ON THE SOVIET-AMERICAN MACROECONOMIC COMPETITION

György Simon, Jr.
Corvinus University of Budapest[1]

ABSTRACT

The paper is devoted to the range of questions related to the macro-level competition of the Soviet and American economies in the four decades between 1950 and 1990. The author believes that the unfavorable outcome of this competition for the Soviet Union can be explained primarily by efficiency causes. Therefore, he reveals the factors of productivity growth relying on both neoclassical and endogenous production functions. In this context, the application of an endogenous growth model makes it possible to deepen the analysis by showing the role of complex factors, including creativity, in the rise of macroeconomic productivity.

Key words: macroeconomic competition, growth accounting, neoclassical and endogenous production functions, Soviet Union, United States

1. Introduction

The competition between the world systems of socialism and capitalism as a key phenomenon of modern epoch had been determining the development of humanity for more than four decades following the end of World War II when two superpowers emerged – the Union of Soviet Socialist Republics (USSR) and the United States of America (USA). This competition may be called universal, since it took place in the socio-economic, political, military, scientific and technological, educational and cultural spheres. The present research is devoted to revealing the determinant factors of Soviet-American economic competition at a macro level, using econometric and statistical tools of analysis. The *central issue* will be the definition of *factors of productivity growth* in the Soviet and U.S. economies with the help of both neoclassical and endogenous production functions. In this connection, we will search for an answer to the question what economic causes led to the eventual loss of the race for world hegemony by the Soviet Union. Our *hypothesis* is that this outcome can be attributed chiefly to efficiency problems.

In the *specialist literature*, various aspects of the subject have been studied. As far as we know, the most comprehensive study was made by *Simon Sr.* (1986: 108–115) who discussed the economic competition between the Soviet Union and the United States at the level of key sectors (industry, agriculture and infrastructural branches) in the three decades from 1950 to 1980. In this connection, he analyzed the development of the so-called *systemic effect*, i.e. the role of different relations of production in the results of economic growth.

The development problems of Soviet economy have also been investigated by many other authors. Among them, *Weitzman* (1970), *Desai* (1987) and *Ofer* (1987) pointed out that the slowdown in Soviet economic growth was primarily related to the predominant reliance on extensive factors which, given the slow growth of workforce and the falling marginal productivity of capital, eventually run out of payoff. They also noticed the declining rate of

[1] Independent researcher. E-mail: gysimon@indamail.hu

productivity growth, or technical progress, associated with the difficulties in adopting adapting to the sophisticated technologies being introduced in developed and newly industrializing market economies, the burden of defense expenditure and a variety of special factors relating to the absence of appropriate incentives in the Soviet system, as well as corruption and demoralization.

Nove (1992) reviewed the development of Soviet economy from the Bolshevik seizure of power to the perestroika and aftermath of the failed coup of August 1991, which speeded up the disintegration of the USSR. He emphasized the central role played in that development by the question of achieving economic stability.

Goldman (1992) explored the causes of failure to reform the Soviet system, with a particular emphasis on perestroika. As a result of the latter process initiated by Gorbachev, the Soviet people eventually rallied around the idea of democracy and fought off an attempt to return to the totalitarian regime. Goldman attempted to explain why such a result, tragic for Gorbachev but exultant for the Soviet people, had been inevitable.

Easterly and *Fischer* (1994, 1995), who considered both aggregate and industrial output and inputs, emphasized that the declining Soviet growth rate from 1950 to 1987 could be accounted for by a declining marginal product of capital with a roughly constant rate of growth of total factor productivity (TFP), based on a Cobb-Douglas production function with constant elasticity of substitution (CES). They contended that the Soviet reliance on extensive growth, reflected in rising capital-output ratios, had been no greater than that of Japan or South Korea. However, a low elasticity of substitution between capital and labor implied especially acute diminishing returns to capital compared with the case in market economies. The authors have found out that the assertion that the Soviet economy was overly burdened by excessive military spending[2] or that central planning stymied the effectiveness of research and development (R&D) expenditure does not provide a plausible explanation for the extreme nature of the Soviet experience. Easterly and Fischer believe that Soviet economic growth from 1960 to 1989 was the worst in the world, conditional on investment and human capital accumulation, and that relative performance worsened over time. An important *message* from the empirical results reported by these authors is that Soviet-style stagnation awaits other countries that have relied on extensive growth. In this context, Soviet experience can be read as a particularly extreme dramatization of the long-run consequences of extensive growth.

Maddison (1998) investigated the methodological and practical problems in comparing the performance of capitalist and communist economies. These problems have been carefully analyzed for the USSR, for which there was a huge research input, mainly by the U.S. Central Intelligence Agency (CIA). He emphasized that the CIA effort had had considerable merit, particularly in assessing Soviet rates of economic growth.

Beare (2008) points out that during the 1950s Soviet economic growth in per capita terms significantly exceeded the world average. In this connection, he criticizes the approach taken by *Easterly* and *Fischer* (1995) in explaining the slowdown in Soviet growth with the help of *extensive growth*, or low elasticity of substitution *hypothesis*. Extensive growth is driven primarily by input accumulation rather than a rise in productivity. As discussed by Easterly and Fischer, the decline in Soviet economic growth after the 1950s was accompanied by a substantial increase in the rate of investment, which more than doubled between 1950 and 1987. Similar increases were experienced in such East Asian economies as Japan or South Korea. Whereas extensive growth through capital accumulation led to rapid rates of growth in several East Asian economies, the rising rate of investment in the Soviet economy was accompanied by a declining rate of growth. The extensive growth hypothesis, originally

