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Soviet led Economic Alliance – Quantitative Model and Analysis (1960-1985)

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Abstract: This study addresses economic performance of the Soviet Union and its allies.
Important points of this study are:

- The study identified major deficiencies of the Soviet-led bloc (by its member countries) in terms of the factors facilitating economic performance.
- The economies of the East-European bloc were evaluated in the context and in comparison to the performance of "High Income" developed countries. First, a general model of factors facilitating economic performance (based on cross-national data from over 120 countries) was constructed, and then the results of the general model were applied to evaluate specific East-European countries.
- The cross-national model and the evaluations of a specific East-European economies were based on data for the years 1960, 1970, 1978, 1985 and 1992. Much of the data for the Soviet-led bloc, came from the hard-copy publications of the World Bank, published before the collapse of the bloc, so there are no data updates/ modifications in retrospect. The study covered the performance of the bloc during the last decades towards its collapse – sufficient time-span to reach solid conclusions.
- Generality of the method. The same method could be applied to evaluate any other group of countries or any individual country, characterized by different political ideologies, institutions, culture, etc. The effectiveness and the reliability of the method were demonstrated and explained.

Keywords: Cross-national model, Soft Regression, fuzzy logic, Soviet-led Bloc.

JEL classification: O10, N10, C31.

INTRODUCTION

During the 1950s – early 1960s, the Soviet Union achieved very impressive advances in space technology (first satellite and first astronaut) and military technologies (nuclear weapons, ballistic missiles and other military hardware). During the same time period, the Soviet Union and its East European allies achieved very rapid rate of economic growth. Nevertheless, the standard of living in the East European economies continued to be much lower when compared to the Western economies. In comparison to their Western rivals, consumption opportunities were severely limited and there were frequent shortages of various consumption products, including basic products.

The governments of the Eastern Bloc countries argued that the lower standard of living was a result of a much lower

starting point. Hence, given a faster rate of economic growth, rapid technological progress, and supposedly superior institutions - the gap in standard of living versus Western bloc will gradually diminish until eventually and predictably the Eastern Bloc economies will overtake the West. However, despite these promises, the standard of living gap persisted, while the pace of economic growth (of the communist East European countries) diminished, resulting in a severe stress on the political system due to unfulfilled expectations.

Extensive literature addressing the performance of the Soviet-led economic bloc focuses mainly on comparison of institutions, modeling possible disequilibria and imbalances, estimating aggregate production functions etc. (see literature below). In this article we construct a model based on broad and objective factors, present in all economies, regardless of their political and institutional characteristics. We focus on the modeling of the general factors facilitating economic performance (obviously these factors are influenced by local institutions, political issues, cultural factors, geography etc.). The factors facilitating economic performance essentially represent the constraints that either facilitate or limit long-term economic growth. They represent necessary (but not sufficient) conditions to achieve relatively successful economic performance. The analysis of the facilitating factors is conducted in the context of the best performers among the world's economies, and hence we postulate that the challengers (attempting to catch up with the leaders) must acquire capabilities that are similar to the capabilities of the leaders, if they (the challengers) want to achieve similar performance. Obviously, these facilitating factors or constraints, if not addressed properly, can preclude the possibility for any given country to attain the success level of better performers in the long run.

The study is based mostly on cross-national data originated from the World Bank databases and hard copy publications and covers the period from 1960 to 1992. More specifically, we constructed a cross-national model for the years 1960, 1970, 1978, 1985 and 1992. We presented results for the year 1992 – to illustrate the situation following the collapse of the Eastern Bloc, because some conclusions can be reached in retrospect. Thus, we followed the performance and illustrated the constraints of the Soviet led alliance till its end.

In order to assure reliability and robustness of the results, the idea was to build a general model based on the data from over 120 countries and then to apply the results specifically to the countries of the East European Bloc. The generality of the model (rather than building a specific model for the East European countries) is one of the points of strength in this study, because of its world-wide scope.

The modeling method "Soft Regression" (SR) is an Artificial Intelligence tool (more specifically it is a Soft Computing tool, based on fuzzy information processing). Utilizing newest methods based on the most advanced technological features, presents new and unique angle to analyze and evaluate the performance and the reasons for failure of the Soviet-led Bloc. Utilizing SR rather than traditional econometric tools makes it possible to overcome some difficulties associated with the traditional modeling tools and allows to build more reliable and robust model, as explained below.

Additional unique feature of this study is its data inclusiveness. We included all the data series that we could find for the variables used in the model. For example, we used the variable "Economic activity per capita" as our dependent variable. For this variable we found data series such as GNP per capita, GDP per capita, GNI per capita, some based on regular currency conversion method, some based on PPP method, some in current US dollars (USD) and some in constant USD. In addition, there were changes in measurement methodology over the years. For some years we had over 15 data series, representing (from our perspective) essentially the same variable. Under similar circumstances, modeling professionals usually try several of the data series, and then often select the ones that generate the best results for their purposes. However, such method can justifiably be criticized: why the selected data series were chosen and not the others. We avoided this problem by utilizing all the data series available to us by applying ranges of values in our modeling process according to the method presented in [17]. Using all the available data instead of just some conveniently selected data series adds additional level of confidence in the results.

The importance of the study presented in this article is beyond the narrow scope of studying economic alliance that disintegrated about three decades ago. The methodology introduced in this study can be applied to any country or group of countries to evaluate where they stand in comparison to the leading performers at any given point of time. For

example, we can address the performance of the present challengers to the West such as China, Russia, Iran, BRICS, etc. Addressing the factors facilitating long term economic performance will clearly point out to what degree these challengers have the potential to continue the impressive performance of the past, or they will experience induced slowdown of their growth rate (as happened to the Soviet Union and its allies). Furthermore, it is possible to evaluate, to what extent it is reasonable to expect that the evaluated countries will be capable to overcome the constraints within the reasonable time horizon. However, it is not a static catching game where the challengers are required to attain certain fixed target. While the challengers are attempting to catch up with the better performers, these leading economies are continuously moving forward, thus redefining the targets that the followers must attain in order to catch up. Hence the importance to evaluate the performance of any given economy in the context of the best performers at that specific point of time. Similarly, we can address the opposite question and to evaluate where any of the leading performers stands versus other countries and to what extend these leaders can maintain their leadership?

Thus, the method presented in this study can generate important information necessary for designing effective long-term policies to "contain" the challengers and it can generate important information for the lagging countries to identify their basic weaknesses. Hence, the method can be a useful tool for economic policy makers as well as for foreign policy strategists.

RELEVANT LITERATURE

Vast majority of the economic literature addressing issues of the Eastern Economic Bloc describes and evaluates various institutions and compares (where relevant) to the parallel institutions of the West, and much of these studies are not quantitative. We address some elements of the extensive literature dealing with the economic performance of the Soviet led East European economies that are relevant to our study (which involves quantitative modeling).

