995: 3 ff). Finally, the decrease in production was accompanied by a significant reduction in the Research and Development (R&D) expenditures (Goskomstat 1997).

However, the aggregate output decline did not affect all the branches of the Russian economy equally resulting in significant sectoral restructuring, which benefited the service sector at the expense of the industry's share in G.D.P. (Milios 2001). In the industrial sector, electric energy and metallurgy achieved the highest share increases, whereas the light industry and machine building, traditionally "technology intensive" sectors, were the most negatively influenced sectors (O.E.C.D. 1995: 4). Furthermore, the high inflation rates prevented the national currency from functioning as a means of storage of value and resulted in the abandonment of the ruble for international transactions, in favor of the U.S.A. dollar (I.M.F. 1994: 71).

Despite the dramatic decline of G.D.P. and of industrial production until 1998 (see Maroudas 2001: 62), the rate of the reported unemployment in Russia continued to remain low, i.e. bellow 10%, until the mid 1990s. More specifically (see *Table 1*), the rate of unemployment rose from 5.7% in 1993, to 8.9% in 1995. However, the fact that official figures underestimate real unemployment rates, or that early retirement of the elderly as well as a decline in women's participation rates in total employment help holding unemployment rates down, is not enough to explain why production collapse did not result in a rapidly increasing unemployment (Milios 2001).

As is illustrated in *Table 1*, the situation was quite different in the following years and the rate of unemployment "climbed" up to a high 14% in 1999. This behavior goes hand in hand with the positive rates of change in output (since 1998) and in investment (since 1999). The low unemployment rate did not avert the substantial decline of the living standards of the Russian population (see O.E.C.D. 1995: 125, 128-129).[2] The deterioration of the living standards of the Russian population is also associated with the increasing income and social inequality among the population[3] (Milios 2001).

[2] For a study on the factors that affected the deterioration of the living standards of the majority of the Russian population see Milios (2001).

[3] With an average per capita G.D.P. not exceeding the amount of 1.500 U.S. dollars yearly, the share of the other (than labour) means of income raised in just one year (1993-94) from 20,1% to 34,5%, while the wealthier 20% of the population enjoyed, in 1994, the 50% of the aggregate income (Milios 2001).

3. Methodological Framework

The empirical investigation will be based, partly, on the *Growth Accounting* approach. Growth accounting was pioneered by Abramovitz (1956) and Solow (1957) and aimed at explaining the determinants of growth worldwide, after World War II. In growth accounting (see e.g. Romer 1996: 26-33), growth in a single country is decomposed over time, using a production function, into a part explained by growth in factor inputs and another part (i.e. the Solow residual), which is attributed to technological change, and is called Total Factor Productivity (T.F.P.). The basic framework can be extended in other ways (see e.g. Denison 1967, Mankiw, Romer and Weil 1992), the most common of which is to consider different types of capital and labour (Romer 1996: 26). Growth accounting has been applied to numerous cases in the last two decades (see e.g. Page 1994, Young 1994, Jorgenson 1988, Griliches 1988, Baily and Gordon 1988, Denison 1985, etc) with very satisfactory results.[4]

The most commonly used production function in empirical investigations using aggregate data is the Cobb-Douglas production function (Thirlwall 2001: 181). We, thus, assume a Cobb-Douglas production function with two inputs, capital and labour and Hicks-neutral technological progress.[5] So production at time t is given by:

$$Y(t) = A(t) \bullet L(t)^{\alpha} \bullet K(t)^{\beta} \quad (1)$$

$$Y(t)>0,\ L(t)>0,\ K(t)>0,\ A(t)>0,\ \alpha>0,\ \beta>0$$

The notation is standard: Y is output, L labour, K capital, A the level of technology, while α and β are the elasticities of output with respect to labour and capital, respectively.

A central problem in examining technological change and one that makes it difficult to define or characterize it is that it takes many different forms (Rosenberg 1982: 3). The most useful common denominator underlying its multitude of forms is that it constitutes any change in the application of knowledge that can make it possible to produce (i) a greater volume of output from a given amount of resources (ii) a qualitatively superior output, or (iii) a completely new output (Mokyr 1990: 6, Rosenberg 1982: 3). Technology constitutes a very crucial determinant of an economy's total productivity and competitiveness (O.E.C.D. 1996), however its direct quantification is difficult and it is often estimated indirectly using a production function.

From equation (1), using simple mathematics, we get that (see e.g. Thirlwall 1999: 181):

$$\frac{\partial Y(t)}{\partial t} \bullet \frac{1}{Y(t)} = \frac{\partial A(t)}{\partial t} \bullet \frac{1}{A(t)} + \alpha \bullet \frac{\partial L(t)}{\partial t} \bullet \frac{1}{L(t)} + \beta \bullet \frac{\partial K(t)}{\partial t} \bullet \frac{1}{K(t)} \quad (2)$$

and

[4] For instance, Young (1994) used the growth accounting methodology to argue that rapid growth of Taiwan, Singapore, South Korea and Hong Kong was mainly due to increasing labour-force and investment, and not to technological progress. Also, growth accounting has been extensively used for the study of the slowdown in productivity in the United States since the 70's.

[5] The assumption of (Hicks-) neutral technological progress is, according to the empirical literature, a very reliable one (Thirlwall 2001: 187).

$$\frac{\partial A(t)}{\partial t} \bullet \frac{1}{A(t)} = \frac{\partial Y(t)}{\partial t} \bullet \frac{1}{Y(t)} - \alpha \bullet \frac{\partial L(t)}{\partial t} \bullet \frac{1}{L(t)} - \beta \bullet \frac{\partial K(t)}{\partial t} \bullet \frac{1}{K(t)} \quad (3)$$

Equation (2) implies that the rate of change in output depends on the growth in labour and capital, and on technological change, while equation (3) allows us to estimate technological change, indirectly.

Using simple mathematics, the rates of growth of labour productivity (Y/L) and capital productivity (Y/K) respectively, are given by:

$$\mathrm{l} = \frac{\partial Y(t)}{\partial t} \bullet \frac{1}{Y(t)} - \frac{\partial L(t)}{\partial t} \bullet \frac{1}{L(t)} \quad (4)$$

$$\mathrm{k} = \frac{\partial Y(t)}{\partial t} \bullet \frac{1}{Y(t)} - \frac{\partial K(t)}{\partial t} \bullet \frac{1}{K(t)} \quad (5)$$

Thus, given that, typically, the sum of the values of α and β are set equal to unity (see e.g. Dornbusch and Fischer 1993, Thirlwall 2001, Stikuts 2003, Billmeier 2004), the Cobb-Douglas production function takes the form:

$$\frac{Y(t)}{L(t)} = \mathrm{A}\ (\mathrm{t}) \bullet \left(\frac{K(t)}{L(t)} \right)^{1-a} \quad (6)$$

It is also an important challenge for the economy's authorities to determine, as close as possibly, the level of potential output, the level of actual output at any given time, and the direction in which they are heading. Both the level of potential output and the output gap are estimated numbers, and therefore, there is a major uncertainty in their calculation. For the case of the Russian Federation, this uncertainty may grow larger now because the economy seems to have undergone some significant changes during the 1990s. As a result the Russian authorities should place increased weight on a range of relevant indicators to assess the degree of pressure on the economy's production capacity.