[2] In this connection, *Steinberg* (1992) presented a study that made use of the Soviet input-output, gross national product (GNP) and budgetary data in estimating the defense budget of the USSR. He thus tried to reconcile the official defense budget with national accounts.

proposed by *Weitzman* (1970), posits that this decline was due to sharply diminishing returns to capital brought about by a low elasticity of substitution between capital and labor. Easterly and Fischer argue that the elasticity of substitution was indeed much lower in the Soviet economy than in the newly industrializing East Asian economies and suggest that the difference may be fundamentally related to the contrasting nature of planned and market economies. Beare stresses that *the empirical estimation of the CES production function for the Soviet economy is complicated by the relatively poor quality of data*. There is evidence that the rate of technical change was declining over the sample period, but we can say almost nothing about the elasticity of substitution or capital share parameters. The standard errors and the discrepancies between various data sets are simply too large. Therefore, in Beare's opinion, the apparent support provided to the extensive growth theory hypothesis by Easterly and Fischer is nothing more than an artifact of their inappropriate trend specification.

Kara-Murza (2012) presents selected quantitative indicators with typical dynamics, characterizing the results of economic activity and the standard of living in the USSR. He shows the production and consumption of key goods and services mostly in a natural expression, as well as the indicators of the resource intensity of economic activity that reflect the ability of economy to develop. In this context, the main emphasis is put on the study of "big systems" that constituted the backbone of the Soviet economy: education, health care, housing and communal services, defense industry, the single energy system and railroad transport – systems which concentrate in themselves the experience of Russia's entry into the industrial and scientific epoch.

On the American economy, a general historical overview was made e.g. by *Heilbroner* and *Singer* (1999). Post-war U.S. macroeconomic policies were reviewed by *Turgeon* (1996) from a critical Keynesian position, while *Sargent* (1998) gave the subject a neoclassical perspective.

This paper has the following structure. After the introduction, the analytical framework of research will be presented which contains the presentation of a neoclassical and an endogenous model of economic growth. Then the empirical results obtained with both models will be expounded separately for the Soviet and the American economy, along with some comparisons of the two economies, including the issue of military spending. Finally, the relevant conclusions will be drawn.

2. The Analytical Framework

In connection with the Soviet-American macroeconomic competition, we will search for an answer to the *central question of growth theory*, viz. what factors determine the growth rates so different both by countries and in time, and what causes the frequently very big differences in the levels of income (cf. *Romer*, 2012). More concretely, the subject of our investigation is *productivity and its determinant factors*, since the standard of living and capital accumulation as well as cross-country income differences depend in essence on these indicators. Regarding the fact that the economic result of technical progress can primarily be characterized by the increase in productivity, the analysis of the latter's factors also imply the investigation of technical progress. For the examination of the level of productivity and its factors, *growth models* will be used here. We chose two models – a neoclassical and an endogenous one. The econometric investigation to be expounded here covers the period 1950–1990 for both the USSR and USA. Its initial data in an annual breakdown may be found in the Appendix.

2.1. The Neoclassical Growth Model

The production function of the standard *neoclassical model* (*Solow*, 1956) can be written down in the following form: $Y = A_o K^{\alpha} L^{1-\alpha} e^{\lambda \Delta t}$, (1)
where Y is output, A_o is a multiplier of efficiency (constant), K is physical capital (practically fixed capital), L is labor (practically, as a rule, the number of persons employed or the number of working years), t is time, Δt is the number of years (t-t_o) elapsed from an initial point of time (t_o), and α, 1-α and λ are the elasticity of output by physical capital, labor and time, respectively.

For the analysis of productivity, relation (1) can be rewritten as $Y/L = A_o (K/L)^{\alpha} e^{\lambda \Delta t}$. By taking the logarithm of both sides, we arrive at the expression below:

$ln (Y/L) = ln A_o + \alpha ln (K/L) + \lambda \Delta t$. (2)

Thus, according to the neoclassical model, the output per worker or working hour, i.e. productivity, in a given year depends only on parameter α, on capital intensity (K/L) and on the multiplier of efficiency (A_o). A very important assumption of the model is that parameter α in an equilibrium state corresponds to the profit share (practically to the production share of profit containing depreciation), which in the case of developed countries is usually taken as 1/3 or a value close to it. In the course of our investigation, we will use the value $\alpha = 1/3$ for both the USSR and USA.

In analyzing *productivity growth*, the neoclassical model is appropriately modified: the multiplier of efficiency, A_o, drops out; or rather its value becomes unity, which in a logarithmic form is zero, while the time factor ($\lambda \Delta t$) gains an individual role. The latter was earlier called *neutral technical progress*. Recently, specialist literature has been applying the term *total factor productivity*, already referred to above. The new name, however, does not change the fact that an *unexplained effect* is at issue, which is not attributed to concrete causes.

In the case of analyzing productivity growth, the *neoclassical model* takes the following ultimate form:

$\Delta \ln(Y/L) = 1/3 \Delta \ln(K/L) + \lambda \Delta t + \varepsilon$. (3)

In relation (3), ε is a *logarithmic residual* whose magnitude for the most part depends primarily on *cyclical volatility*. Here it is *the parameter λ expressing the specific magnitude of TFP that must be estimated*, for which we used the *least squares' method* in the course of our investigation.

2.2. The Endogenous Growth Model

2.2.1. Growth Theory and the Mechanism of Technical Progress

The endogenous growth model to be applied below was elaborated by Gy. Simon, Sr. and first called the *Simon model* by *Ligeti* (2002: 134). This model will be expounded here in the wake of *Simon Sr.* (2005). The author sets out from the consideration that *productivity, viz. output per unit of working time, is a cumulative result of technical progress which depends on a combined effect of physical and human capital*. He further assumes that the factors in point are not only in a *multiplicative*, but also in an *inverse multiplicative* (divisional) and an *exponential interaction* with one another. By contrast, the neoclassical growth theory and the other versions of the endogenous growth theory reckon with only the multiplicative interaction among factors.