One important aspect of the scholarly research of the Soviet Union and the Eastern Bloc countries addresses the reliability and comparability of data. Harrison [7] discussed the reliability of measurements of the Soviet economic growth. The article postulates that the CIA (The U.S. Central Intelligence Agency) measurements of the Soviet economic growth showed Soviet performance in a much less favorable light than the official Soviet figures. He claimed that the Soviet economy expanded more rapidly than the United States economy until the early 1970s, but by a small margin, and kept pace with Western Europe. In the years 1964 and 1973, the Soviet economy stood at roughly half the value of output per capita of Western Europe and a little more than one third of the United States. However, by 1973, half way through the Brezhnev period, the process of catching up with the West ended.

Charemza and Quandt [3], as well as Podkaminer [12] addressed the issue of macroeconomic disequilibrium of the centrally planned economies. They used econometric modeling tools and evaluated the issues arising due to structural differences between market economies and the centrally planned economies. Both articles were published before the collapse of the East-European Bloc, and they attempted to address what at that time was considered as the main weakness of the Centrally Planned Economies: their inherent imbalances and inadequate adjustment mechanism.

Brada [1] estimated frontier production functions for the industrial sector of four East European countries including Czechoslovakia, the German Democratic Republic, Hungary, and Poland. The estimates revealed that the slowdown in industrial growth in these countries was due to a decline in the efficiency or intensity of factor utilization rather than due to declining rates of growth of technological progress. The author addressed the efficiency of resource utilization in response to changes in macroeconomic policies versus economic reforms.

Easterly and Fischer [5] defined Soviet growth from 1960 to 1989 as weak if we control for the investment in physical and human capital. They concluded that declining Soviet growth rate from 1950 to 1987 can be accounted for by a declining marginal product of capital with a constant rate of growth of total factor productivity. They postulated that the Soviet economy was characterized by a low elasticity of substitution between capital and labor, which implied severe diminishing returns to capital in comparison to market economies.

Gwartney, Lawson and Holcombe [8] focused on growth theory based on increase of inputs and technological progress and they attempted to expand the theory by adding factor "economic freedom". They refer to Solow's study [19], and to more recent works (Lucas [11] and Romer [13]) where the growth model included broader interpretation of labor to include human capital and hence investment in education, training, etc. The authors constructed index that measures economic freedom and added it to the model. They concluded that economic freedom is a significant determinant for the economic growth.

Duffy and Papageorgiou [4] argued that many growth models assume that aggregate output is generated by a Cobb-Douglas production function. The authors questioned the empirical relevance of this specification. They used a sample of 82 countries over a 28-year period to estimate a general constant-elasticity-of-substitution (CES) production function specification. They found that for the entire sample of countries, the Cobb-Douglas specification was rejected.

Levine and Renelt [10] stated that there is a vast literature involving cross-national regression studies that attempts to find empirical linkages between the long-term growth rates and the variety of economic policies, political and institutional indicators. The authors tested the robustness of existing studies by conducting sensitivity tests. They concluded that almost all studies failed sensitivity tests. The only robust relations they identified were:

a. Correlation between growth and the share of investment in GDP

b. Correlation between the investment share and the ratio of international trade to GDP.

Note: Several studies above address general methodologies pertaining to the modeling of economic growth, and not necessarily are specifically limited to the performance of the East European Bloc.

The model of factors facilitating economic performance (which is utilized in this article), was introduced in Shnaider and Haruvy [14]. The study utilized a cross national data for 1997 and utilized both Soft Regression as well as conventional Multi-Variate Regression as modeling tools. The model is explained in detail below.

The method of Soft Regression (SR), is presented in Kandel et. al. [9]. Comparison of SR to Multivariate Regression (MVR) appears in Yosef et. al. [21]. The study illustrates numerous advantages of SR versus MVR. Reliability of computing relative importance of explanatory variables (RELIMP) is presented in Shnaider and Yosef [18]. The study demonstrates that commonly practiced computation of RELIMP using traditional MVR is unreliable and inconsistent, in contrast to the SR which generates reliable and consistent results. More detailed discussion regarding the SR method is provided below – in particular the issues and terms that are necessary for understanding the results and implications of this study.

MODEL

The model of factors facilitating economic performance was first introduced in [14]. The model was tested based on 1997 cross-national data. In the present study we utilize the same model, but generate results based on 1960, 1970, 1978, 1985 and 1992 data. The large number of cross-national regression runs allows to follow the performance of the Soviet-led Bloc for about 30-year time period to reach solid conclusions.

The model consists of three broad factors that can be considered as facilitating factors (or constraints) for successful long-term economic performance:

1. International Competitiveness
2. Human Capital
3. Degree of Social Progress

1. **International competitiveness** (see [18], [14], [2], [6]): The more globally competitive is the country and the higher is the combined value (per capita) of its products and services sold in global markets, the greater is economic

success as reflected by higher standard of living. The term "international competitiveness" reflects:

a) The ability of a given country to produce products and services in a competitive manner within international markets. The meaning of a country being competitive in a given international market is: this country supplies products and/or services such that its producers are capable to outcompete suppliers from other countries in generating revenues from sales in those markets. The combination of factors such as product price, quality, reliability, type of warranty, customer support, durability, etc., reflect the various aspects of being competitive.

b) Factors determining international competitiveness are: innovations and entrepreneurship; unique technologies and skills; relative value of country's currency; financial, marketing and insurance networks; government support (degree, sophistication) or obstruction (negatively affecting international competitiveness); natural factors; infrastructure; brand names and international reputation; business and work ethics; etc. In other words, it is a complex combination of many factors which enables to out-compete rival producers and sellers in the long run.

c) For any individual country, being internationally competitive means having the capability to supply globally large enough amount of products and services while generating substantial income per capita. And vice versa, the economies that are not internationally competitive, not only will fail to generate substantial income based on the world markets, but they will also have difficulties within their domestic economy due to import competition in tradable markets and variety of inefficiencies in non-tradable sectors of their economy.

d) The degree of international competitiveness of an economy at any given time period is a cumulative result of multiple long-term processes.

2. Human Capital (see [11], [13], [18] [14]): Human capital includes factors such as education, knowledge, skills, experience, and tradition. It is reflected by features such as development of new technologies and products, research and development capabilities, advanced technology infrastructure, education and research facilities and infrastructure, organizational and management skills, etc. Human capital is an important factor in determining international competitiveness of the economy, as well as economic efficiency in the non-tradable sector of the economy.

Countries possessing substantial human capital capabilities are able to:

a) Develop new technologies and products and thus enjoy at least temporary world monopoly (until imitations are developed),

b) Develop new methods of production and organization,

c) Rapidly enter technology intensive markets initiated by their rivals (once it becomes apparent that such markets hold substantial economic promise),

d) Enable improved efficiency and thus higher income generation in domestic non-tradable sector of the economy (including the public sector).

3. **Degree of Social Progress** (see [14], [18]): We characterize socially advanced countries by:

a) Degree of social sophistication and flexibility required for effective functioning of modern and internationally competitive economy,

b) Social environment facilitating growth and retention of human capital,

c) Higher degree of personal and economic freedom,

d) Greater adaptability to ever-changing global economic-political environment,

e) Greater flexibility to find a reasonable compromise between local traditions and the requirements necessary for functioning of successful modern economy.