General research on output gap started with Okun (1962) and has been abundant ever since (for instance, see Kuttner 1994). A variety of methods can be used to estimate potential output and the output gap. However, roughly speaking, there exist two broadly used methods for the estimation of potential output: The HP-filter and the production function. For a review see Bolt and Els (2000). For a brief presentation of some less popular techniques see Slevin (2001). The linear, two-sided HP-filter approach is a simple and widely used method by which the long-term trend of a (macroeconomic) series is obtained using only observable, i.e. actual, data. The trend is obtained by minimizing the fluctuations of the actual data around it, i.e. by minimizing the following function:

$$\sum [\ln y(t) - \ln y^*(t)]^2 - \lambda \sum [[\ln y^*(t-1) - \ln y^*(t)] - [\ln y^*(t) - \ln y^*(t-1)]]^2$$

where y^* is the long-term trend of the variable y and the coefficient λ determines the smoothness of the long-term (output) trend, expressing the potential output in this case.

The HP-filter approach has two positive features (Stikuts 2002): First, the obtained trend is influenced by shocks. Second, it is simple to measure. However, the HP-filter alone produces a good result only when data on a relatively stable economic environment are used. In this case, the HP-filter along with the relevant and econometric methods has to be used instead of simple linear trend.

Numerous shocks affect economic growth in developing countries, and substantial and accelerated changes in actual output do not necessarily signal either expansion or contraction of potential output. In this context, reliance on the HP-filter approach *alone* may lead to erroneous conclusions. In addition, sources often subject to criticism such as biases at the ends of the time series may influence the economic policymakers' decisions. Irrespective of the given drawbacks, the HP-filter approach is widely employed because of its simplicity.

This method, in contrast to the production function approach, does not use information provided by the factors of production, such as capital stock, workforce and technological development. It does not measure the influence of structural shocks on potential output and hence the output gap estimation may sometimes be biased. In order to avoid it, the estimation of the production function is used as an alternative output gap estimation approach.[6] Practically, its most important advantage lies in the possibility to account explicitly for different sources of growth (Billmeier 2004).

This method estimates a production function where real G.D.P. is some function of capital, labour and technology. The production function is then estimated when the capital stock is being fully utilized and the labour force is fully employed. This method has been used by various researchers (see Artus 1977, Giorno et *al.* 1995, De Masi 1997, Bolt and Els 2000, Senhadji 2000, Slevin 2001, etc.) Continuously, HP filter smoothing techniques have been used in the production function approach to filter technical progress and potential employment (see Giorno et *al.* 1995, Bolt and Els 2000, Fagan et *al.* 1998).

The production function may take various forms, yet the most widely used is the Cobb-Douglas (CD) production function specification.[7] As seen, the CD function may be written as follows:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \quad (1)$$

where Y_t denotes output at constant prices, K_t denotes capital stock at constant prices, L_t denotes the number of the employed persons, A_t characterizes the Total Factor Productivity (T.F.P.) and α is the elasticity of production factors.

Alternatively, equation (1) can be written as:

$$\frac{Y_t}{L_t} = A_t \left(\frac{K_t}{L_t} \right)^{1-a} \quad (6)$$

[6] For overviews of the HP filtering method shortcomings see Harvey and Jaeger (1993), King and Rebelo (1993), Cogley and Nason (1995) and Billmeier (2004).

[7] The CD function has drawbacks as well (Stikuts 2003): First, it is a simplified reflection of reality. For instance, it considers as homogenous the production and labour expanded originating from different sectors and skills. In other words, labour force or capital of the manufacturing industry is regarded as being the same as in the banking sector and can be easily transferred from one sector to another. Second, the data employed may result in a biased estimation, as in any econometric estimation, since the application of more accurate data is restricted by irregular availability (e.g. data concerning the utilisation of capital are not accessible with adequately high frequency to be used in econometric studies). Third, natural or optimal factor utilisation capacity is difficult to define. Finally, the Solow residual is a substantial component of the production function, which is calculated as estimation residual and as such is economically unexplained and freely interpretable. Irrespective of its drawbacks, the CD function is one of the methods, which along HP-filter is widely used to estimate the potential output (Stikuts 2003). For a brief review of the model's theoretical limitations see Thirlwall (2001:185-7), which are, however, of limited practical character, as the author himself implies (see ibid :187).

Taking *logs* equation (6) yields a linearised form:

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln A_t + (1-\alpha)\ln\left(\frac{K_t}{L_t}\right) \quad (7)$$

This linearization reduces the number of coefficients to be estimated and eliminates the multicolinearity problem of the explanatory variables (Stikuts 2003).

Alternatively, taking *logs* equation (1) can be written as:

$$\ln Y_t = \ln A_t + \alpha \ln L_t + (1-\alpha)\ln K_t \quad (8)$$

Potential output Y^*_t is derived by inserting the potential values of the production factors. In other words:

$$\ln Y^*_t = \ln A^*_t + \alpha \ln L^*_t + (1-\alpha)\ln K^*_t \quad (9)$$

where * denotes the potential value of the production factor.

The next step is to measure the potential value of production factors. The actual value of capital stock is used as a substitution for its potential value, as capital stock cannot fluctuate substantially, and it is assumed that the capital stock available is always used at its potential. Thus, we have that:

$$K^*_t = K_t \quad (10)$$

The Total Factor Productivity A^*_t is partly estimated by the production function as the residual ε_t of equation (7) and the potential level is determined by the HP-filter to obtain a smooth time series. Consequently:

$$A^*_t = A_{s_t} \quad (11)$$

where A_{s_t} is the HP-filtered residuals of equation (3) characterising T.F.P.

Potential labour input is estimated using the NAWRU (non-accelerating wage-inflation rate of unemployment) concept. The NAWRU is the unemployment rate at which wage inflation is constant. Several studies (see Layard et al. 1991) show that the equilibrium unemployment rate changes over time, but it generally follows the actual unemployment rate (due to hysteresis and labour market inelasticity).

Elmeskov's (1993) popular method is used in this paper to construct a time varying NAWRU. This approach has also been used by Bolt and van Els (1998) and Bolt (2000) to estimate the output gap in European Union (E.U.) countries and in Slevin (2001) for the case of Ireland. It is based on an equation, which relates changes in unemployment with those in wage inflation:

$$u_t - NAWRU_t = \lambda \Delta^2 w_t, \lambda<0 \quad (12)$$

where u_t is the actual unemployment rate, $NAWRU_t$ is the (natural) unemployment rate, which has no effect on wage inflation and w(t) is the average gross wage in the national economy. Δ is the first difference, Δ^2 is the second difference and Δ^3 is the third difference operator.

Taking left and right first differences of equation (12) leads to an equation for λ:

$$\lambda = \frac{\Delta u_t}{\Delta^3 w_t}, \Delta^3 w_t \neq 0 \quad (13)$$

when inserting the latter (13) into equation (12) we get:

$$NAWRU_t = u_t - \frac{\Delta u_t}{\Delta^3 w_t}\Delta^2 w_t \quad (14)$$

Equation (14) implies that the NAWRU is equal to the actual unemployment rate, which is adjusted by unemployment rate changes and wage inflation relationship. The resulting series in then smoothed to eliminate erratic movements using the HP filter. Consequently, potential employment is calculated as follows:

$$L^*_t = L_{s\,t}\,[1\text{-}NAWRU_{s\,t}] \quad (15)$$

where L_s is the HP-filtered labour time series and $NAWRU_{s\,t}$ is the HP- filtered NAWRU time series.

Substitution of the potential values of the production factors obtained from equations (10), (11), and (15) into equation (6) yields the time series of the potential output.

4. Data and Variables

The significance of the factors, entering the production function of the Russian economy, is tested using the available data collected from the publications of the International Monetary Fund (I.M.F.) entitled *International Financial Statistics* (2001, and 2002a, 2004). The data available is on an annual basis and covers the period 1992-1999 (eight observations).