The Simon model is based on the *mapping of mechanism of technical progress*. The *source of technical progress* is human inventiveness whose economic effect has considerably changed in the course of history essentially for two reasons: (1) the accumulation of physical

capital insured increased opportunities for further development, and (2) as a result of accumulation and transfer of knowledge (education). In our days, the whole process is enhanced by wide-range research and development (R&D) within the framework of enterprises, research institutes and higher education.

However, the tendency toward *acceleration* is only one aspect of this process, since there appear retarding forces, or *negative feedbacks*, in connection with technical progress, which at a higher stage of development significantly decelerate economic growth (contradiction of intensification). *One type of negative feedback* is caused by the fact that the raising of the level of technical progress *requires* increasing *accumulation*: investment, educational and R&D inputs, etc. This relationship is mapped through the so-called *intensity indicators* in the model. The production function reckons with the following intensity indicators: *capital intensity* (fixed capital per worker), *schooling* (number of schooling years), *research intensity* (the share of R&D specialists in the number of persons employed), *land intensity* (arable land per worker) and *mineral resource intensity*. The last indicator can approximately be characterized by oil and gas resources per worker.

The intensity indicators contain an *inverse multiplicative interaction* among the factors determining technical progress. Relying upon these findings, it is not difficult to see that in the production function to be expounded here *homogeneity of degree one and a constant return to scale are fulfilled, but at the same time, increasing returns to factors can also be considered* (see below). The *intensity functions* based on intensity indicators provide an opportunity for a concrete mapping of the *economic development force effects* emerging in the process of technical progress.

Another type of negative feedback appears because at a higher level of development, it is more difficult to cope with the increasing volume of material and informational results of preceding development, whereas earlier achievements become partly or completely obsolete (moral amortization). In this connection, the so-called immobile and mobile effects are well separable from each other. The *immobile effect* in the capital intensity function increases to the end, while the *mobile effect* is increasing only to a certain level of capital intensity and then begins to decrease, as the negative feedback characterized above is prevailing. The immobile effect is a pure form of embodied technical progress, whereas in the mobile effect, the embodied technical progress is combined with the explicit effects of schooling and research and development.

2.2.2. The Production (Technical Progress) Function

The starting point of the Simon model is Kaldor's *technical progress function* (see *Kaldor*, 1957), in essence generalized by a more differentiated treatment of the effect of capital intensity and by explicitly considering the role of schooling, research and development and natural resources.

Variables:[3]

Y = volume of output (GDP) in comparable prices (in billion dollars of year 1985);

K = average annual gross fixed capital in comparable prices (including apartments, in billion dollars of year 1985);

[3] The number of schooling years was taken into consideration on the basis of *Barro* and *Lee* (2000). Data on population aged 15 and over were used, assuming that they also pertain to the persons employed. The indicator R pertains to a two years and the indicator O to a one year earlier period because of effect lag. Soviet value indicators in rubles (Y, K) were converted into U.S. dollars on the basis of *Heston* et al. (1995) and *Hall* and *Jones* (1999). The conversion rates pertain to purchasing power parities. Their concrete values, along with the values of all the variables, are given in the Appendix.

L = number of persons employed in millions;

H = number of schooling years;

R_{t-2} = number of scientists and engineers engaged in R&D, considering a two-year lag (thousands);

Z = arable land (in million hectares);

O_{t-1} = crude oil and natural gas resources in million metric tons of oil equivalent (at the end of the year preceding the reference year);

N = population (mid-year, millions).

All the variables are a function of time (t). The time index is put out in case of retarded effects. In formulas, a capital letter denotes a function and a small letter a parameter (except variable t). In the model, intensity functions are used on the basis of intensity indicators. An intensity function is a logarithm of an expression in which the basic component of human capital (L) figures along with another type of capital, the latter multiplied by a normalizing coefficient. The normalizing coefficient is a constant which regarding its economic effect makes the given factor, e.g. physical capital, comparable to the basic component of human capital. An intensity function is in essence the specific value of the basic component of human capital increased by another factor, considering the latter's relative efficiency in a logarithmic form. By taking the logarithm, the exponential interaction among factors can be written down in a multiplicative form.

Intensity functions:

$F_K = \ln (1 + n_K K/L)$ (capital intensity);

$F_H = \ln (1 + n_H H/L)$ (schooling);

$F_R = \ln (1 + n_R R_{t-2}/L)$ (research intensity);

$F_Z = \ln (1 + n_Z Z/L)$ (land intensity);

$F_O = \ln (1 + n_O O_{t-1}/L)$ (mineral wealth intensity).

The *normalizing coefficients* are $n_K = 1/250$, $n_H = 1$, $n_R = 1000$, $n_Z = 1$ and $n_O = 1/200$, where the parameter n_K refers to the 1985 dollar prices. These are rounded values, which do not differ significantly from the estimated ones. The estimation was made by using the production function (see below).

While increasing the growth factors in the same proportion at a point in time, the output in the Simon model also increases in that proportion. The *constant return to scale* is thus fulfilled, similarly to the Solow model. The constant return to scale does not exclude that the return to some factors could be increasing, since there is a factor, the number of employed, the return to which is negative and, in an absolute value, equals the joint return to all the other factors, except labor. The *negative return* originates from the fact that if solely the number of employed increases, there will be a decrease in intensities, in the returns derived from that. The *return to labor is constant* in the Simon model. The elasticity of output by is unity, whereas that by the other factors, according to the preceding basic assumption, is jointly zero. Thus, *despite the possible existence of increasing returns, the Simon model is homogeneous of degree one*.