There is a definite relation expected between the degree of social progress and the previously defined factor "human capital". In addition, we expect substantial relation between human capital (technology, knowhow) and international competitiveness. Hence, the factors included in this model are not independent of each other. This fact constitutes a severe limitation for modeling tools based upon assumption that all explanatory variables are independent (conventional regression methods such as MVR). Therefore, conventional regression methods would not be appropriate modeling tools in this study.

When advancing from the initial stage of theoretical definition of the model to practical implementation, it became apparent that there are no data available in the World Bank databases for the three factors discussed above (international competitiveness, human capital and the degree of social progress). Thus, it was necessary to define proxy variables instead. It is important for the set of proxy variables to reflect very closely the behavior of the originally intended theoretical variables. In order to capture various aspects in the behavior of the original variables, sometimes more than one proxy variable was needed to substitute for the original broad variable, as seen in the section below.

PROXY VARIABLES

This section introduces variables that could serve as proxies for the factors defined in the theoretical model. We utilized the following variables as proxies for the three explanatory factors of our model: international competitiveness, human capital and social progress ([14], [18]).

1. **Exports per capita (Exports)-** being a proxy for the degree of international competitiveness of a given economy in global markets (adjusted for population size). This variable indicates the bottom line: How much revenue (per capita) was earned by any given country in international markets, no matter what is the mix of factors creating competitive advantages or disadvantages. This is not a very accurate proxy because in some countries re-export of imported components may constitute a substantial portion of their exports, while in other countries such re-exported component is small or insignificant.

2. **Tertiary education enrollment (Tertiary)-** Percentage of the relevant population group that attends tertiary education institutions. Percentage of population attending academic studies can be viewed as a good quantitative proxy for the degree of social progress. It can also be considered as an indicator of investment in human capital – at least from the quantitative view point. However, this variable does not inform regarding the quality of human capital created: to what extent high education studies of that country are contributing, for example, to competitive advantage, higher productivity, greater responsibility, improved work ethics, etc.

3. **High technology per capita (High-Tech)-** refers to exports (per capita) of products associated with advanced technologies. This variable is an important proxy variable of international competitiveness, representing activities where technologies and human skills are dominant components of competitive advantage, in contrast to natural factors such as natural resources, weather, geography (location, distance) etc. In addition, this variable can supplement "Tertiary Education" variable by illustrating to what extent the skills generated by higher education help to improve competitiveness in the Technology-intensive markets. In other words, this variable is also a proxy variable for Human capital and is supplementing the variable "Tertiary Education" (which measures quantity of academic education) with some indication of quality (necessary for being competitive).

   Note: in the World Bank data sources, the variable named "High-Technology exports per capita" could be used only for 1992, and was not available for the previous years included in this study. For years 1960, 1970, 1978 and 1985, we used instead the variable "Exports of machinery and equipment" to represent High-Tech.

4. Secondary education enrollment (Secondary)- Percentage of the relevant population group that attends secondary education institutions. This variable represents different aspect of human capital (in comparison to "Tertiary education"). It provides general education background as well as provides basis for higher education. In addition, Secondary Education is also important in influencing social progress based on its unique mix of covered topics,

depth of studies and the final outcome of shaping the social characteristics of young generation just entering adulthood. Since Secondary education enrollment reflects mostly quantity of education rather than quality, this variable is probably more reflecting the degree of social progress in comparison to human capital.

5. **Birth Rate -** This is a proxy representing a degree of social progress. Large families are in general associated with agrarian economies, where the agricultural sector is usually characterized by traditional (and technologically backward) methods of production, where large families are customary and where children since a very young age are utilized as a labor force, thus negatively affecting their investment in human capital. On the other hand, smaller families are usually associated with the aspiration to be part of the middle class (or above), and to acquire education and skills needed for a successful career.

Therefore, as stated above, there is no one-to-one relation between the proxy variables and the variables they supposedly represent:

a. International Competitiveness is represented by: Exports and High Technology

b. Human Capital is represented by: High Technology, Tertiary and Secondary.

c. Degree of Social Progress is represented by: Tertiary, Secondary and Birth Rate.

It seems that the combinations of proxy variables reflect fairly well the various aspects of variables they supposedly represent. However, it is also clear that the proxy variables are not independent of each other. Therefore, modeling tools assuming independence of explanatory variables cannot be applied successfully in this project. This is additional argument for using SR, which does not require independence of explanatory variables (will be discussed below). In other words, we decided not to constrain our modeling process by the technical limitations of the traditional methods. This way the integrity and the common sense of the original model have been maintained.

As a dependent variable representing successful long term economic performance we selected various measures of income/output per capita, such as GDP per capita, GNP per capita and GNI per capita.

DATA PREPARATION

We utilized cross-national data obtained mostly from the World Bank data bases and hard copy reports. We excluded from the study all the countries having small populations (half a million or less) because small (by population) countries are characterized by different features (such as less diverse and small domestic market, etc.) in comparison to large countries. In particular, when the purpose of the model is to investigate Communist East-European bloc, the exclusion of small countries seems reasonable. Additional countries such as Taiwan and North Korea were excluded due to missing data. The total of over 120 countries were included for the years: 1960, 1970, 1978, 1985 and 1992. We supplemented missing data for individual countries (where it was possible) from adjacent years (this procedure was also used in the world bank hard copy publications). The above-mentioned data supplementing procedure is reasonable in the case of cross section analysis of variables, usually characterized by relatively small annual changes, and in the context of the inherent imprecision of the data in the first place.

There are some data series that are essentially representing the same factor but are measured differently. They are based on different methodologies, baselines, conversion/comparability methods, etc., thus leading to substantial differences in numerical values for basically the same things (or at least, the same things from our perspective). For example, as a dependent variable we used measurements of aggregate economic activity per capita: GDP/cap, GNI/cap and GNP/cap. All of them are considered common and legitimate measurements. Some of these data series are in current U.S. dollars (USD), while others are in constant 1990 USD, in constant 1995 USD, in constant 2000 USD, and in constant 2005 USD. There are data series based on regular currency conversion method vs. PPP (purchasing power parity) conversion method. Also, since we downloaded World Bank data (or used hard-copy data) over the span of many years, there were most likely some differences in measurement methodology because the numbers were different. Despite the fact, that all the

above-mentioned measurements are (from our perspective) measuring essentially the same thing, there are very substantial differences among various data series in terms of values, and even in their scale. We ended up with 7 aggregate output/ income per capita variables in 1960, 10 in 1970, 14 in 1978, 17 in 1985 and 21 in 1992.

Similarly, for the variable Exports per capita, we found different measurements, such as: Merchandise Exports, Exports of Goods and Services, Exports of Goods and Services-BoP, Exports of Goods, Services and Income- BoP, and we found these variables in current USD, in constant 1995 USD, in constant 2000 USD and in constant 2005 USD. In addition, similarly to the case discussed above, since we extracted the data over the span of many years, there could have been some differences in measurement methodology because of the differences in values. We ended up with 6 Exports per capita data series in 1960, 7 in 1970, and 12 in 1978, 1985 and 1992.