The econometric method used for the estimation of Russia's technological level employs annual G.D.P. data starting with the year 1992. The selection of data has been determined by several factors: First, we start with 1992 because it is the first year, after the major economic reform process in the early 1990s, that data are available. On the other hand, we stop in 1999, because, it is the year that a significant reform process causes Russia's national economy to experience structural shocks, (such as increasing balance trade, decreasing pattern of inflation, changes in terms of trade, slowly growing competitive markets, etc.), the intensity and scope of which differentiates the model estimation for the given period when compared with the prior 2000 situation (IMF 2002a, Milios 2001) and is consistent with the thesis of Stikuts (2003: p. 7) who, explicitly, stated that the Russian crisis ended in 1999. In addition, no sufficient and reliable data are available for the study of the extremely short remaining (recovery) time span and so we are prevented from attaining a statistically very satisfactory level of estimation.

Data on the capital stock at constant prices is not published. However, we estimated it using the *Perpetual Inventory* method. Data on labour or the number of employed persons is provided by the International Monetary Fund annually. As can be seen from a simple inspection of our data concerning labour, since 1992 we observe a slight decline in labour due to the shrinking number of economically active population because of demographic reasons and migration. The demand for workforce in the last decade, on the other hand, has been influenced by a number of factors. The most significant decrease in labour demand could be related to the Russian crisis. Many enterprises had to narrow production and this led to contracting labour demand. This time, however, the unemployment rate did not rise in proportion to the fall in the output growth rate, which may be seen as an indication of producers' unwillingness to dismiss "redundant" workforce completely as they were convinced that the incurred economic hardships were temporary, and, with production soon recovering, hiring of labour would be related to extra costs.

In accordance with the decreasing tendencies of capital stock, labour has decreased since 1992. This implies that resources leading to a sustainable and robust

growth in Russia currently are unavailable. Russia's economic development relies basically on an upswing in capital productivity driven by technological advances and a more intensive utilisation of capital stock rather than employing additional workforce.

Dependent Variable

1. The Gross Domestic Product (G.D.P.) of Russia at constant 1991 prices measured in billions of Rubles.

Independent Variables

2. Labour in Russia is measured as the number of employees in billions.
3. Fixed Capital Formation in Russia is estimated using the *Perpetual Inventory* method (see Appendix) and is expressed in billions of Rubles at constant 1991 prices.

5. Empirical Results

As seen, the most widely used functional form of the production function is the linearised Cobb Douglas specification (Thirlwall 2001, Stikuts 2003), which reduces the number of coefficients to be estimated and eliminates the multicolinearity problem of the explanatory variables (Stikuts 2003). The relationship is, thus, linearised and we use a time-series data set for the period 1992-1999, when data is available. The results of the regression through Ordinary Least Squares (O.L.S.), which is used for the estimation of the linearised Cobb-Douglas production function (Andrikopoulos 2000: 358), are presented in *Table 2* :

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln A_t + (1-\alpha)\ln\left(\frac{K_t}{L_t}\right) \quad (7)$$

Table 2 presents the regression results for the dependent variables.

***Table 2*:** Regression Results for the Cobb-Douglas Production Function for Russia, 1992-1999

Independent Variables	*Estimate*	*t-statistic*
Intercept	2,35	
β	0,41	2.08*
implied a	0,59	
R^2	0.42	
F-Ratio	4.33	
S.E.E.	0.21	
M.A.E.	0.16	
D.W.- statistic	0,70	

Note: * Significance at the 10% level

The signs of the estimated coefficients are consistent with the stated hypotheses and economic theory; the results are statistically significant for the

independent variable, while the equation explains a considerable part of the variability of G.D.P. The results should be assessed as satisfactory given the various imperfections in this sort of country data (Mankiw, Romer and Weil 1992: 408), as well as given the crisis period and the various violent shocks that the Russian economy faced in the under investigation period (Stikuts 2003). [8]

Also, there are no signs of serious violation of the basic assumptions concerning the residuals, as was easily confirmed with the aid of the relevant procedures (see Samouel et al. 1996: ch. 12): specifically, the normality of the errors was assessed through the examination of the frequency distribution of the residuals as well as by reference to the Q-Q or P-P normality plot, which is a special type of plot for checking normality. As far as the assumption of homoscedasticity is concerned, compliance with this assumption was evaluated by examination of the scatter plot of the standardised residuals against the predicted values. Finally, as for the assumption that the residuals are independent of each other, investigation of the scatter plot of the standardized residuals against the time variable provided some idea of possible dependence between successive values, i.e. autocorrelation effect.[9]

Labour elasticity derived is 0.59, and the value of capital stock elasticity is 0.41. These values are, in general terms, consistent with estimations produced by researches on other countries. For instance, as known, the majority of research papers indicate that the value of labour elasticity for the developed countries is around 2/3, while that of capital is 1/3 (labour elasticity estimates in the US are within the range of 0.59 and 0.87, and from 0.57 to 0.59 in Germany) (see Bolt and Els 2000, Dimitz 2001). Recent studies show that in Estonia labour elasticity is around 0.67 (Stikuts 2003). On these grounds, the estimation of labour and capital elasticity of Russia's production function may be regarded as credible.

Potential labour (L*) and actual labour (L) are illustrated in Figure 1.

Figure 1: Potential (L*) and Actual (L) Labour, 1992-1999 (bn of employees)

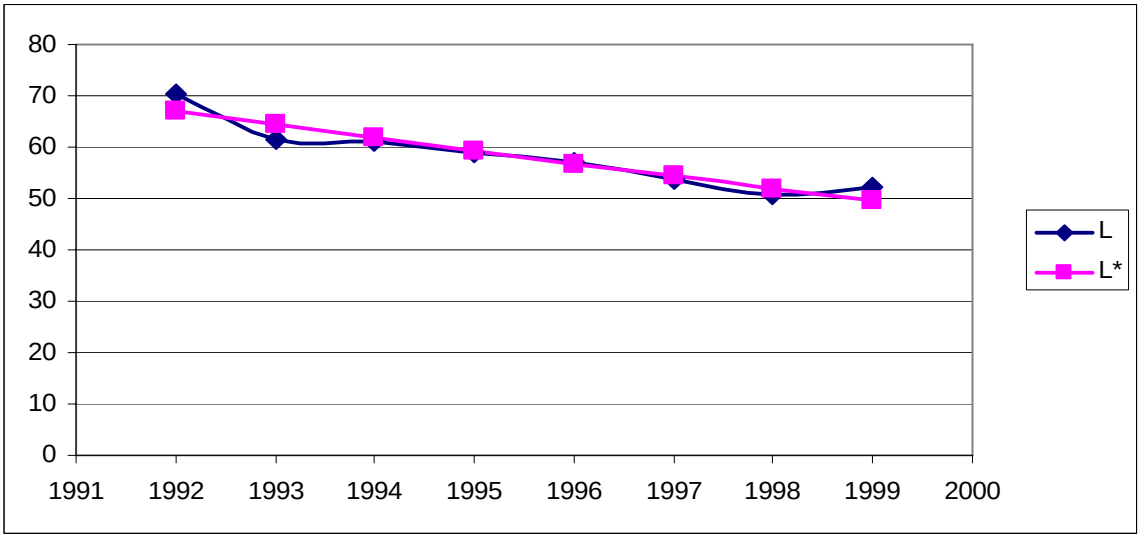
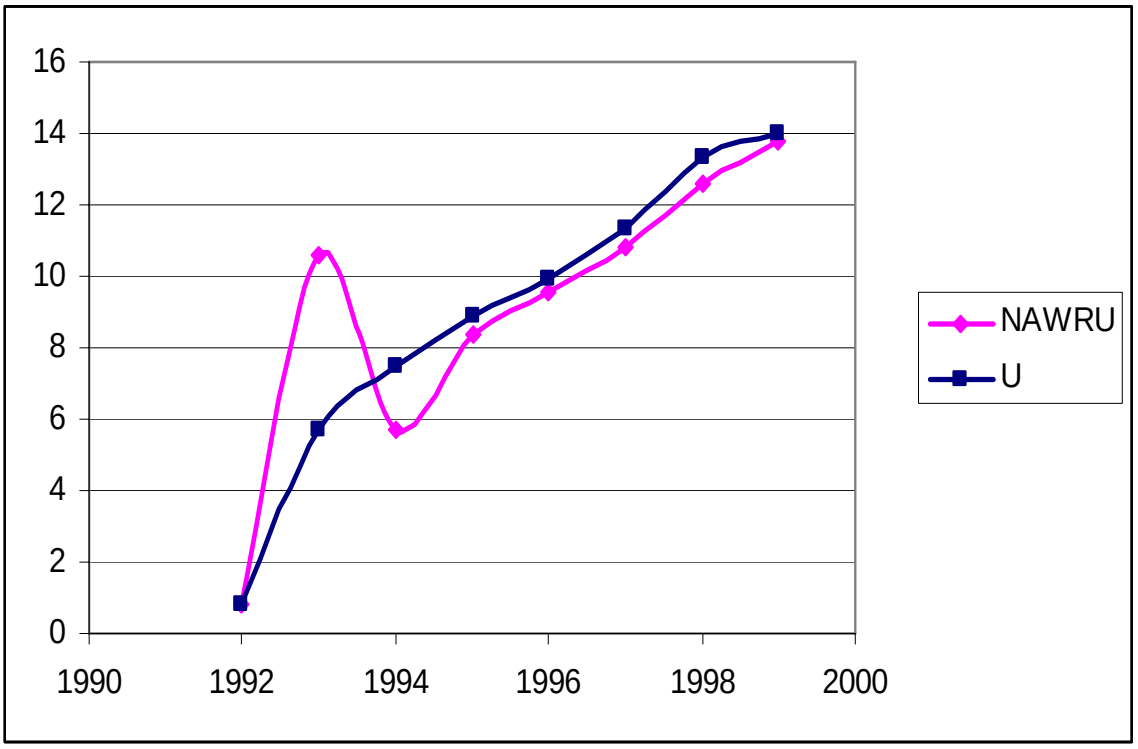