The *production function* is as follows:

$$Y = gM \exp [F_K(G_I + G_M + G_{HR})], \quad (4)$$

where Y is the volume of output, M is the number of working years and the parameter g is the output produced without fixed capital during a working year, which approximately corresponds to an economy's initial productivity level lacking working tools. It was estimated by using the production function. The sum of the components of relation (4) in parentheses (G) is approximately the *production elasticity function of physical and human capital*, i.e. the mechanism of technical progress, and its negative value is that of employment. Thus, $G = G_I + G_M + G_{HR}$, where component G_I is related to the immobile and components G_M and G_{HR} to the mobile effect. In formulas:

$G_I = 1 - \exp(-F_K [g_I F_K \exp(g_L \Delta t \exp\{-F_K / 5\}) + g_Z F_Z])$;
$G_M = g_M F_K^2 \exp[-F_K / 2 - g_{MZ} F_Z + g_O F_O \exp(-F_H^3 / 3)]$;
$G_{HR} = g_{HR} (F_H F_R)^2 \exp(-F_K / 3)$.
Here $\Delta t = t - 1950$, where 1950 is the base year.

Table 1: **Parameters of the Simon Model**
(Production Function)

Denotation	*Estimated values*	*t statistics*
g	363	22.25
g_I	0.0033	22.19
g_M	0.317	22.24
g_{HR}	0.00883	21.39
g_L	0.028	20.94
g_Z	0.0372	14.18
g_{MZ}	0.43	15.41
g_O	0.16	13.02

Source: *Simon Jr.* (2005: 40).

From data in Table 1, it is visible that the estimated values of parameters are significant. Their sign and magnitude meet theoretical expectations. From the value of parameter *g*, the conclusion can be drawn that the productivity of the initial state must have been approximately half of the present level of the *least developed countries*.

How can the production function be interpreted economically? If physical capital (*K*) is zero, than the economy is in an initial state: the output is *gM*. But if physical capital is greater than zero, productivity will increase compared to the initial state depending on the magnitude of intensity indicators (capital intensity, education of workers, research intensity, the economy's endowment with natural resources). Output and productivity also depend on the amount of time available for learning by doing *under a given capital intensity*. The *production elasticity function* (*G*) multiplies the capital intensity function (F_K), i.e. it *approximately raises to power the K/L ratio*, or *capital equipment*.

The component G_I related to the *immobile* effect depends *positively* on capital intensity, on time available for learning by doing and on arable land intensity. In the function of all that, the value of G_I is a magnitude between zero and one. It tends asymptotically to unity at a very high level of capital intensity or in a very distant future. A relatively high level of capital intensity restrains the positive effect of learning by doing.

A *characteristic feature of components relating to the mobile effect* (G_M and G_{HR}) is that a higher level of capital intensity increases their magnitude only to a certain limit after which it has a diminishing effect. If capital intensity increases beyond all limits, their value will tend asymptotically to zero. Component G_M is also affected by the economy's endowment with natural resources – positively by mineral wealth intensity and negatively by arable land intensity. The latter effect is connected with the fact that land is a relatively *inert* factor from the viewpoint of technological development. The positive effect of mineral wealth at a higher level of development relatively decreases also because of economic diversification. This effect is represented here in the function of education considering that in more developed economies education is mostly higher.

In our production function, the *positive effect of human capital* appears as an impact of learning by doing and in the form of component G_{HR} of the mobile effect. The negative effect appears in connection with employment (factor *L*). *Education also functions as a factor of complementary character.* At the same time, the function G_{HR} expresses not only the explicit, i.e. not merely implicit, complementary effect of education on economic growth and productivity, but also the close connection of that effect with the R&D activity. Generally, we can state that (1) *the explicit effect of education on economic growth is measurable only if*

there is an R&D activity, (2) *R&D exponentially increases the explicit effect of education*, (3) *the result of R&D can be utilized in an economy with educated workers and, in general, more effectively with a higher educational attainment*. Essentially these were the econometrically proved regularities that necessitated the consideration of function G_{HR}.

The *returns to growth factors* can be determined analytically as partial derivatives of output by those factors. In terms of labor, the partial derivative is Y/M, i.e. the marginal product of labor does not differ from its average product. Like in the Solow model, the return to any factor is a product of elasticity of output by the respective factor and the average productivity. However, as noted above, elasticity is not constant here, disregarding labor.

To determine the *contribution of* individual *complex factors to productivity growth*, relation (4) should be transformed in the following way:

$$\Delta\ln(Y/gM) = \Delta F_K G_I + \Delta F_K G_M + \Delta F_K G_{HR} + \Delta\varepsilon, \qquad (4')$$

where $\Delta\varepsilon$ characterizes the deviations from the world level.

It is visible that the endogenous model in point does not have a component ($\lambda\Delta t$) which would depends *exclusively* on time. As already noted, this model is *homogeneous of degree one* like the neoclassical production function, i.e. its application does not lead to economically absurd results, e.g. to an economic "big bang". It is important to note that in relation (4'), the *economic content of the logarithmic residual* (ε) is in a certain sense other than in the case of the neoclassical model. It can characterize not only random effects (cyclical fluctuations, etc.), but also the way how the efficiency of an economy is relating to the group of leading capitalist countries (United States, United Kingdom, France, Germany and Japan) at the same level of intensity. This is primarily the consequence of the fact that the parameters of the model were defined relying on the economic data of these countries.