There are implications when the amount of data series is that large: for example, it would be necessary to perform over 200 initial regression runs (17 economic performance per capita data series times 12 exports per capita data series) if we wanted to utilize all the data available for 1985. Moreover, for all the other years there would be hundreds of additional initial regression runs. Obviously, the amount of regression runs becomes unreasonable. The problem is not only the amount of work, but also the question of how to summarize so many results and reach meaningful conclusion. Nevertheless, for the reasons explained above, we utilized all the available data by creating the ranges (intervals) of values based on all the available data series, according to the method described in [17].

There are several important advantages of transforming numerical vectors as discussed above into intervals of values:

a. The very basic principle in the field of Information Science is: all available data are valuable (unless suspected of being severely distorted) and should be utilized in the modeling process.

b. Confidence in the modeling results: when the approach is inclusive and involves all the available data series, then obviously the confidence in results is greater vs. modeling process involving selected data series while ignoring others.

c. Efficient handling of missing observations: This issue arises when in many data series there is a large number of missing measurements. For example, in our study, we utilized data from over 120 countries, but in many data series (numerical vectors), we encountered a problem of missing data for dozens of countries. In addition, the set of missing countries was not the same in different data series. However, constructing the data representation in terms of intervals, makes it possible to include the countries, for which there is at least one measurement in all the available data series. Of course, in some intervals (for some countries) there will be more data points and in others less, but we can include all the countries appearing in at least one data series in the modeling process, and thus increase our confidence in the results.

d. It is much easier to reach meaningful and unambiguous conclusion due to the drastic reduction of the amount of regression runs [17]. Instead of a need to have hundreds of initial regression runs (as mentioned above), the amount of regression runs drops to 4 for every year:

I. Regression using only Minimum values

II. Regression using only Maximum values

III. Regression of Minimum for dependent variable vs. Maximum of explanatory variables

IV. Regression of Maximum for dependent variable vs. Minimum of explanatory variables

Note: it does not matter how many explanatory variables are expressed in terms of intervals, the method will still require only four regression runs for a given year. It is also important to note, that no follow-up regression runs are needed if we utilize soft regression as our modeling tool.

There is a very important issue that must be addressed when constructing intervals of values: it is critical to make sure that before we construct the intervals, all variables are converted into the same scale, otherwise the interval is distorted and meaningless. In general, bringing all the different numerical vectors into the same scale is possible by recalculating all of them based on the same reference point. Selected reference point should be reasonable and reliable. This procedure is known as "Data Normalizing". When utilizing method based on fuzzy logic (such as Soft Regression), defining all the numerical vectors in terms of membership in the same fuzzy set is a very effective way to normalize the data and address the scale problem (for details see [17]).

Another important issue to consider when constructing intervals is the potential presence of outliers and their implications. By including all the available information (including unavoidable outliers) we will necessarily end up in some cases with intervals that are very extensive, and therefore not very helpful for modeling. In order to perform successful modeling, it is desirable to identify the core area of each interval which represents, even in approximate terms, its central tendency. Narrow intervals do not differ much from their core central tendency. However, very extensive intervals require additional work of interval reduction in order (if and when possible) to create a better reflection of their central tendency.

We utilized the Range Reduction Algorithm (RRA), which is explained in detail in [17]. RRA also identifies cases where interval reduction is not working, and the length of the interval is such, as to seriously question the reliability of the data. In such cases the data for that specific country are deleted.

There were very few countries in this study, that were deleted by RRA algorithm because of severely unreliable and inconsistent data. This of course had very little influence on the results of a general model where the data for over 120 countries were used. However, one of the problematic countries as far as inconsistency of the data was Bulgaria, which was one of the countries of the Soviet-led bloc, and we excluded it from our study. Other countries of the Eastern bloc, despite the suspicion that some components of their data were not very reliable (see [7]), at least they were consistent enough for using "Fuzzy" modeling process and the follow-up evaluation. Hence, we applied the results of the model to six major former communist countries: USSR, Poland, East Germany, Czechoslovakia, Hungary and Romania.

SOFT REGRESSION

SR is a modeling tool based on soft computing concepts (such as Fuzzy Logic [22]). The technical details of the SR method are described in [18], [21] and [20]. Previous works leading to the development of Soft Regression are: [15], [9] and [16].

We will briefly describe several of the important features of the SR that are preferable in comparison to the traditional MVR when constructing a model characterized by highly interrelated explanatory variables. These features are:

1. Soft regression does not require precise model specification. This regression tool is based on Fuzzy Logic, which is designed in the first place to handle information under severe conditions of uncertainty and imprecision [22]. The idea here is to give up on the possibility of building a precise model and satisfying ourselves with the opportunity to work with whatever data are available. We build a partial/less-precise model, and as long as the model is logically reasonable and based on common sense, it is expected to be very reliable in a general direction of its conclusions because it avoids the problem of misspecification bias. It could be summarized as follows: It is preferable to have imprecise, but broadly correct results (SR), rather than have precise results (containing a small expected statistical error) which are incorrect (due to misspecification bias – MVR). Of course, in the cases where some potentially important variables are excluded from the model due to lack of data or because of appearing insignificant due to multicollinearity (MVR method), the models are misspecified by definition.

2. Relative importance of the explanatory variables among themselves is not affected by adding or removing variables. When a model is constructed, the significance of the explanatory variables and the relative importance of those variables among themselves are not affected by adding additional variables to the model or removing some variables from it. This is in contrast to the behavior of MVR, where addition or removal of an explanatory variable can change drastically the significance and even coefficient sign of other explanatory variables of the

model. This characteristic of the SR adds an important element of stability into the modeling process and the subsequent conclusions.

3. Explanatory variables are not required to be independent of each other. In the fields such as Economics, Finance, etc. the variables are usually intangible concepts, that are often highly correlated among themselves mathematically even while logically they could each represent separate and independent (at least to some extent) concepts. When using MVR, high correlation among explanatory variables causes some of the important explanatory variables to appear as insignificant, and therefore being removed from the model - thus leading to model misspecification. In SR, the modeling process and the results are not affected by multicollinearity. Hence, this feature of SR (not requiring independence of explanatory variables) constitutes a major advantage in comparison to MVR, in particular if explanatory variables are highly correlated.

Basic Terms

Similarity: Denoted and ranges between 0 and 1.

In the Soft Regression method, we utilize the measure of similarity which indicates the degree to which explanatory variable () behaves in a similar pattern, whether direct or inverse, in comparison to dependent variable (). Therefore, the measure of similarity is an equivalent to the statistical measures of significance (t-tests or sig.). Significant relation is found with similarity levels of. However, in addition to fully significant relation, there is an option of partial significance, so that as is approaching closer to 0.7, it is closer to insignificance (see [15]). When the similarity measure is below 0.7, the explanatory variable is insignificant. The gradual transition from being fully significant to being fully insignificant provides additional stability to the modeling process while utilizing SR.

Combined Similarity of all explanatory variables to the dependent variable: Denoted and ranges between 0 and 1.