Figure 2 illustrates the NAWRU and the actual unemployment rate (U).

[8] The estimation of the unrestricted non-linearised Cobb-Douglas model did not yield acceptable statistical or theoretical results.

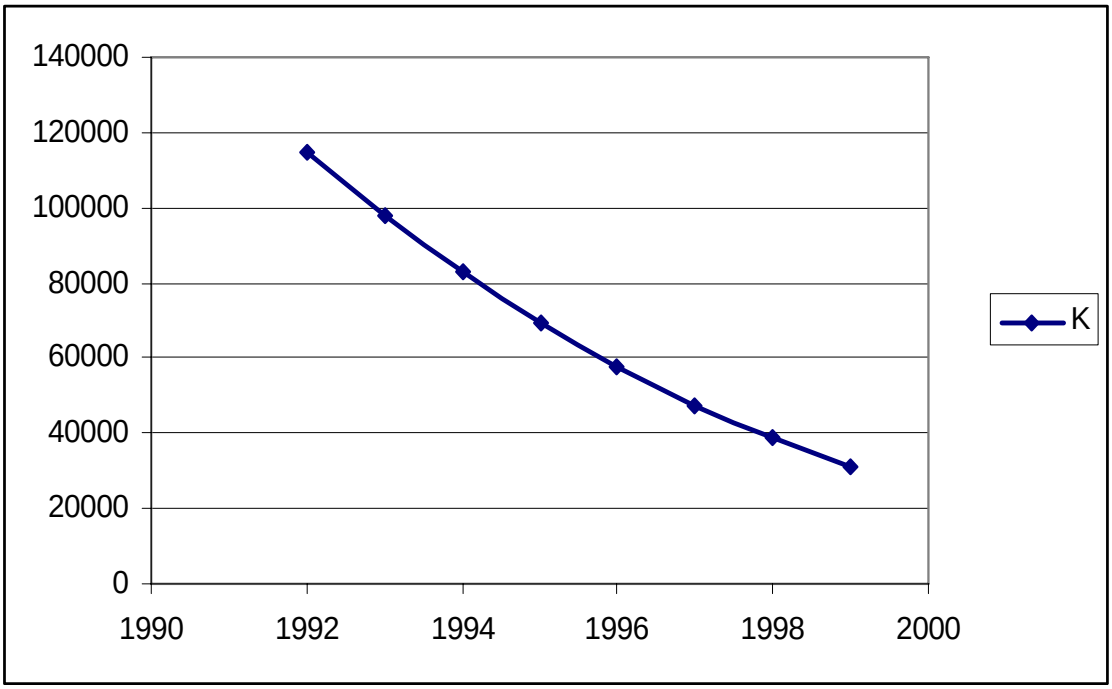
[9] An alternative diagnostic is provided by the Durbin–Watson statistic which indicates the degree of autocorrelation in our dataset. However, given the value of this statistic in our dataset, the hypothesis that the residuals are autocorrelated cannot be accepted.

Figure 2: NAWRU and Actual Rate of Unemployment, 1992-1999 (%)



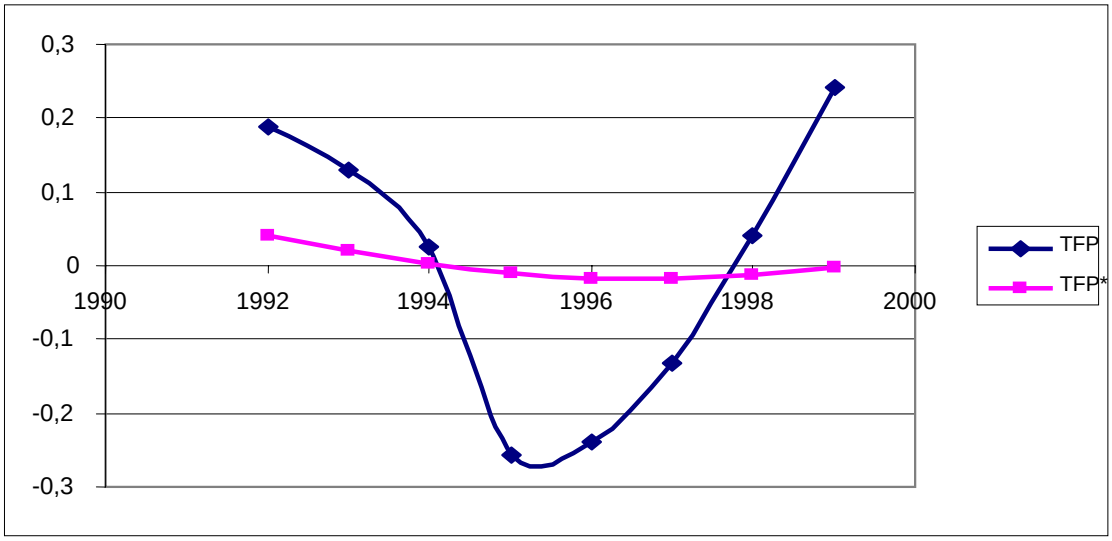
The actual level of capital stock, which is by assumption equal to its potential level, is illustrated in figure 3.