3. Empirical Results

3.1. The Soviet Economy

The Union of Soviet Socialist Republics came into being on December 30, 1922 and ceased to exist on December 25, 1991. The demise of the USSR raised numerous questions about its causes. Western observers pointed to the general crisis of the socialist system and its Soviet version, the centrally planned command economy. The secessionist movements posed as an additional cause of the ultimate disintegration of the country. But the demise of the Soviet Union was brought about above all by the imperative need for economic opening and the slowdown in the arms race with the United States that imposed a heavy financial toll on the USSR, as the historical inadequacy of the country's ossified economic structure with regard to flexible international markets was revealed (cf. *Rosser* and *Rosser*, 2004: 265).

As regards our investigated period, *Kara-Murza* (2001) distinguishes four *stages of Soviet development after World War II*, viz. (1) the post-war reconstruction of national economy and the end of Stalinism (1946–1953), which he also calls the years of *mobilizing socialism*; (2) N.S. Khrushchev's reforms and the *"thaw"* (1953–1964); (3) the period of *stagnation* under L.I. Brezhnev and his immediate successors (1964–1985); and M.S. Gorbachev's *perestroika* (1985–1991).

It should be emphasized that *Russian communism*, which took as its banner the postulates of Marxism-Leninism, represented a trajectory of civilization different from the social democratic project of the West including the so-called Scandinavian model. Russia was a peasant country with a traditional society whose culture preserved many structures of an agrarian civilization. By contrast, Western social democracy is a product of civil society in which peasants as a class and as a culture have been preserved in a relict state and are replaced by farmers in agriculture.

Implementing *socialism in one country* required speedy industrialization for self-sufficiency, military buildup and social transformation of the agro-industrial economy into an urban industrial one. *Accelerated industrialization* heavily favored producer and military goods at the expense of agriculture. It disallowed market allocation of resources. At the same time, enterprises were shielded against insolvency and bankruptcy through centralized subsidies. They were not subject to financial discipline and their managers' performance was assessed on the basis of their compliance with the government's plans. The inter-regional government transfers propped up under-producing regions and individual union republics. The people were protected against economic fluctuations and the possibility of unemployment through coordinated public education and mandatory assignment of guaranteed jobs. The state assumed authority over foreign trade and foreign currency transactions through state monopolies. It closed the economy through restrictions on foreign trade, *currency inconvertibility* and limited trade specialization. The *state monopoly of foreign trade* protected domestic firms from external shocks and from competition with foreign goods. The network of inter-republican commodity flows with preset prices and quotas created a sense of certainty in domestic trade and increasing interdependence (*Rosser* and *Rosser*, 2004: 269, 277, 279).

Kara-Murza (2001) indicates that *Soviet state-owned enterprises* (SOEs) were established and operated in a cultural milieu imbued with communal thinking which denied individualism. The anthropological model on which the social structure of Soviet enterprise was based presented the man not as a specific atom, but a supportive individual who has the natural right to receive from the community the minimum of living benefits. The acts of enterprise violating that right were perceived as wrong and unjust.

In Soviet Russia after the revolution of 1917 the Bolsheviks were able to revive the peasant community, or *mir*, in the countryside, because it had only partly been undermined in 1906–1914 by the reforms of P.A. Stolypin and his successors. Actually it was this latter attempt to destroy the communal social structures that eventually led to the Bolshevik revolution. The labor resources necessary for *industrialization* and redundant in rural areas were mobilized through *collectivization*, i.e. establishment of collective and state farms which the state supplied with machines and other means of intensive agricultural production. The peasants crowded out of the countryside had not become proletarians. They were sent to the construction sites of industry, becoming workers, technicians and engineers. They lived in hostels, barracks and shared apartments and later in working-class districts built by enterprises. This was a process of *transfer of peasant community from the countryside to the urban industrial enterprise*. It turned out that the main characteristics of the communal way of life manifested themselves in the urban enterprises even stronger than in the rural collective farms. Therefore, the *Soviet industrial enterprise turned neither into a western-type firm nor into a pure unit of production*. It was a lifestyle center like the rural community. Thus, the formation of the communal system of social services in the enterprise and around it became a quite natural process that did not contradicted but originated from the cultural genotype of Soviet enterprise.

Soviet *planning* prioritized industry over agriculture for socio-political reasons emphasized regional specialization and deemphasized republic-level diversification, having established *state monopolies in key industries*. This model was intended to complete the socialist transition in the shortest possible time and to eliminate the entrepreneurial sub-systems alien to socialism. In such a context, I.V. Stalin launched agricultural collectivization, which forced collective ownership on peasants as a stepping stone to comprehensive public ownership (*Rosser and Rosser*, 2004: 270).

The State Planning Committee, or *Gosplan*, was responsible for plan feasibility studies and for research on the methodology of balancing nationwide proportions. But the need to obtain adequate information posed a critical challenge. With limited markets, this information was incomplete, therefore full implementation of plans could not be guaranteed. This fact made planning intrinsically unstable. *Target planning* emphasized specific sectors and forced unbalanced growth; absolute numbers of output were deemphasized and relative indicators of economic dynamics were elevated (Ibid. 271).

Prices were used by planners to insure compliance with plans and continuous control over plan implementation. Although resources were allocated mostly in physical terms, prices

permitted their comparative valuation. Soviet domestic prices were distorted because they reflected planners' priorities in distribution and production rather than relative scarcities. Industry-based ministries overseeing production of a specific industry nationwide made executive decisions. Organizationally, these ministries were vertically subordinate to Gosplan and the Council of Ministers and ultimately to the Central Committee of the Communist Party and its Politburo (Ibid. 273, 280).