Once similarity measures are computed for all the explanatory variables (), the next step is to calculate collective contribution of all the explanatory variables combined in explaining the behavior of dependent variable (). This measure is denoted (see [20], [21]). It reflects, to what degree all the explanatory variables combined, explain the behavior of the dependent variable, which is equivalent to , used in the conventional regression methods. One important difference between the two measurement methods is that by using we allow for overlap of explanatory variables in their relations with the dependent variable (which is of course more reasonable and more in line with the "real world" behavior), and therefore explanatory variables are not required to be independent of each other.

Relative Importance of explanatory variables: Denoted RELIMP

The way to compute relative importance of the explanatory variables () is to find out how much each of them contributes to the . Relative importance of a given explanatory variable (in contrast to traditional regression methods) is not affected by correlation with other explanatory variables and is determined solely by the contribution of a given explanatory variable to explaining the behavior of the dependent variable. In models characterized by a substantial correlation among at least some explanatory variables, SR is a more reliable tool to compute RELIMP in comparison to MVR (see [20], [18]).

As was described in the section "Data Preparation", when using data expressed as intervals of values, it is necessary to run soft regression four times for every year (Max values for all variables, Min values for all variables, Max for dependent variables vs. Min values of explanatory variables, and Min for dependent variable vs. Max values of explanatory variables). The four regression runs generate four results, which again appear as a range between the lowest result and the highest results, and this way the results are presented in Tables 1 and 2.

Normalizing Data

Based on [17], we normalize data by introducing the heuristically determined maximum and minimum thresholds. Data normalizing requires projection of the values from every numerical vector into equivalent normalized numerical

vectors having values between zero and one, based on predefined function which is expected logically to reflect common sense in projecting such values, while maintaining the integrity of the data. In this study, for every variable we define a group of best performers: "High Income Economies". During the normalizing process we assign value of 1 to all the data points which are equal to or greater than the average value for the group of "High Income Economies". In other words, the normalized data displays the performance of every country (variable by variable) in comparison to the group of best world performers – "High Income Economies" (see Table 3 and Graphs 6-10, where all the data should be viewed in reference to the value "1" representing "High Income Economies").

The first step in the normalizing process is: we define as the value in a given vector such that all elements equal to or greater than are assigned the value of one. For example, if represents a value of GDP per capita which logically belongs to a category of "High Income Countries", then any country having higher value – will definitely be considered a "High Income Country" as well. We selected "Average of High-Income Economies" as our for the dependent variable as well as for all the explanatory variables. Such average values appear in the data bases and hard copy publications of the World Bank for all variables. The logic of such selection is convincing: if average value calculated for the High-Income economies fully belongs to the data set of "High Income countries", then all other data elements which have higher values will definitely belong to that group. On the other hand, other High-Income economies, which are close to the average of "High-Income Economies" from below, will have their normalized value close to 1 (but smaller than 1). By turning all the numbers above into 1, we neutralize the negative effect of the outliers having excessively high values without deleting these data points.

Similarly, we define as the value in that vector such that all elements equal to or smaller than are assigned value of zero. In other words, if represents a value of GDP per capita which logically belongs to a category of "Low Income Countries", then any country having lower value – will definitely be considered a "Low -Income Country" as well. We selected "Average of Low-Income Economies" as representing to handle excessive outliers from the lower side. We emphasize again: and must be determined based on logic and common sense for each domain (for every variable), so as not to distort the data (for more detailed explanation and example see [14]). For all other elements (between and) we project all othervector elements into the interval [0,1] proportionally. Thus and are Maximum cut-off point and Minimum cut-off point correspondingly.

Note: in the cases of several numerical vectors which essentially represent the same variable (see discussion above), data normalizing procedure explained above brings all these vectors into the same scale, thus helping to express all of them in terms of undistorted intervals (ranges) of values.

THE RESULTS

This section consists of the two subsections. The first subsection ("evaluation of the model results") consists of the analysis of the general model, involving its consistency over the years covered under this study, stability, reliability and general conclusions regarding the relative importance of the explanatory variables. The second subsection ("evaluation of the East-European bloc") consists specifically of the analysis of the East-European bloc by its individual countries, based on the results of the model and in comparison to the "High-Income Economies".

Evaluation of the model results

Similarity results (Table 1) show that the first three proxy variables (Export, High-Tech, Tertiary) are significant every year throughout the period of study (See graphs 1-3). On the other hand, variables Secondary and Birth Rate were significant during 1960 and 1970, but in the following years the lower end of the results drops into partial significance, and the whole range of the results is gradually declining. In other words, we can see that for both variables higher part of the range is significant (for 1978 and 1985), but the lower part of the range is only partially significant for the same years. It can be interpreted as follows: as more and more countries experienced decrease of their birth rate, as well as managed to enroll increasingly larger percentage of the relevant age group into secondary education, those two variables gradually lost their

explanatory power to distinguish between the rich and the poor countries. This is an interesting example where utilizing ranges of values leads to more complete picture than utilizing individual data series. These two variables are the only proxies used in this study, where the Soviet-led bloc came close to, or actually reached the performance comparable to the "High Income economies". However, due to the dynamics of general world-wide developments, the importance of these variables continuously declined towards the end of the period under study, thus undermining these achievements of the communist bloc. (Graphs 4 – 5).

When looking at RELIMP, we can see that Tertiary Education variable more or less maintains the same relative importance, while Export and High-Tech (which are persistently among the most important variables), having their relative importance gradually increasing due to relative decline of Secondary Education and Birth Rate (Secondary declined continuously since 1960, Birth Rate declined continuously since 1970). By 1985, Export and High-Tech became the two most important variables (both are proxies for "International Competitiveness"). In addition, High-Tech and Tertiary Education, both continuously significant variables are major components of the "Human Capital" factor. Hence, we can summarize Table 1 as follows: the empirical evidence based on cross-national model definitely supports International Competitiveness as well as Human Capital as the major factors facilitating successful economic performance. Since Tertiary education is also a proxy for Social Progress" factor, we can conclude, that based on proxy variables used in this model, Social Progress is also important factor facilitating economic performance, even-though some of its proxy variables became less successful indicators for the later part of the study.

Note: We must keep in mind that the relevant period to evaluate Soviet-led bloc is 1960-1985. The year 1992 represents the situation after the collapse of the bloc. The year is presented because it helps to identify some trends that continued and accelerated after the bloc disintegrated.

Table 1

		Export	High-Tech	Tertiary	Secondary	Birth Rate
Similarity	1960	[0.822,0.874]	[0.856,0.888]	[0.853,0.878]	[0.872,0.891]	[0.823,0.836]
	1970	[0.836,0.894]	[0.820,0.896]	[0.816,0.898]	[0.867,0.870]	[0.813,0.845]
	1978	[0.791,0.936]	[0.858,0.897]	[0.860,0.863]	[0.784,0.819]	[0.784,0.815]
	1985	[0.881,0.922]	[0.886,0.922]	[0.845,0.847]	[0.776,0.819]	[0.751,0.805]
	1992	[0.886,0.924]	[0.831,0.882]	[0.811,0.832]	[0.701,0.750]	[0.702,0.739]
RELIMP	1960	[0.163,0.210]	[0.196,0.227]	[0.193,0.215]	[0.220,0.229]	[0.123,0.181]
	1970	[0.173,0.240]	[0.170,0.224]	[0.169,0.236]	[0.200,0.222]	[0.146,0.199]
	1978	[0.154,0.288]	[0.199,0.281]	[0.204,0.238]	[0.135,0.188]	[0.135,0.186]
	1985	[0.251,0.277]	[0.230,0.292]	[0.189,0.213]	[0.128,0.163]	[0.100,0.148]
	1992	[0.312,0.379]	[0.225,0.325]	[0.218,0.231]	[0.058,0.124]	[0.043,0.109]

Table 2 displays measurements: to what extend all the variables combined explain the behavior of the dependent variable. We can see that all the measurements are above 0.949 on the scale between 0 and 1. The high value of means that the model is highly successful in explaining the behavior of the dependent variable. In addition, the consistency of the results throughout the years under study should be noted.