Figure 3: Potential (K*) and Actual (K=K*) Capital, 1992-1999 (bn Rubles)



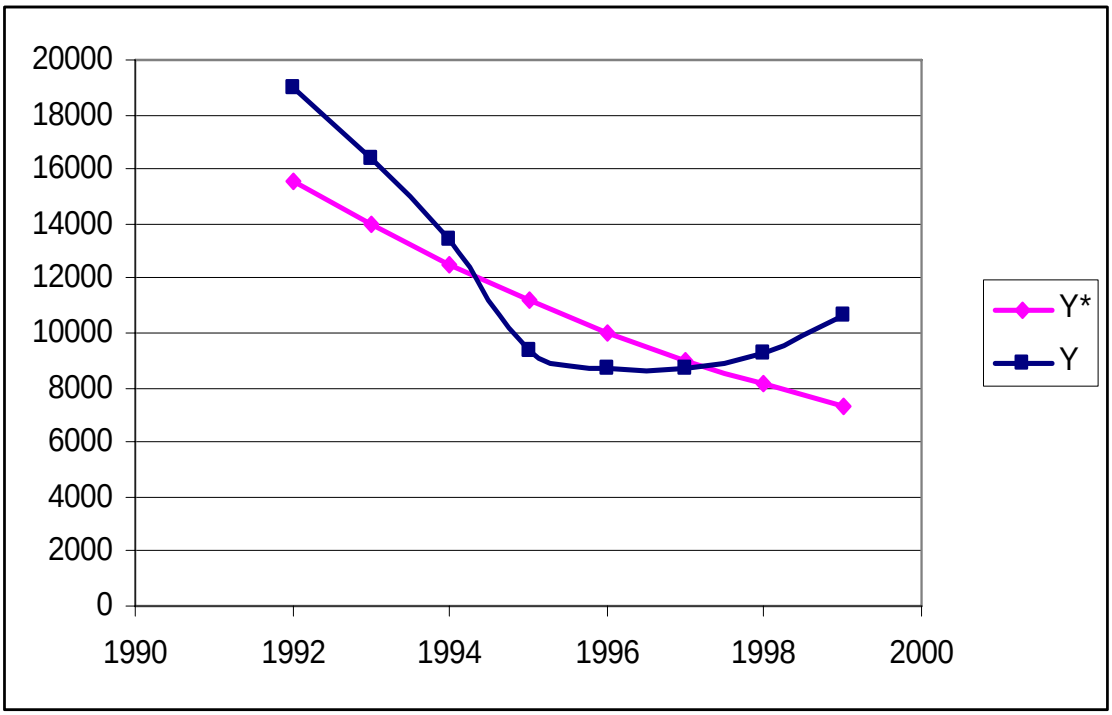
Finally, Figure 4 illustrates the potential (*TFP**) and actual (*TFP*) level of TFP, expressed by the residuals of the CD production function.

Figure 4: Potential (*TFP**) and Actual (*TFP*) Level of TFP, 1992-1999



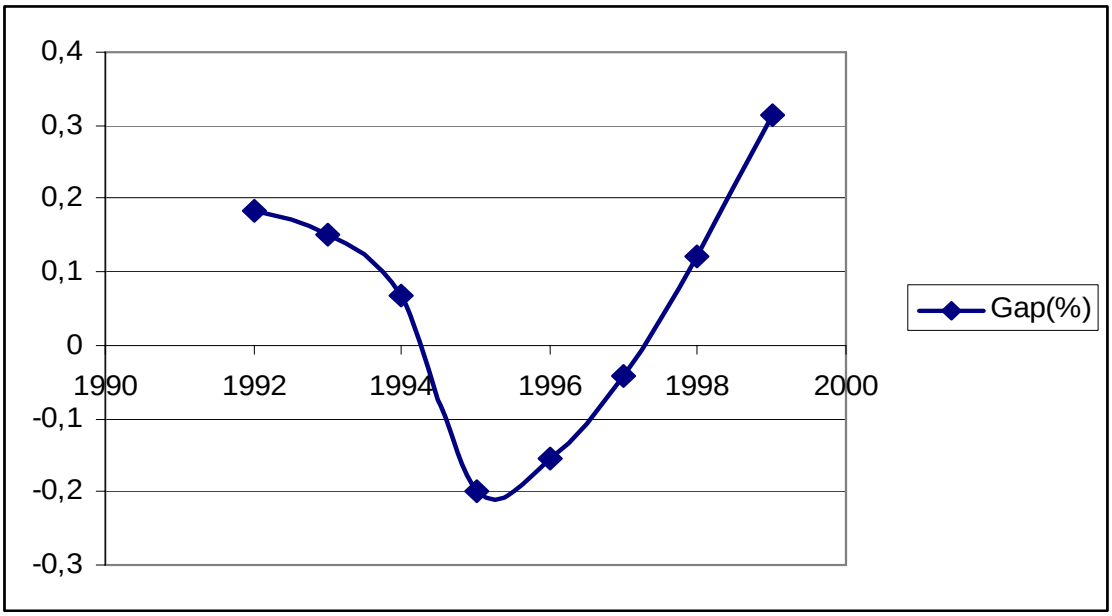
Substituting potential estimates for actual data and the technological variable for the estimated residual variable, Russia's potential (Y*) and actual (Y) G.D.P. are calculated (Figure 5). Potential G.D.P. (Y*) has decreased by about 10% per annum on average. In this case, changes in actual G.D.P. are much closer to the level of potential G.D.P., and movements in the latter are explained by changes in the production factor capacity utilisation. Actual G.D.P. has decreased by about 8% and fell behind potential G.D.P. only in the years 1995, 1996 and 1997.

Figure 5: Potential (Y*) and Actual (Y) Output, 1992-1999 (bn Rubles)



Finally, figure 6 summarises the output gap performance.

Figure 6: Output Gap, 1992-1999 (% of actual output)



We notice that the elasticity of production, as far as labour is concerned, is higher than the elasticity of capital, because the estimated $\alpha = 0.59$ is greater than $\beta = 0.41$. Thus, production is much more "sensitive" with respect to labour than with respect to capital. These findings suggest that the Russian economy tends to be a labour-intensive economy and, at a first level, it seems that this way we are offered, *ceteris paribus*, a possible explanatory parameter of the limited unemployment under the conditions of economic crisis.

In *Table 3* that follows, we can see the estimated average annual rates of change in production and inputs, labour productivity, capital productivity and total productivity (i.e. technological change), as a result of the application of equations (4), (5) and (3) respectively, after the empirical estimation of the production function.[10]

Table 3: Average annual rates of change in production, labour, capital, productivity of labour, productivity of capital and total productivity (T.F.P.) (1992-1999).

[dY/dt]/Y	[dL/dt]/L	[dK/dt]/K	[dY/dt]/Y– [dL/dt]/L	[dY/dt]/Y– [dK/dt]/K	[dA/dt]/A
- 7.9 %	-2.3 %	- 16.9 %	- 5.6 %	9.0 %	0.4%

Source: I.M.F. (2001, 2002a), authors' elaboration

In the time period 1992-1999, the growth rate in production was negative, and declined by -7.9% per year. The capital stock contributed to this fall with a rate equal to -16.9% per year (which was caused by the collapse of investments), while labour declined by -2.3% per year and managed to withhold the significant decline of production, given its higher share in production. Finally, the annual average rate of change in T.F.P. during the time period 1992-1999 was slightly positive and equal to

[10] The change in T.F.P. is expressed through $\frac{\partial A(t)}{\partial t} \bullet \frac{1}{A(t)}$ which is, as seen, attributed mainly to technological change.

0.4%. We can see, therefore, that labour and technology constituted the "sheet-anchor" of the Russian economy during the under investigation time period, since they kept the negative average annual rate of change in the G.D.P. to "only" -7.9%, when a dramatic decline of the capital stock took place in the economy.

The average annual rate of change in the productivity of capital (Y/K), during the specific time-span is high (9%) and is due to the capital's over-employment, which is the result of the rapid capital decline that takes place at a faster rate than that of product, resulting, in turns, in the production of more output by a smaller part of the capital used, as time goes by. The average annual rate of change of labour productivity (Y/L) is negative (-5.6%) and it is practically due to the limited decline of labour (-2.3%) in the under investigation time period, while the product has more than dwindled (-7.9%). This practically means that less product is being produced by a slightly less amount of labour as time goes by, and is consistent with the findings of Kaitila (2003: 15).

