5 EXTENDING THE AUGMENTED SOLOW GROWTH MODEL TO EXPLAIN TRANSITIONAL ECONOMIES

John M. POLIMENI[*]
Raluca IORGULESCU POLIMENI[**]
W. Scott TREES[***]

Abstract

The development of countries in economic transition is often misunderstood. These countries are neither underdeveloped nor are they developed, they are somewhere in between. Therefore, macroeconomic models of transitional economies must include aspects of both underdeveloped and developed countries. Two such variables that should be included are institutions and learning-by-doing. Institutions that are established in the society are important because they can either hinder or accelerate economic growth. Just as important for transitional economies is learning-by-doing, as it takes time to learn how a new economic system works. This paper presents a macroeconomic model for transitional economies that extends the Augmented Solow Growth Model to incorporate learning-by-doing and institutions.

Keywords: Solow Growth Model, Transitional Economies, Economic Development
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1. Introduction

Joseph Schumpeter (1942) stated that inherent in a capitalist economy is a tendency toward self-destruction. Those countries of the former Soviet Union and Central and Eastern Europe must have thought Schumpeter's statement to be accurate because the transition that began in 1989, from a centrally planned to a market economy, certainly has been harder and longer than most would have expected. The years immediately following the fall of communism have brought high unemployment,

[*] *Assistant Professor of Economics, Department of Humanities and Social Sciences , Albany College of Pharmacy, 106 New Scotland Avenue, Albany, NY 12208, United States of America, polimenj@acp.edu*
[**] *Assistant Professor of Economics, Department of Economics, Siena College, 515 Loudon Road, Loudonville, NY 12211, United States of America, rpolimeni@siena.edu*
[***] *Chair and Professor of Economics, Department of Economics, Siena College, 515 Road, Loudonville, NY 12211, United States of America, trees@siena.edu*

hyperinflation, declining GDP, social dislocation, broken families, and falling life expectancies (Bromley, 2000).

Now, more than a decade after the collapse of communism, these countries have yet to reach a sustainable growth path. There is still no well-developed economic theory or policy to transform their societies from planned to market economies (Kumssa and Jones, 1999). As Bromley states, until the institutional factors of economies in transition are understood, coherent assistance to those countries in economic limbo cannot be offered. However, a true understanding of transitional economies must go deeper than just including institutional factors into the analysis.

Any study of transitional economies must examine the learning process. In these societies, multiple generations have lived under central planning where the system rigidly controlled the lives of people, citizens were guaranteed a job for life, and mistrust abounded. Adjustment to the market economy and its sink-or-swim philosophy is difficult at best. Arrow (1962) found that knowledge accumulation, known as learning-by-doing, occurs as a side effect of conventional economic activity. Arrow was specifically looking at the production process, however the same application holds for transitional economies. In other words, learning how a new economic system operates takes time.

The research presented here will expand on previous research about the effects of either institutions or the learning process on economic development. Any study addressing the interrelated questions about the economic transition from a centrally planned economy to a market economy should ask three questions: (1) how and why do institutions enhance or hinder economic development? (2) how does learning-by-doing affect economic growth?, and (3) which of these countries is likely to reach a sustainable growth path first? However, to answer these questions, a new version of the augmented Solow growth model that incorporates both institutional and learning-by-doing factors must be developed. Creating a model that can explain transitional economies has implications beyond just former communist and centrally planned economies. Transitional economies are slightly better off than underdeveloped economies. Therefore, incorporating institutional factors and learning-by-doing could help in designing economic growth policies for lesser developed countries. A comprehensive model incorporating both these factors will be detailed in the Model Specification section.

The remainder of the paper is organized as follows: Section 2 provides the theoretical framework for the model that is developed in Section 3 and Section 4 concludes with the significance of the research presented.

2. Theoretical Framework

Transitional economies can be defined as those economies that are transforming from one economic system to another; in the case presented here, from central planning to a market system. The transition has proven to be much more difficult than first thought. Part of the difficulty in the transition process has been the incomplete understanding of the role of institutions and their effect on economic growth.

Previous research on economic growth and institutions have typically fallen under five broad categories: (1) institutional quality measures, (2) social capital measures, (3)

social characteristics, (4) political characteristics, and (5) political instability (Aron, 2000). In the institutional quality measures category, most of the research (Knack and Keefer, 1995, 1997; Clague, *et al*., 1996; Barro, 1996; Hassan and Sarna, 1996; Knack, 1996; and Lane and Tornell, 1996) involves the security of property and contract rights. Mauro (1995) and Helliwell (1996) examined the relationship of the judicial system and political and social stability with economic growth. Ng and Yeats (1999) studied market efficiency and economic growth. They examined factors like trade policy, taxation, government intervention, and regulation. Democratic political measures have been examined numerous times (Kormendi and Meguire, 1985; Scully, 1988; Sachs and Warner, 1995; Barro and Lee, 1994; Savvides, 1995; Alesina, *et al*, 1996; Perotti, 1996; Ghura and Hadjimichael, 1996; and Isham, Kaufmann, and Pritchett, 1997). All these studies focused on fair and meaningful elections of political leaders from multiple political parties.