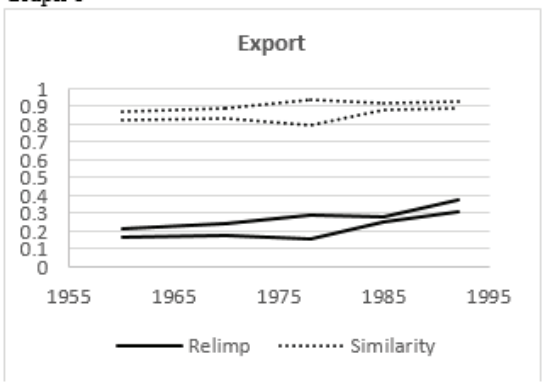
Table 2

	1960	1970	1978	1985	1992
S-comb	[0.959,0.964]	[0.950,0.960]	[0.957,0.985]	[0.956,0.964]	[0.949,0.965]

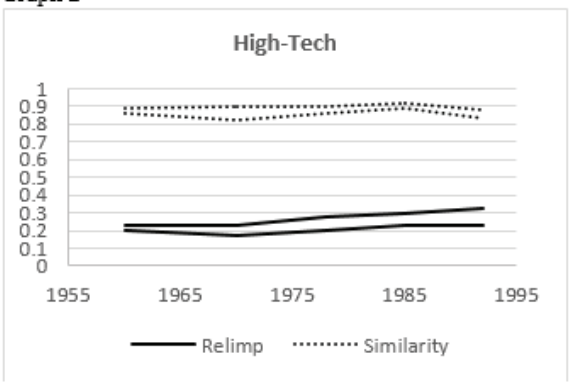
The consistency and stability of the model between 1960 to 1985 as well as the significance of similarity relations of explanatory variables are important factors determining confidence in the conclusions.

Graphs 1 through 5 display visually the results of Table 1. In particular, it is important to note that despite the inclusiveness of the study and utilization of all the data series that we could find for every variable, the ranges appear to be fairly narrow except very few cases , and vast majority of similarity measures are above (which is the lower limit of the significant range). In addition, the graphs show the decline of Secondary Education and Birth Rate in the later years of the study, but still being above 0.7 limit of insignificance – even for the lower end of their range.

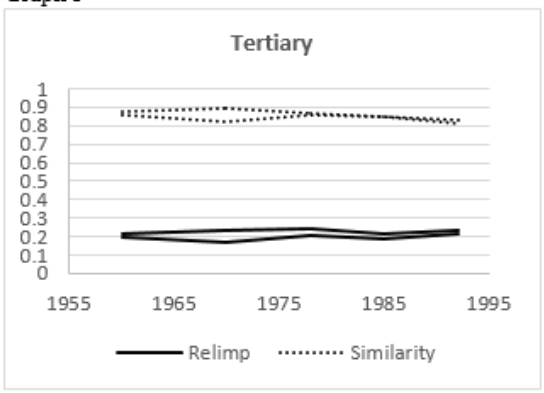
Graph 1



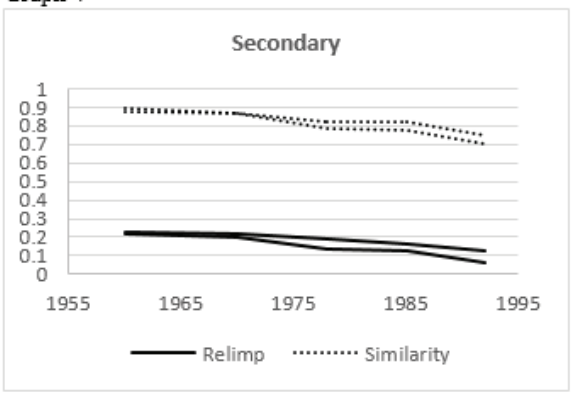
Graph 2



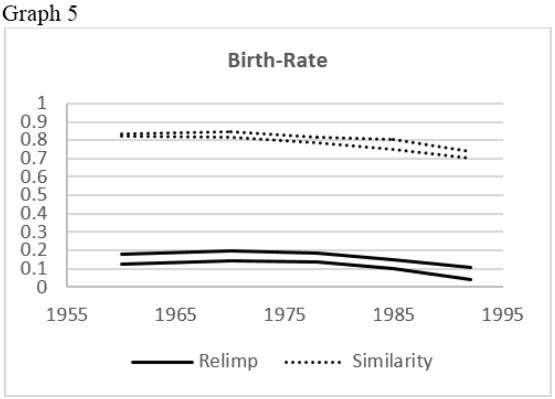
Graph 3



Graph 4



Graph 5



Evaluation of the East-European bloc

Table 3

		GDP	Export	High-Tech	Tertiary	Secondary	Birth Rate
USSR	1960	[0.391,0.442]	0.121	0.154	0.600	0.648	0.888
	1970	0.475	0.189	NA	NA	NA	NA
	1978	[0.427,0.444]	0.144	0.083	0.587	0.807	0.931
	1985	0.388	0.201	NA	0.510	1	0.876
	1992	[0.155,0.363]	[0.063,0.181]	NA	1	0.986	1
Poland	1960	[0.286,0.330]	[0.292,0.333]	0.292	0.466	0.666	0.984
	1970	0.363	[0.329,0.385]	0.495	0.437	0.773	1
	1978	[0.390,0.441]	[0.209,0.281]	0.346	0.486	0.945	0.894
	1985	[0.148,0.310]	[0.124,0.166]	0.196	0.383	0.911	0.899
	1992	[0.122,0.251]	[0.086,0.200]	0.020	0.428	0.901	1
East Germany	1960	0.569	0.659	NA	0.933	0.463	1
	1970	NA	NA	NA	NA	NA	NA
	1978	0.7	0.627	1	0.835	1	1
	1985	NA	NA	NA	NA	NA	NA
	1992	NA	NA	NA	NA	NA	NA
Czechoslovakia	1960	[0.509,0.620]	0.958	1	0.600	0.204	1
	1970	0.563	0.890	1	0.601	0.231	1
	1978	[0.531,0.574]	0.613	0.865	0.432	0.344	0.931
	1985	0.510	0.762	NA	0.366	0.255	1
	1992	0.398	0.295	0.213	0.312	0.756	0.995
Hungary	1960	[0.120,0.397]	0.768	1	0.33	0.592	1
	1970	[0.142,0.421]	[0.321,0.520]	0.802	0.269	0.797	1
	1978	[0.171,0.466]	[0.452,0.499]	0.435	0.320	0.915	1
	1985	[0.145,0.376]	[0.346,0.520]	0.481	0.367	0.939	1
	1992	[0.190,0.382]	[0.245,0.373]	0.082	0.271	0.850	1
Romania	1960	[0.060,0.120]	[0.246,0.274]	NA	0.200	0.185	1
	1970	0.208	[0.270,0.312]	0.291	0.264	0.467	0.901
	1978	[0.096,0.218]	[0.217,0.287]	0.188	0.217	0.980	0.898
	1985	[0.159,0.380]	[0.178,0.250]	NA	0.350	1	0.982
	1992	[0.057,0.220]	[0.031,0.085]	0.005	0.154	0.860	1