Industrialization produced an extensive bureaucracy in planning and executive institutions interested in perpetuating their political and economic power. It formed the basis for the merger between the Communist Party, the planners and the ministerial and local government bureaucracies, resulting in the formation of a new class, the *nomenclature***,** which consisted of party members appointed to particular government jobs and engaged in rent-seeking behaviors (Ibid. 272).

The *strengths of the Stalinist economic model* were the mobilization of resources for industrial catch-up, the development of a defense-industrial complex and the post-war recovery through extensive growth. However, its *weaknesses* became more pronounced in the more complex post-war economy as resources for extensive growth approached exhaustion. This shortage arose from the undervaluation of the opportunity costs of planned priorities and absent appropriate criteria to assess economic performance. *Ubiquitous protectionism* downplayed economic incentives and prevented economic subordinates from making well-substantiated decisions. The vertical institutional structure produced *compartmentalized responsibilities*, shortsighted ministerial bureaucracies and *parochial economic behavior*. With greater complexity of the economy, goals became more varied, coordination became more challenging, and control over subordinate activities and information verification became more difficult. With greater production possibilities and emerging material constraints, *efficient resource utilization* emerged *as a necessary objective* (Ibid. 279–280).

Kara-Murza (2001) notes that in the first post-war years, the implementation of *inter-industrial targeting programs* engendered a qualitatively new type of public administration, though not so much the structure as the functions of government bodies were changed. The conversion of military industry was implemented quickly, which raised the technological level of civil branches and thus made it later possible to produce new military output. *In the system of economic management, the industrial principle was gradually supplemented with the territorial one.*

After Stalin's death, the Soviet leadership abandoned mobilizing socialism by way of destroying first its ideological and then organizational base. *In 1954, an accelerated campaign began to cultivate virgin and long-fallow lands.* This campaign, despite all its errors, resulted in a rapid growth of grain production and eventually (by 1964) guaranteed the food-supply security of the USSR, which was not shattered even by significant food imports.

In 1957, Khrushchev, in order to alleviate the burden of comprehensive control by central authorities, dissolved industrial ministries and established *regional economic councils* as bodies of territorial economic management and planning. He also divided party bodies into urban and rural. Although individual regions were given certain decision-making freedom, the center's mistrust of the regional elites caused the Soviet government to re-emphasize central planning and discourage horizontal linkages among the regions. In 1963, an *All-Union Council of the National Economy* was formed.

The liquidation of industrial ministries deprived the Soviet state of its ability to concentrate assets for the development of science and technology, to pursue a single technological policy and effectively use the best achievements in production. This led to the emergence of strong structures with the legitimized ideology of *regionalism*, which would not be neutralized in the subsequent period. Therefore, the *economic reform of 1957* did not yield the expected results and ended with a return to the centralized system of economic

management. In the course of its implementation, the shortcomings of the Soviet economy and methods of management and planning became apparent, which retarded productivity growth in the national economy. This stimulated an all-Union discussion in 1962–1964, which prepared the ground for the next reform.

The *reform of economic management and planning initiated in 1965* by L.I. Brezhnev and A.N. Kosygin was characterized by introduction of economic methods of enterprise management and increasing autonomy of enterprises, associations and organizations, and a wide use of *material incentives*. A key importance was given to *profit* as an integral indicator of production efficiency, with a general emphasis on the *development of commodity money relations*. The *dissolution of economic councils* resulted in the restoration of the *industrial system of economic management* with all-Union, Union-Republic and republic ministries and departments. *The enterprise became the basic unit of production and management.* A number of *large projects* were implemented (creation of a single electric power system, introduction of automated systems of control, development of civilian motor-car construction, etc.).

The social policy of Soviet state beginning in the 1960s was contradicted by a strong technocratic tendency of apparatus demanding from the enterprises a concentration of assets on productive activities to the disadvantage of social needs. Also, there was always a pressure from the side of the government encouraging the transfer of "non-profile" social services to the competence of local Soviets. *During the 1970s, the multi-stage system of industrial management was replaced by a two- and three-link one* (ministry – association – enterprise and ministry – self-accounting combine – mine administration). *The functions of management and planning were correspondingly redistributed and decentralized.* At the same time, the scale, diversity and dynamics of national economy had already surpassed the possibilities of old-type planning. *Production became not sufficiently operative in responding to changes in technology and social needs. In addition, scientific and technological progress was retarded by narrow institutional interests.* Moreover, the *formation of regional elites* comprising employees of departments and local administrations engendered a new type of political subjects – *nomenclature clans*. This process of clan formation was joined by the nomenclature of central party and state apparatus. *Yet, in the years of stagnation, the Soviet Union managed to become the only self-sufficient country in the world, endowed with all the basic resources for a long time.*

The *perestroika*, which took place between 1985 and 1991, was a "revolution from above" in which the ripening crisis of state legitimacy threatening to redistribute power and wealth was resolved by the actions of ruling elite through the state apparatus. An extreme case of such revolutions is the self-destruction of the regime through an organization of a "popular uprising". The perestroika brought about deep changes in the political and socio-economic system, national relations, way of life and culture of all citizens and peoples of the USSR. It cardinally altered the world's geopolitical structure and has engendered international processes that are still far from completion. *The perestroika is a phenomenon of world-wide historical significance*, which was a part of a world conflict – the Cold War. In its development and in the use of its results, foreign political forces were playing an active and important role. *The end of perestroika with the dissolution of the Warsaw Treaty Organization and the Council for Mutual Economic Assistance, followed by the break-up of the USSR itself, has been considered in the West as the defeat of the Soviet bloc in the Cold War.*

According to *Kara-Murza* (2001), the *driving force of perestroika* initiated by M.S. Gorbachev was an alliance of the following socio-cultural groups:

(1) a part of the party and state nomenclature that aspired to overcome the ripening crisis of legitimacy by preserving its position even at a cost of changing its ideological profile;

(2) a part of intelligentsia imbued with western liberalism, driven by the ideals of democracy and freedom and the image of "counters full of foodstuffs"; and

(3) criminal strata related to the shadow economy.