The above findings could be better highlighted if we take into consideration the fact that during the period under investigation (1992-1999) emerge both a dramatic crisis and a tendency towards recovery (after 1997) of the Russian economy. *Table 4* that follows isolates the crisis period (1992-1997) from the recovery period (1998-1999).

Table 4: Average annual rates of change in production, labour, capital, productivity of labour, productivity of capital and total factor productivity (T.F.P.) (1992-1999).

Έτος	[dY/dt]/Y	[dL/dt]/L	[dK/dt]/K	[dY/dt]/Y– [dL/dt]/L	[dY/dt]/Y– [dK/dt]/K	[dA/dt]/A
1992-'97	-14.6%	-3.3 %	-16.2 %	-11.2 %	2.4 %	-6.0%
1992-'99	- 7.9 %	-2.3 %	- 16.9 %	- 5.6 %	9.0 %	+0.4%

Πηγή: I.M.F. (2001, 2002a), authors' elaboration

If we take a closer look at the results concerning the sub-period 1992-1997, in relation to the under investigation period 1992-1999, we believe that the following two fundamental and interrelated conclusions are drawn effortlessly. First, except for the growth rate of the capital stock – which remains almost unchanged during the period under investigation – all the other variables experience an almost dramatic deterioration, in terms of growth rates, during the crisis sub-period, since the negative change in production progresses with an almost double average growth rate (-14.6%) compared with the -7.9% of the whole period. The negative average annual rate of change in employment for the sub-period, compared with the slightly changed one for the whole period indicates that the positive change of employment progresses in parallel with the observed significant rise in the unemployment level, during the recovery period (see *Table 1*). Second, the sub-period of the emerging recovery (1998-1999), which is related positively to the changes in employment, in labour productivity and especially in capital productivity and, partly, to the change in the technological level, comes to blunt without however to obliterate (yet), the results of the crisis period of the Russian economy (i.e. negative growth rate in production, in capital stock, in labour productivity and, almost non existing technological progress between 1992-1999).

A symptom resulting from the latest findings is the decrease in the ratio of the (fixed) capital's value to the labour force's value for the period 1992-1999 (as can be easily computed with the aid of the data available) or, in other words the decrease in

the fixed capital's value per labour force's value unit. This indicates the relative decrease of the fixed capital's value with respect to the aggregate capital and corresponds conversely to the "economy in the use of constant capital". This finding demonstrates the reduced efficiency – as to the saving of fixed capital – of the intense-discipline methods of labour, etc. for the period under investigation.

We will insist on the subject of the technological level, which remains practically unchanged, in the period under investigation, and is responsible for about 5% of the change in G.D.P., as is evident from the data in *Table 3*.[11] Thus, we notice that the production decline is limited, in the long run, by the non-negative growth rate of the technological level of the Russian economy.[12] However, the problematic – concerning the level of technology – situation in the crisis sub-period, namely between 1992-1997, was caused by the cut down of the Research and Development (R&D) expenditures. The R&D statistics for the sub-period of crisis in Russia are overwhelming.[13] Additionally, from surveys in various productive branches it became evident that the Russian factories' machinery and equipment were technologically "old".[14] Furthermore, the poor state of the production infrastructure had a negative effect on exports (O.C.D.E. 1997) as well.[15] Thus, the findings of our investigation confirm the so-called "Russian paradox" (Milios 2001), expressing the fact that *a reform which has advanced in the name of economic development and modernization led the country to economic and technological retrogression*, or, in the words of Kagarlitsky (1995: 88): "What is unusual about the capitalist reforms in Russia is that for the first time in history, the 'old' structures are on the technological level […] far higher than the 'new'" (see also Maroudas and Rizopoulos 2002: 126).

Finally, as far as the estimation of the potential output is concerned, this is associated with the supply side of economy and the positive output gap should be expressing excess demand and the negative output gap should be expressing excess supply. Positive output gap is associated with the inflationary pressures in the

[11] Doyle *et al* (2001) estimated that in the last decade total factor productivity contributed 9% of G.D.P. in Slovakia, 44% in Poland, 51% in the Czech Republic, 82% in Slovakia and 122% of G.D.P. in Hungary.

[12] It is interesting to note that in a seminal article, Wladimir Andreff (1978) followed, in general terms, a similar methodological framework, concerning the relation between the level of technology and the economic slowdown of the Eastern European countries in the 1950s and in the beginning of the 1960s. Also, for a brief survey of some classic articles measuring the percentage of growth which rises from an increase in total factor productivity in the former U.S.S.R, see Andreff (1978: 50).

[13] In 1991 the expenditures for R&D amounted to approximately 1.85% of G.D.P. and in 1997 they were cut down to 0.5%. Namely, between 1991-1997 a rapid decline in the expenditures for R&D is observed, equal to 72.97%, which implies a decline of 19.59% annually. Until 1993, the capital funds allocated in the various scientific programs in Russia were cut down approximately four (4) to ten (10) times, in comparison with 1990. Meanwhile, more than five hundred (500) high-leveled scientists had emigrated and over seventeen thousand (17,000) had fled "for long term employment abroad". Furthermore, many of the 4,500 research centers disappeared and 1,100 became private (Milios 2001).

[14] For example, according to O.E.C.D. (1997-8: 37-38) about half of the existing oil pipes were older than twenty (20) years of age and, as a result, approximately 2% of oil production was lost because of leakages and accidents. However the "aging" of machinery and equipment has a historical background in the past regime (see on this, among other works, Pavlovitch 1996, Goskomstat 1997, O.C.D.E. 1997, Fakiolas and Fakiolas 1999).

[15] For example, the inoperative drillings of oil – which constitutes one of the basic export products of Russia (Analytis 1999: 299, Kaitila 2003: 8, 19) – increased from 4,000 to 32,000 in 1993, due to the shortage in appropriate capital and technological infrastructure, whereas the absence of the appropriate chemical substances for the improvement of the oil-bearing process's efficiency enhanced the problem. In general, the inefficient technology resulted in pumping half of the quantities of oil possible (Analytis 1999: 298).

economy and therefore policy makers are very concerned about it. Let us correlate the output gap with the consumer prices index for the case of Russia.

Table 5: Correlation of Output Gap with Inflation

	t	t-1	t-2	t-3
Consumer Price Index	0,14	0,02	0,12	0,76
Wage Inflation	0,14	0,05	0,02	0,55

As we can see from the correlation Table 5 the highest (linear) correlation is with lag 3, meaning that output gap transforms into inflation after about three (3) years. The contemporaneous correlation coefficient over this period of 0.76 indicates strong correlation. We note a roughly similar performance when using the two different measures of inflation, a thing which is due to the – generally – similar pattern that the two inflation measures follow. Consequently, the results indicate that there is a strong relationship between the consumer price index and the output gap. We also note that the Cobb Douglas production function output gap, which uses HP filtered T.F.P. as a measure of technology, is significant in explaining inflation in the presence of lagged inflation.

However, the length of the data series is a serious limitation towards the explanation of the empirical results. The resulting inflationary pressures are also caused by external factors, such as depreciation of the currency, high oil prices, since Russia is, now, an open economy and excess domestic demand partially results into imports growth and probably because the limited competition among importers partially excess demand influence also prices.