The second broad category studied has been social capital measures. Spindler (1991) examined the impact of economic freedom on economic growth. Easterly and Levine (1997) studied the impact of eliminating political opposition through either incarceration or execution. Further, the authors studied peaceful antigovernment public demonstrations of at least one hundred people voicing opposition to domestic government policies or authority. Knack and Keefer (1997) examined the impact of cultural values, such as determination, thriftiness, and religious faith, on economic growth. Helliwell and Putnam (1995) studied community and economic growth. They examined factors like voting and voter turnout, sports and cultural associations, number of day care centers and family clinics, as well as industrial, housing, and urban development instruments.

Social characteristics and their impact on economic growth have also been studied extensively. Collier (1999) studied fractionalization of ethnic groups. Specifically, he examined the probability that any two randomly selected people from a country will not belong to the same speaking ethnic group. Temple and Johnson (1998) researched the relationship between social development and economic growth studying the extent of dualism and urbanization, as well as other social factors of the indigenous middle class.

Political characteristics and political instability are the final two categories of institutional measures that have received considerable attention. De Vanssay and Spindler (1992) used nineteen constitutional variables, such as the rights to privacy and to unionize, and whether a supreme court exists with final constitutional authority, to study their effects on economic growth. Many studies (Murphy, Schleifer, and Vishny, 1991; Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Ojo and Oshikoya, 1994; Sachs and Warner, 1995; Caselli, Esquivel, and Lefort, 1996; Levine and Zervos, 1996; Alesina and Perotti, 1994; Hassan and Sarna, 1996) have examined how political instability affects economic growth. These studies used factors such as the number of revolutions, coup attempts, political assassinations, riots and demonstrations, and violent deaths per million people as proxies for political instability.

The institutional measures used in the studies cited above represent some of the institutions that should be studied to understand transitional economies. Institutions

are plentiful and highly inter-related and they provide the framework for any society. However, it should be recognized that transitional economies are unique and, therefore, require an in-depth, country-specific study which incorporates the various institutions for each culture.

One such institution is the legal system. Laws are vital for any economy, establishing property rights, enforcing contracts and compensation, determining the obligations that both firms and individuals have under the tax system, establishing environmental regulations, health codes, minimum working ages and wages. Laws can and do determine both the behavior and character of other institutions.

In market economies, the legal institution has many functions. Probably the most important role is to establish property rights. However, under socialist systems, nearly all property rights are controlled by the state which eliminates individualized decisions on what and how much to produce, and to whom these goods are distributed. The few private property rights that exist are established by practice and custom. One of the struggles that transitional economies have had to overcome is the changeover to private property rights, as this had to be done gradually to ensure stability.

Government is an important economic institution because it plays a vital role in the establishment of individual rights and the regulation of industry. The government's main role is to create appropriate policy (fiscal, monetary, or structural) to pursue economic, political, or cultural objectives. For transitional economies the challenge in developing these policies has been the pace of change; if the changes are too fast or too slow problems arise.

Industry is also an important economic institution. Under central planning, industry is owned by the state. One of the chief objectives of socialist economies is the industrialization of the economy, creating, in essence, a one-sector economy. Transitional countries face the challenges of overcoming their one-sector economies and developing a fully functional multi-sector economy.

The institutions described above are just a few examples that should be examined. However, institutions are not the only variables that need to be considered. Learning a new economic system is a dynamic process in which institutions play an important role for the economies in transition. Adaptation from a centrally planned economy to a market economy often depends on the average age of the population because the older the people are the more difficult it is for them to adapt. Moreover, while transition to new concepts and technologies is difficult, the passage is complicated further by new cultural influences threatening the transitional countries' heritage. Therefore, understanding the different types of institutions is only one part of the equation for developing a model to better comprehend the process that transitional economies take.

It takes time, learning time, for a society to adjust to a new economic system. Entrepreneurial knowledge is not something that just happens, but must be accumulated over time. In centrally planned economies, given the nearly total control by the state over many generations, improving economic conditions is especially related to society's learning processes. Transition introduced a new economic environment that requires knowledge that did not exist before (Petrakos and Tsiapa,

2001). Expanding Arrow's (1962) findings beyond the production process, this knowledge can only be accumulated by studying and operating the market system. The ability of a region to learn is conditioned by the interaction of a large number of economic, social, and technical factors (Sternberg, 1996).