On the whole, all these groups eventually gained what they wanted. The nomenclature and shadow businessmen obtained property and shared power, whereas the intelligentsia got "full counters" and the right to travel freely abroad.

The simultaneous *glasnost* was a wide program aimed at destroying images, symbols and ideas constituting the cultural core of the Soviet society and strengthening the hegemony of the Soviet state. The ideological pivot of perestroika was *euro-centrism* – the idea of existence of a single world civilization having its own "right" high road passed through by the West. It was argued that Russia in the Soviet era had deviated from that road. From this was derived the concept of "return to civilization" and orientation toward "common human values".

In the course of perestroika, each stage of reform was substantiated by different ideological concepts. These concepts had become more and more radical and increasingly departed from the main principles of the Soviet system. Initially, the need to accelerate scientific and technological progress was emphasized. However, beginning in 1986, the central apparatus of economic management was practically incapacitated as a consequence of a transition to a *two-link, ministry – enterprise system of industrial management*. The late 1980s produced legal recognition of a variety of proprietary arrangements. As a first step, the Law on Individual Labor Activity, adopted in 1986, articulated rules for operating private enterprises but did not encourage entrepreneurship.

The Soviet Union had long had a specific dual financial system. Normal money received by the population in the form of wages, salaries, pensions, etc. circulated only in the market of consumer goods. Its quantity was strictly regulated in accordance with the mass of available goods and services. In production, non-cash money circulated, the quantity of which was determined by the inter-industry balance which was mutually cleared off by written order. In essence, this meant that *there were no financial capital and loan interest in the USSR*, as money could not be sold. All this made it possible to maintain *low prices* and did not permit inflation. Such a system was able to operate only with a strict ban on conversion of non-cash into cash money. As noted above, the Soviet ruble was not convertible. The rate scale in the USSR was quite different from that in the world market and thus the ruble could circulate only inside the country. Therefore, cash money should have been strictly closed in relation to the external market by the state monopoly of foreign trade.

The *liberalization of financial system and market* in the Soviet Union could be carried out only after bringing the domestic rate scale and wages in accordance with those in the world market. The first step in that direction was the abolition of state monopoly of foreign trade from January 1, 1987. In June 1987, a *concept of perestroika* was announced, which supposed a *transition to a market economy*. Economic management was reoriented from natural to monetary indicators. Moreover, instead of planned deliveries, a network of commodity and commodity and raw material exchanges (the last commodity exchange in the USSR was closed in the late 1920s) was established. The 1987 Law on State-owned Enterprise (Association), based on complete self-accounting, permitted the conversion of non-cash into cash money, opening the way for the subsequent privatization of the banking system. According to the 1988 Law on Cooperatives, a network of cooperatives and joint ventures emerged under the auspices of SOEs and local Soviets, engaged in merchandise exports. However, the activities of these economic units sharply reduced the commodity supply on the domestic market. Increasing incomes and simultaneously diminishing stocks of goods led to a *consumer market crash*. In March 1989 the specialized banks (Promstroybank, Agroprombank, etc.) became self-accounting financial institutions, and in 1990 they began to

be transformed into commercial banks. On March 14, 1990 the *Third Congress of People's Deputies* of the USSR excluded from the Soviet Constitution Article 6 on the leading role of the Communist Party and thus *recognized the existence of a multiparty system* in the country. In August 1990, an all-Union *currency exchange* was established. In 1990 the notion of *communal* (municipal) *ownership* was introduced by a special law. This was an important step toward a division of people's property and decentralization of state power, representing a big concession to regionalism. *In 1991 came the legalization of private enterprise* with the Law on Enterprise and Entrepreneurship, followed by the Law on Principles of Entrepreneurship and the Law on the Destatization and Privatization of Enterprises, in which target dates for state decontrol of enterprises were tentatively set. These reforms did not fully apply in agriculture, where long-term leases of land still owned by the state were preserved. On April 1, 1991 the Gosplan was dissolved and in May a law on the privatization of industrial enterprises was passed.

Table 2: **Some Supply-Side Characteristics of Soviet Economic Growth, 1950–1990**

Year	*Y*	*Y/M**	*K/Y*
1950	535	6.69	1.25
1960	885	9.28	1.91
1970	1419	12.68	2.66
1980	1793	13.69	4.27
1990	2086	15.01	6.25
Period	Average annual growth (%)		
1951–1960	5.16	3.33	4.33
1961–1970	4.83	3.17	3.37
1971–1980	2.37	0.77	4.85
1981–1990	1.53	0.92	3.88
1951–1990	*3.46*	*2.04*	*4.11*

*Thousand dollars per working year.
Note. *Y* is gross domestic product (GDP), *M* is the number of working years and *K* is gross fixed capital (*Y* and *K* are in billion dollars of 1985).
Source: calculated from the Appendix. The same concerns the following tables if not otherwise indicated.

What were the main *characteristics of Soviet economic growth* between 1950 and 1990 considering its *supply-side determinants*? We can answer this question relying on data summarized in Table 2.

1. The rate of economic growth in the Soviet Union continuously slowed in 1951–1990 if we view the latter period as broken down into four decades.