6. Further Discussion

The main approaches to the case of the economic crisis in the countries of Eastern Europe and the former Soviet Union make use of arguments, which are based on the view that the crisis had mainly "external" causes as far as the transition process is concerned, while the factor of technology is systematically neglected (see Milios 2001).[16] Nevertheless, the statistical data available (see *Table 1*) and our findings that output gap fuels inflation, or in other words the "domestically generated" character of the inflationary mechanism, which locates its origin inside the Russian social formation, and only partly in external factors, seem to refute these analyses. On the contrary, it seems that the restructuring of external trade and the adoption of the international market prices improved the situation for the Russian trade, and in combination with the rapid decline in internal demand, it accelerated Russian exports (traditionally consisting of raw materials and oil-products[17]) to the countries of O.E.C.D. In the past, Russia exported this kind of products mainly to the COMECON countries, but the prices had been significantly lower than those of the western capitalistic markets.[18] The dissolution of the COMECON and the adoption of the

[16] According to these approaches, output decline is due to the deterioration of the position of the former "socialist" countries in the global market, i.e. to "external" factors. For a political economy approach in modelling the transition process, see Marangos (2003a).

[17] For a comparative analysis of the Russian trade fleet's performance before and after the break-up of the Soviet Union, see Economakis *et al* (2004).

[18] For alternative transition strategies to market relations in Eastern Europe, see Marangos (2003b).

prices of the global capitalistic market improved the Russian trade balance and the balance of payments on current account in real terms, even during the period of the appreciation of the ruble since the 1993 (O.E.C.D. 1995)[19].

In a first attempt to interpret the Russian social formation's economic crisis, it can be mentioned that the collapse of the Soviet regime followed by the cessation of state regulation and price liberalization for the sake of competition, allowed the "free" enterprises to adopt to high prices (a fact that led to very high inflation rates, especially during the first years of the transition process, see *Table 1*), in an effort to increase their profit margins and to cope with demand decline, caused by the drastic cut in "planned" state orders (Gorbachev 1987: 145, O.C.D.E. 1997).

However, this price explosion caused a further dramatic fall in demand. A vicious cycle of rising prices and decreasing demand sunk, thus, the Russian economy into continuous output decreases and economic crisis. Meanwhile, in the monopolistic economic structure that emerged (Maroudas 2001), the few new technologies created led to high prices, driving to further price increases. In this way, many enterprises were prevented from further buying and using new technologies, because of a lack of strong incentives due to their high costs.

In the present paper, we defend the thesis that the particularities of the Russian private business economy, which are expressed – at least until 1998 – through the coalition of the new ruling class with the employees, the preservation of the main volume of labour, the limited development of competition, the non-pursuit of profitability (as the main objective of production/reproduction) and the absence of entrepreneurial incentives for business plans, and consequently for technological innovation, formed a special historical framework for the expression of the crisis, the overcoming of which constitutes a precondition, as well as the result, of the liberation of the counterbalancing tendencies of the crisis (concerning these counterbalancing tendencies see Marx 1991: 362-364, see also Liodakis 2001: 57).

More precisely, as the stagnation of the Soviet economy perpetuated (Clarke 1993, Rutland 1985, Nove 1977), the soviet (political) leadership moved towards the encouragement of the tendency for enterprise autonomy, with a view not of their being autonomous from the "economic plan", but with the hope that competition would prevail among the "free" enterprises (Filtzer 1994). However, the privatization process was nothing more than a transfer of enterprise ownership from the central planning authorities to managers and senior cadres (Radyguine 1997, Milios 2001, O.E.C.D. 1995), who were supported by the delegates of the employees (O.E.C.D 1995, Earle and Estrin 1997, Blasi, Kroumanova and Kruse 1997, Radyguine 1997, Milios 2001, Maroudas and Rizopoulos 2002).[20]

Specifically, the particularities of the Russian private business economy could be expressed as "a particular form of socio-economic organization" that seems to persist after the demise of the Soviet Union (see Maroudas 2001: 52, 60). This particular form of socio-economic organization consists of *four structural elements, in their unity:* First, "the creation of a paternalistic-type coalition between managerial staff and workers" (Maroudas 2001: 52). This coalition between managerial staff and workers was expressed, as seen, from the workers' point of view, through their support to the transfer of the enterprises to the existing managers and their senior

[19] However, the external value of the ruble fell considerably in real terms during the autumn of 1998 (I.M.F. 2002a), while import prices increased correspondingly in ruble terms (O.E.C.D. 2003).

[20] For an excellent attempt to model the privatization process in Transition Economies, see Marangos 2004.

cadres,[21] and from the new owners' point of view by the promise of the maintenance of the current employment levels. This ability to promise is based, in turns, on a second structural element: the limited development of competition. Both these structural elements are reduced to the particular type of privatization of the ex-Soviet enterprises (see Milios 2001). At the same time, the absence of competition development, but also the increasing negotiating power of enterprises *vis a vis* the national, regional and local power centers (see Maroudas 2001: 61-64) is connected directly with an additional, third structural element of the particular form of socio-economic organization in Russia: The reproduction of the given status of economic authority and power, and not the creation of profit is probably the central question of production. It is a fact that, in turns, determines as a fourth main characteristic a low level of entrepreneurial incentive and – consequently of risk – for long-term investment plans (see Maroudas and Rizopoulos 2002: 127) and, therefore, for technological innovation as well.[22]

At this point, it is interesting to note that, to the extent that the paternalistic-type coalition between managerial staff and workers sets restrictions and/or limits to the control of the first over the production process it sets, at the same time, disincentives for the introduction of new technologies, as long as technological change is also a process used by the employers in order to introduce new ways of control over labour (Bowles and Edwards 1993: ch. 11).

In this way, "[t]he monopolistic capitalism that emerged from the state's withdrawal is deprived not only of the 'planned' state markets but also of all traditional incentives,[23] without being able to create new ones" (Milios 2001: 82).

To the crisis factors for the period until 1998, we should add "the weakening of the state to the extent that it could clearly no longer perform its most elementary functions" (Maroudas and Rizopoulos 2002: 126), primarily of a consistent and reliable economic policy[24] (also see O.E.C.D. 1995: 1). The institutional deregulation is an additional factor immanently connected with the technological fall back.[25]

However, after 1997 the Russian economy shows signs of recovery from the dramatic crisis that it has been experiencing: In brief, the inflation rate decreased considerably, while the declining trend of the real G.D.P. was reversed to increasing, and investments, in constant prices, have increased in the specific time span (see *Table 1*). At the same time, as we have already noted, the period of recovery (1998-1999) that comes to blunt without, however, being able to obliterate the results of the crisis period of the Russian economy, is related to changes in employment (and unemployment), in labour productivity and especially in capital productivity, and of course to the change in the level of technology. It is not possible, at present, to formulate safe predictions for the overcoming of the crisis. It is also early for final

[21] In the same line of argument, "wage arrears representing in practice interest-free loans granted from employees to their enterprise" (Maroudas and Rizopoulos 2002: 130).

[22] "The major way for capitalists to compete within sectors is by introducing technological innovations. This move is spurred not only by the need to save on rising costs, but also by the need to improve efficiency, that is, the units of output per capital invested, and thus competitiveness and profitability" (Carchedi 2001: 79).

[23] "Given the monopolistic structure of the economy, the old system was bound to an inherent type of rationality, by redistributing income, creating incentives, setting 'production norms' and 'plan objectives', and pursuing a moderate growth" (Milios 2001: 82).

[24] For the importance of state intervention in ensuring macroeconomic stability in transitional economies see Siriopoulos and Asteriou (2001).

[25] Following Loasby (2002:41): "[I]nstitutions provide both the necessary baseline and the boundaries across which one may move to an adjacent state of knowledge".

conclusions concerning the causes of the observed signs of recovery of the Russian economy. Yet, we will attempt to formulate very briefly some first thoughts defending the thesis that the observed signs of recovery and their prospects should probably be looked up in the following factors and directions.