NA-Not Available

Table 3 displays normalized data for individual countries. In the cases we had more than one data series for a given variable – we present range of values. If there was only one numerical vector per variable, there is only a single value. The fact that results are normalized makes it easier to compare the status of each Eastern-Bloc country to the average performance of the High-Income developed economies, which have a value of 1. Graphs 6 through 10 are graphical illustrations of the normalized data by country. In the cases of ranges, in graphs we used mid-point of the range. We did not present a graph for East Germany due to a large amount of missing data.

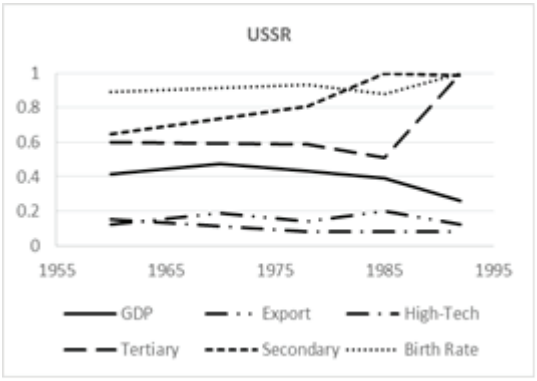
International Competitiveness (represented by proxies Export and High-Tech)

We can see a general trend in all the countries of the bloc: a major decline in performance by both, Exports and High-Tech variables. This can be interpreted as follows: International competitiveness was one of the major weaknesses of the Soviet-led bloc. This problem was addressed not by attempting to make the economies more competitive, but by arranging trade agreements among governments within the bloc. Due to deficiency in international competitiveness, the sales (per capita) in global markets were very low, but after the bloc disintegrated, also internal trade within the bloc collapsed, thus leading to a major decline observed in 1992. In general, the performance of the bloc in terms of international competitiveness has been dismal: USSR had persistent, very low performance (less than a quarter in comparison to the average high-income economies throughout the period under study), Poland and Romania showed some improvement from 1960 to 1970 (still less than 50% in comparison to the average high-income economies for both proxy variables), but afterwards experienced continuous decline until reaching the low

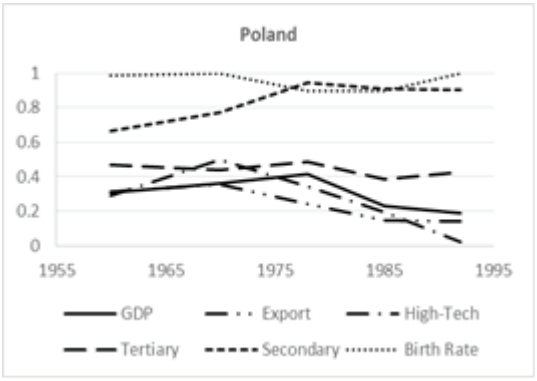
levels comparable to other countries of the bloc. Czechoslovakia and Hungary started relatively well for 1960 (Czechoslovakia: 0.958 for Export and 1 for High-Tech; Hungary: 0.768 for Export and 1 for High-Tech), but from 1970 and on there was continuous decline in performance until eventually reaching the low levels comparable to other countries of the bloc.

We can summarize the performance of the Soviet-led East European bloc regarding international competitiveness as follows: The performance of the bloc was not at its best in 1960, and thereafter continuously deteriorated throughout the period under study. Instead of closing the gap vs. High-Income Developed Economies, the gap continuously widened, thus making the possibility of catching up with the performance level of the leading economies - unattainable.

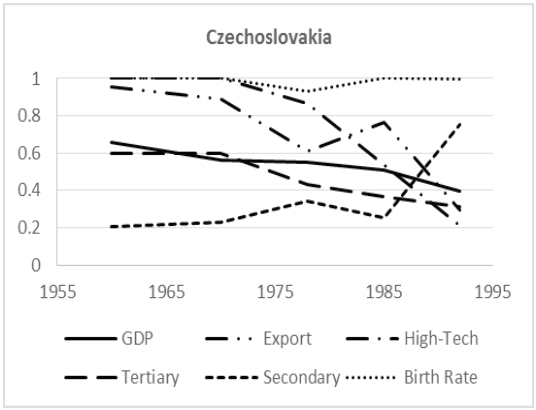
Graph 6



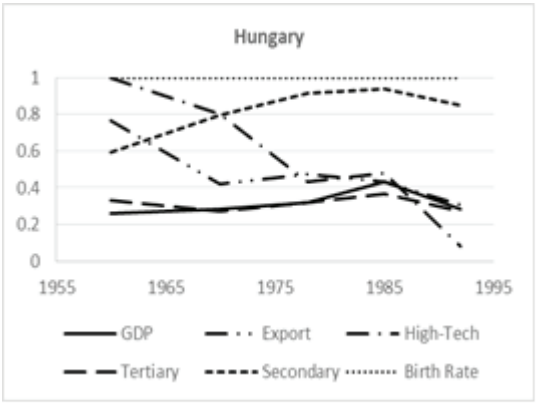
Graph 7



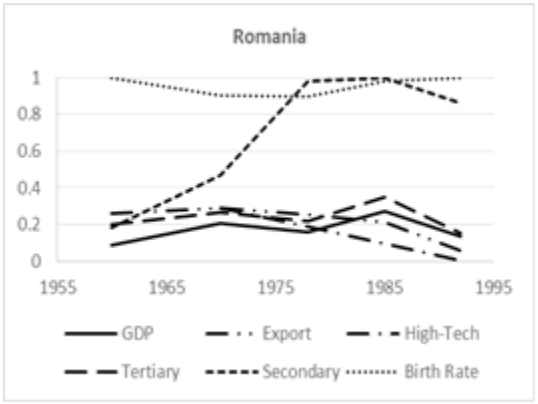
Graph 8



Graph 9



Graph 10



Human Capital (represented by proxies: High-Tech, Tertiary and Secondary)

Education was one of the major propaganda items of the communist bloc. Free education was available for all levels: primary, secondary and tertiary. Publicly funded research & development centers were also well known, especially for their achievements in the fields of space and military technology. However, when looking on the figures in Table 3 and graphs 6-10, the performance of Eastern bloc was far from successful.