Using the type of variables described above, an augmented Solow (1956) growth model will be developed in the next section to analyze growth in transitional economies.

3. Model Specification

The basic Solow growth model uses output, capital, labor, and knowledge as the four variables to determine a country's growth path. The model takes the savings rate, population growth, and technological progress as exogenous variables. Capital and labor are the two inputs to production and are paid their marginal products. From these specifications, using a Cobb-Douglas production function, production at time t is

$$Y(t) = K(t)^{\alpha}\ (A(t)L(t))^{\beta} \quad 0 < \alpha < 1, \beta = 1 - \alpha \tag{1}$$

where Y is output, K is capital, L is labor, and A is the effectiveness of labor. Under the Solow growth model, capital and technology grow exogenously at rates *n* and *g* respectively, where *n* is the population growth rate and *g* is the growth rate of labor productivity. Therefore,

$$L(t) = L(0)e^{nt}, \tag{2}$$

$$A(t) = A(0)e^{gt}. \tag{3}$$

A(t)L(t) is defined as the effective units of labor, which grows at rate *n+g*.

The model also assumes that a constant fraction of output, *s*, is saved and defines the stock of capital per effective unit of labor as

$$k = \frac{K}{AL}, \tag{4}$$

and the level of output per effective unit of labor as

$$y = \frac{Y}{AL}, \tag{5}$$

With these definitions, *k* becomes

$$\begin{aligned} k(t) &= sy(t) - (n + g + \delta)k(t) \\ &= sk(t)^{\alpha} - (n + g + \delta)k(t), \end{aligned} \tag{6}$$

where δ is the rate of depreciation.

The implication of equation (6) is that capital per effective unit of labor (*k*) converges to a steady-state value k^*, where k^* is defined by

$$sk^{*\alpha} = (n + g + \delta)k^* \tag{7}$$

Rearrange equation (7) to obtain

$$k^* = \left(\frac{s}{n + g + \delta}\right)^{\frac{1}{(1-\alpha)}} \tag{8}$$

Equation (8) implies that steady-state capital increases with higher levels of saving and decreases with higher rates of population growth.

The Solow model implies that saving and population growth affect output per worker by their impact on capital per worker. The implication is that a country that saves more of its output has more capital per worker and more output per worker. Further, a country with higher population growth has less capital and output per worker because savings must be depleted to maintain its capital-labor ratio.

Equation (8) can be substituted into the production function (1) and the natural logarithms can be taken to find that the steady-state income per worker is

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A(0) + gt + \left(\frac{\alpha}{1-\alpha}\right)\ln s - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) \quad (9)$$

where $\frac{\alpha}{1-\alpha}$ is the elasticity of output with respect to s, and $-\left(\frac{\alpha}{1-\alpha}\right)$ is the elasticity with respect to $(n+g+\delta)$.

The Solow growth model provides a good starting point for explaining economic growth. However, the model cannot explain differences in income per worker on a cross-country level. The only determinant of income other than capital is the exogenous variable A. Therefore, a deeper examination of the growth process is necessary.

The Solow growth model ignores human capital. Mankiw, Romer, and Weil (1992) explored the effects of including human capital, such as educational attainment, into the model. The production function now becomes

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta}, \quad (10)$$

where H is the stock of human capital. Mankiw, Romer, and Weil define s_k as the fraction of income invested in physical capital and s_h as the fraction invested in human capital.

Similar to the derivation of equation (6), capital per effective unit of labor is defined as

$$k(t) = s_k y(t) - (n+g+\delta)k(t), \quad (11)$$

and human capital per effective unit of labor is defined as

$$h(t) = s_h y(t) - (n+g+\delta)h(t) \quad (12)$$

where h = $\frac{H}{AL}$. Mankiw, Romer, and Weil assume $\alpha + \beta < 1$, decreasing returns to capital. Using equations (11) and (12), the economy converges to a steady-state defined by

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta}\right)^{\frac{1}{(1-\alpha-\beta)}} \quad (13)$$

$$h^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta} \right)^{\frac{1}{(1-\alpha-\beta)}} \tag{14}$$

Following the analysis for equation (9), Mankiw, Romer, and Weil substitute (13) and (14) into the production function and take the natural logarithm, deriving an equation for income per worker

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A(0) + gt - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \\ + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) \tag{15}$$

where, $-\left(\frac{\alpha+\beta}{1-\alpha-\beta}\right)$ is the elasticity of output with respect to $(n+g+\delta)$, $\frac{\alpha}{1-\alpha-\beta}$ is the elasticity with respect to s_k, and $\frac{\beta}{1-\alpha-\beta}$ is the elasticity with respect to s_h. Equation (15) states that income per worker is dependent on population growth, accumulation of physical capital, and accumulation of human capital.