First, in the means of overcoming the crisis, which is connected to tendencies that the crisis itself liberates during its evolution; that is the intensity of competition, the massive capital destruction, the rise of the unemployment rate (sometimes despite the rise in employment volume) and the decrease in real wages.[26] As far as the latter three are concerned, our findings are clear and already analyzed earlier. Specifically, since the recovery is based on the ground of a continuous destruction of fixed capital – which goes along with the increase in investments after 1999 – a possible trend of "modernization" of the productive basis is implied. As for the former, that is the strengthening of competition, which constitutes a critical factor driving to a dynamic development from a capitalist point of view, we only have some first indications of the strengthening of competition[27] in the economy (see E.B.R.D. 1999, O.E.C.D. 1995: 27 ff, B.C.C.R. 2003 Broadman 2001, Kaitila 2003: 12).

On the basis of the arguments we unfolded before, a first indication is surely the strengthening of the surplus population. However, we are not in a position to know the depth of the restructuring of the paternalistic type of class coalition between owners and workers, to the expense of the latter (finally the depth of the overthrow of class framework, which determined what we called particularities of the Russian private business economy and special historical field of expression of the crisis), which constitutes a precondition for the development of competition, except from the fact that the crisis itself weakens the negotiating power of the working class.

Second, in the state economic policy – as an expression of the class balance of power – which seems to be establishing an institutional environment of macroeconomic stability that permits the emergence of the main financial institutions (see O.E.C.D. 1997-8: 3, 149).

7. Conclusions

To sum up, the present paper used the *growth accounting* methodology to estimate technological change, in an attempt to formulate an explanation of Russia's economic decline and (signs of) recovery in the 1992-1999 time span, in relation to technological change. The results showed that, as a consequence of the economic collapse during the 1990s – rooted in the Soviet economy's very structure – the growth rate of the technological level remained practically unchanged, which, in turns limited the further deterioration of the Russian economy. Furthermore, the optimistic trends of the Russian economy towards recovery were discussed briefly.

[26] Since real wages decrease and the family income also decreases, more family members enter the labour market looking for employment. Obviously, as long as the increase in labour supply exceeds the labour demand the rise in unemployment can go along with the rise of employment.

[27] According to Kaitila (2003: 12), "the continuing existence of old state monopolies […] is constraining growth". Enterprise structures change slowly, whereas market monopolisation has not been treated fully yet. An antimonopoly law in 1991 lacked effective enforcement, and the 1995 law on the regulation of natural monopolies despite being approved by the Duma, was vetoed by the President (O.E.C.D. 1995: 27 ff). Finally, the law "On competition and limitation of monopolistic activity on commodity markets" has been enforced only after some changes were introduced in 1998 (B.C.C.R. 2003). Most antimonopoly laws were adopted between 1991 and 1995 and are slowly being enforced.

The present paper also estimated potential output and output gap using the Cobb Douglas production function approach and the HP-filter technique. The Russian economy seems to be operating close to its potential. More precisely, potential GDP fell dramatically at 10% annually, while actual GDP fell at 8% rate annually. For the largest part of the 1992-1999 time span, actual output remained above the potential output, despite the decreasing pattern of both of them.

Furthermore, the paper examined the relationship between output gap and inflation. A positive gap for a time lag of three (3) years, where demand pressures on resources were present, tended to be associated strongly with increases in inflation. However, the short time series for the lag estimations reduced the capabilities of the statistical analysis. Also, the overall inflation rate is subject to external factors, such as depreciation rate of euro, high oil prices etc., and the output gap alone is not totally sufficient to explain inflation.

Our findings are, in general terms, consistent with the available theoretical and empirical literature. More precisely, the similar pattern that the natural and actual rates of unemployment follow is consistent with the findings in the seminal paper by Layard et al. (1991). Also, a rough comparison of the change in T.F.P. calculated and using the Growth Accounting methodology and the respective findings of the output gap methodological framework are absolutely consistent. Finally, the fact that output gap fuels inflation, or in other words the "domestically generated" character of the inflationary mechanism, which locates its origin inside the Russian social formation, and only partly in external factors, is another example of the general consistency of our results with the relevant literature (e.g. Milios 2001).

Closing, we would like to draw your attention to the fact that all estimates of output gap are subject to a margin error and the production function estimate is contingent on an estimate of the NAWRU to calculate potential employment. In the words of Arthur Okun: "The quantification of potential output – and the accompanying measure of the 'gap' between actual and potential – is at best an uncertain estimate and not a firm, precise measure". (Okun 1962, cited in Billmeier 2004, p. 3). The method we used is popular and appropriate, but it should be treated with caution in the Russian economy where a big share of shadow salary still exists. Obviously, future and more extended research on the subject would be of great interest.

As a conclusion, we may say that although a remarkable recovery has taken place in the Russian economy between 1998 and 1999, the dominance of monopolistic structures continues to exist, as the transition to more competitive structures is continuous but slow. Following Broadman (2001), it can be said that: "Despite privatization, robust competition is still lacking […]. Many established firms enjoy protection from new […] rivals. Reforming anticompetitive business structures and lowering barriers to entry are key to Russia's post-privatization reform"

In this framework, technical change and innovation are considered in Marx's perspective to emerge from the regularities determining the capitalist system as a whole, i.e. from the trends regulating the expanded reproduction of social capital, on the base of competition: Innovation and technical change are the main means of increasing labour productivity and "no less than other socio-economic activities, were best analysed as social processes" since "the focus of Marx's discussion of technology is […] upon a collective, social process" (Rosenberg 1982: 35).[28]

[28] Marx wrote: "A critical history of technology would show how little any of the inventions of eighteenth century are the work of a single individual" (Marx 1990: 493).

Consequently, production relations *per se* impose on *all individual capitals* the urge towards innovation and technical change. Capitalism cannot be technologically static, as much as it is identical with competition. Continuous innovation ensures on the one hand the increase in the rate of exploitation of labour by capital – and thus may raise the rate of profit – (what Marx describes, in Vol. 1 of *Capital* as "production of relative surplus-value"), while on the other it is the means *par excellence* for improving the individual enterprise's position vis-à-vis its competitors (Marx 1990: 959, 1037).

Conclusively, competitive market structures and enterprise restructuring are essential prerequisites for technological progress and economic growth. Following Milios *et al* (2002: 115): "The development of capitalism can be associated only with the evolution, not with the abolition, of free competition". Thus technological progress and sustainable economic growth in Russia still seem to "entail a long lasting process of […] social rearrangements" (Milios 2001: 82-3). After all, crises are temporary destabilizations of the capitalist process of expanding reproduction and they also function as mechanisms that "re-establish the disturbed balance for the time being", as Marx (1991: 357) himself wrote.

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Appendix

The Fixed Capital Formation in the Russian Economy was estimated using the *Perpetual Inventory method* and the Production Prices Index (I.M.F. 2002a, 2004). The equations used are the following:

$K(i) = [S(i) + S(i-1)]/2$

$S(i) = \sum_{t=1}^{i} I(t)$

$I(t) = E(t) - d(t)$

$E(t) = E'(t)/p(t)$

$d(t) = E(t)[\gamma \bullet (\gamma+1)^{t-1}]/[(1+\gamma)^{1+T} - 1]$

where:

K(i): fixed capital in the middle of year i (constant prices)
S(i): fixed capital at the end of year i (constant prices)
I(t): net fixed capital investments (constant prices)
E(t): gross fixed capital investments (constant prices)
E'(t): gross fixed capital investments (current prices)
p(t): production prices (index)
d(t): consumption of fixed capital depending on the depreciation policy
$\gamma = 0.20$ parameter depending on the time-structure of investments (Tsolas 1995)
$T = 15$ the average lifetime of machinery and equipment (Goskomstat 1997).