First, we evaluate the variable High-Tech as a proxy of human capital. It reflects, among others, the following factors needed for successful advanced technology sector:

1. Ability of the education system to generate practical technological skills needed for successful and globally competitive advanced-technology based industry.
2. The availability and performance of basic research as well as applied R&D (Research and Development), including facilities and infrastructure.
3. Incentives to retain scientists and technological personnel.

All those Human Capital factors are not captured by Tertiary Education and secondary Education proxy variables, which only reflect the quantity of Human Capital related training, but says nothing about quality and focus. For example, in several Latin American countries, there has been a very wide discrepancy between the high percentage enrollment in the tertiary education system and the very poor performance in the High-Tech.

Considering the above, we will evaluate the performance of individual countries. As analyzed above (in relation to International competitiveness), the performance regarding the High-Tech variable is indicative of a major failure. In other words, the component of Human Capital that relates to the commercial success of industries based on advanced technologies – failed. USSR, Poland and Romania did not exceed 0.5 throughout the time frame of this study. In fact, the maximum value for the USSR was 0.154 (but some data points are missing). Both, Poland and Romania continuously declined from 1970 to 1992. Czechoslovakia and Hungary started well for 1960 (both countries had value of 1), but from 1970 (Hungary) and from 1978 (Czechoslovakia) until the end of the time frame for this study, there was a continuous decline in performance for both countries until eventually reaching the low levels comparable to other countries of the bloc. East Germany could not be evaluated because there is only one data point available (for 1978 and had value of 1).

Tertiary enrollment is another major proxy variable for the "Human Capital" factor. Soviet Union began in 1960 at value of 0.6, and from that point on continuously declined. The value of 1 for 1992 requires explanation: this is the value for Russia and not for USSR. As USSR disintegrated, Russia emerged as a country having approximately half of the population of the USSR. However, most of the Tertiary Education facilities of the USSR were on the territory of Russia, and thus the new combination of the population vs. tertiary education facilities increased the value of this proxy variable to 1. However, it does not represent a success in the Soviet investment in Human capital: it happened after the disintegration of the Soviet Union and merely reflects the changes in country's border. All other countries of the bloc did not do any better regarding this variable: Czechoslovakia also started at 0.6, but then continuously declined. Poland, Hungary and Romania began in 1960 below 0.5, and remained there throughout the time frame of this study, moving up and down. Only East Germany had 0.933 for 1960, but dropped to 0.835 in 1985. Unfortunately, we had no more data points for East Germany, but the decline fits the general downward trend or stagnation in the indicators for the bloc.

Secondary Enrollment: This is the only component of "Human Capital" factor, where East-European bloc was successful. In 1960, the values were 0.648 for USSR, 0.666 for Poland, and the rest of the bloc had even lower values. However, by 1985, all the countries of the bloc were above 0.9 (notable exception being Czechoslovakia, which lagged behind). It must be noted, that the relative importance of the proxy variable "Secondary Education", has been continuously declining. It means that large enough amount of countries world-wide reached (or came close to) the performance level of High-Income economies, so that this variable gradually lost its ability to facilitate distinction between the high-income economies and the poorer economies. Thus, the success of the bloc in terms of Secondary Education enrollment had

continuously declining impact on the overall performance of the bloc in comparison to the High-Income economies. Hence, the "Human Capital" factor became increasingly determined by the performance in terms of the two other proxy variables having higher relative importance: High-Tech and Tertiary Education, and in terms of those two parameters, the Soviet-led bloc failed to close the gap vs. High Income economies (in fact the gap widened over time).

Degree of Social Progress (represented by proxies: Tertiary, Secondary and Birth Rate)

The variables Tertiary and Secondary were already discussed. As far as the Birth Rate, the lowest performer of the bloc in 1960 was the Soviet Union (0.888), while in four of the bloc's countries the value was 1. Hence, already in 1960, the performance of the bloc was compatible with the High-Income economies and remained more or less at the same level throughout the years under study. However, as in the case of Secondary - the relative importance of the proxy variable "Birth Rate", has been continuously declining since 1970. Combined with the continuous decline in the relative importance of proxy variable "Secondary", this left Tertiary Enrollment as gradually becoming more dominant proxy variable representing the degree of social progress. This is also the variable where Soviet-led bloc failed to improve (see above), while the two other proxies where the bloc was successful, continuously lost their importance by gradually moving from fully significant variables to partially significant variables.

To summarize: based on the model of the Factors Facilitating Economic Performance, the Soviet-led bloc totally failed in the area of International Competitiveness, mostly failed in the area of Human Capital (success in only one proxy variable which continuously declined in its relative importance), and had mixed results in the area of Degree of Social Progress (failure in a major proxy variable, success in two proxy variables which continuously declined in their relative importance). Overall results point overwhelmingly towards the conclusion that the failure of East-European communist bloc to catch-up with the performance of "High-Income Economies" was predictable, based on the data (probably not very accurate) provided by the government agencies of those countries themselves.

Some ideologies sound very attractive. Some governments are very resourceful in concealing and camouflaging their deficiencies and failures. Some governments are very skillful in advertising selective achievements (for example: first satellite, first astronaut in space, etc.). However, there are certain fundamentals ("Factors Facilitating Economic Performance") which must be satisfied (more or less) for any country to be able to reach and maintain the level of the best performers (High Income Economies). Those fundamentals actually represent constraints that the lagging countries must overcome to reach the level of the best performers, and the Soviet-led countries of Eastern Europe definitely failed to do so.

SUMMARY AND CONCLUSIONS

The results of this study are unambiguous: The Soviet-led bloc of East-European economies failed to overcome its deficiencies (in comparison to the advanced Western economies) in terms of International Competitiveness and Human Capital, and the results in terms of Social Progress were mixed. The failure to catch up in terms of the factors facilitating economic performance implied the impossibility to reach the standard of living levels of the advanced economies of Western Alliance.

In this study, we introduced a method to evaluate performance of individual countries or groups of countries, and to assess their capabilities in comparison to the "Best Performers". We utilized cross-national data to build a general world-wide model of factors facilitating economic performance. We applied the model's results to evaluate the countries of East-European bloc over the years 1960 - 1985. All the available data series were utilized, including the cases where there were more than one data series for a given variable, which resulted in the application of intervals. Advantages of including all the available data series and applying intervals in the modeling process were discussed. Soft Regression technique was utilized to build the model. Soft regression is an AI (Artificial Intelligence) modeling tool based on Fuzzy Logic. Advantages of using Soft Regression vs. conventional regression techniques (such as MVR) were discussed. In particular, we emphasized one important advantage of Soft Regression: it does not require restrictive assumptions (often unrealistic) in the modeling process. The process, analysis and conclusions are straight-forward and in line with human-

logic and common sense. Another important advantage of utilizing Soft Regression in this study was: it allowed successful integration of highly correlated (among themselves) explanatory variables into the same model without being affected by multicollinearity.

The method applied in this study displayed high degree of robustness: the data used for the East-European bloc came mostly from the hard copy publications, published before the disintegration of the bloc. Despite complains [7] regarding the biases and the lack of accuracy of the data provided by the East-European government agencies, the method used in this study managed to identify broadly but accurately, the true standing and prospects of the bloc by its individual countries.

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