However, the model still does not provide a deep understanding of economic growth. North (1990) argued that institutions in a country determine its long-run economic performance. Grigorian and Martinez (2000) and Breton (2002) further augment the Solow growth model by introducing variables for institutions. The production function now becomes

(16) $$Y(t) = K(t)^{\alpha} H(t)^{\beta} (J(t)A(t)L(t))^{1-\alpha-\beta}$$

where J is a matrix of institutional measures that reflect the extent to which institutions, such as those in Section 2, affect economic growth. From this, capital per effective unit of labor is defined as

(17) $$k(t) = s_k y(t) - (n+g+\delta)k(t) = s_k J^{1-\alpha-\beta} k^{\alpha}(t) - (n+g+\delta)k(t)$$

and human capital per effective unit of labor is defined as

(18) $$h(t) = s_h y(t) - (n+g+\delta)h(t) = s_h J^{1-\alpha-\beta} h^{\beta}(t) - (n+g+\delta)h(t)$$

The economy converges to steady-state when

(19) $$k^* = J(t)\left(\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta} \right)^{\frac{1}{(1-\alpha-\beta)}}$$

(20) $$h^* = J(t)\left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta} \right)^{\frac{1}{(1-\alpha-\beta)}}$$

Substitute (19) and (20) into the production function (16) and take the natural logarithm to derive the following equation for income per worker

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A(0) + gt + \ln J(0) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) + \\ + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) \tag{21}$$

Let us momentarily diverge from the process laid out previously to examine learning-by-doing. Romer (1996) created a simple model of learning-by-doing occurring as a result of the production of new capital. He finds that knowledge is a function of the stock of capital, leaving only one endogenous variable. Using the original production function (1), Romer defines the effectiveness of labor as

$$A(t) = BK(t)^{\phi}, \quad \text{B} > 0,\ \phi > 0 \tag{22}$$

Substitute (22) into (1) to yield

$$Y(t) = K(t)^{\alpha} B^{\beta} K(t)^{\phi\beta} L(t)^{\beta} \tag{23}$$

Using equation (4), the dynamics of K are

$$k(t) = sB^{\beta} K(t)^{\alpha} K(t)^{\phi\beta} L(t)^{\beta} \tag{24}$$

In this equation, capital is the only productive input.

Romer concludes that if ϕ is less than one then the long-run growth rate is a function of the population growth rate, n. If ϕ is greater than one, then the economy has explosive growth. If ϕ is equal to one, then there is steady-state growth if n equals zero, and explosive growth if n is positive.

Now that the two augmented Solow growth models have been presented, one of the purposes of this project is to create a new model that links these two models into one unified model to better explain economic growth. First, substitute equation (22) into (16) to get

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (BK(t)^{\phi} J(t) L(t))^{1-\alpha-\beta} \tag{25}$$

From (25), capital per effective unit of labor is defined as

$$k(t) = s_k J^{1-\alpha-\beta} y(t) - (n + \delta + \frac{\phi}{K(t)})k(t) \tag{26}$$

and human capital per effective unit of labor is defined as

$$h(t) = s_h J^{1-\alpha-\beta} y(t) - (n + \delta + \frac{\phi}{K(t)})k(t) \tag{27}$$

Using equations (26) and (27), income per worker is

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln B(0) + \ln J(0) + gt - \frac{\alpha}{1-\alpha-\beta}\ln(n+\delta+\frac{\phi}{K}) + \\ + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) \tag{28}$$

Equation (28) is a newly created augmented Solow growth model that can be used to examine the relationship between economic growth and institutions and learning-by-doing. Incorporating institutional and learning-by-doing measures into the augmented Solow growth model is vital for developing a country specific growth model, instead of the general growth models that are used for any situation, which are vitally important for transitional economies where each country has a unique circumstance.

4. Significance of the Study

In order to understand the institutional change and learning-by-doing process is necessary to create an economic model that will properly describe the growth process. Currently, research has been done on the effects of both institutions and learning-by-doing on the growth process. These studies have had good success in describing the growth process. However, none of these studies examine how both learning-by-doing and institutions together influence economic growth. One would expect that a model including both institutions and learning-by-doing would perform even better than the traditional Solow growth model or the augmented models.

This study focuses on creating a new economic growth model that uses both institutional and learning-by-doing factors for transitional economies. Developing such a model has implications beyond transitional economies. Because the process of transition has proven to be longer and harder than anyone would have thought, a growth model that performs better than traditional growth models may be valid for developing countries as well. Future work that introduces data into the model will help validate this claim. Therefore, a model that understands and uses institutional and learning-by-doing measures with traditional economic data is necessary to completely comprehend the growth process of countries.

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