2. The rise in productivity, which also showed a decelerating trend, insured on average three-fifths of the achieved growth.

3. The constantly increasing capital-output ratio (*K/Y*) engendered the problem of *capital deepening*. As a consequence, capital productivity (*Y/K*) in 1990 accounted for only a fifth of the 1950 level.

It should be emphasized that in the Soviet Union, GDP was not officially calculated, though some GNP data appeared during the perestroika. National income statistics of the USSR (Material Product System – MPS) differed from the United Nations methodology (System of National Accounts - SNA) in that it covered exclusively the sectors of material production and did not contain depreciation (consumption of fixed capital).[4]

Kara-Murza (2012) notes that world history knows in essence only two cases of a successful adaptation of non-western countries to the advanced technological structures of the industrial era. These are Japan (after the Meiji restoration) and Russia (twice: under Peter the

[4] In the past, Soviet economists and statisticians liked to compare production in the USSR and USA on the basis of the MPS. For that purpose, they used to calculate the net material product (NMP) of the United States to make direct comparisons with the corresponding Soviet indicator. In this paper, we used generally accepted SNA categories for both countries. *Gy.S.*

Great and Stalin). Moreover, *the Russians have implemented not an imitative version of modernization, but a synthesis of European institutions and technologies with the complex natural and cultural originality of their country*. The *tragedy of the Soviet Union* was that the process of convergence of the world socialist and capitalist systems, which began in the mid-1960s by a mutual agreement of the ruling elites of the USSR and USA, eventually ended with an almost total destruction of socialism. The processes taking place today in China and India also have all chances to become examples of a successful industrialization and even of an achievement of a higher, post-industrial level of development, but they are far from being accomplished and touch only a small part (not more than 15%) of the population of these countries where the overwhelming majority of society still lives under patriarchal, pre-industrial conditions.

As already mentioned, the neoclassical model breaks down productivity growth into the effect of two factors (disregarding the logarithmic residual): one of them is the effect of changes in capital intensity (*K/L*), usually called *embodied technical progress*, and the other is *TFP*. Concerning the latter, the parameter λ, and *TFP* in general, can be estimated from relation (3). The estimation can be made not only for the whole investigated period, in our case for 1951–1990, but also for sub-periods, assuming that the latter's length, or rather the number of observations, is greater than a certain minimal value.

Table 3: **Productivity Growth and *TFP* in the Soviet Economy**

Period	*Number of observations*	Average annual change (%)*				In percentage of productivity growth		
		GDP per person employed	Embodied technical progress	TFP	ε	Embodied technical progress	TFP	ε
1951–1990	40	2.020	2.012	0.096 (0.835)	-0.088	99.6	4.8	-4.4
1951–1960	10	3.272	2.494	0.457 (0.928)	0.321	76.2	14.0	9.8
1961–1970	10	3.122	2.151	0.776 (0.937)	0.195	68.9	24.9	6.2
1971–1980	10	0.766	1.830	0.045 (0.582)	-1.109	238.9	5.9	-144.8
1981–1990	10	0.921	1.571	0.038 (0.892)	-0.688	170.6	4.1	-74.7

* Logarithmic values.
Note. In parentheses is the coefficient of determination R^2.

How did productivity and *TFP* change in the Soviet economy over the investigated period?

Data in Table 3 show that the relevant results obtained with the neoclassical growth model are significant, with relatively high coefficients of determination. It is striking that *TFP* in the Soviet Union used to be of secondary importance; and after 1980, it even showed a decline. However, the neoclassical model does not explain the causes of these phenomena.

How large was the weight of embodied technical progress and *TFP*?

As seen from Table 3, embodied technical progress had always made a decisive contribution to productivity increase in the Soviet Union. Moreover, it insured on average more than 99% of that increase[5], in which total factor productivity played only a marginal role. This means that in the case of the USSR, the neoclassical model can *almost totally* explain the rise in productivity by a concrete cause (embodied technical progress) with a

[5] With a very capital-intensive production of goods, including capital goods, the Soviets were close for a while to the model of growth through rapid reproduction of capital – described by G.A. Feldman in the 1920s as "using machines to make more machines" (cited by *Easterly* and *Fischer*, 1994: 17).

negligible error percentage (ε). Nevertheless, if shorter time intervals are considered, the picture becomes less unequivocal as the explanatory force of the neoclassical model gradually diminishes. In that context, it is noteworthy that in the first two decades of the study period, the share of embodied technical progress declined from over three quarters to about two-thirds, whereas the share of TFP rose from about a fifth to more than a quarter. Initially, the error percentage was rather small and decreasing, but after the epoch change in world economy, it sharply increased assuming a negative sign.

More accurate results can be obtained with a growth model considering the role of human capital, namely education and R&D, too. This has been attempted by the *endogenous growth models* (see e.g. *Barro* and *Sala-i-Martin*, 2004). The solution is made difficult by the fact that human capital, first of all education, is not to a little extent a factor of complementary character. Its effect is interwoven with physical capital. The production (technical progress) function to be used here (*Simon Sr.*, 2005: 39–41) reckons with not only the effect of human capital but also with the effect of learning by doing. This makes it possible to compare economic efficiency to the international level, to the results that would be insured by some factor combination in the case of world-level efficiency. Since the parameters of the model were determined on the basis of a worldwide investigation using data on 131 countries[6], a *world model* is at issue.

Table 4: **The Role of Endogenous Factors in Soviet Productivity Growth**

Period	*Indicator**	$\Delta\ln(Y/gM)$	$\Delta F_K G_I$	$\Delta F_K G_M$	$\Delta F_K G_{HR}$	$\Delta\varepsilon$
1951–1990	a	2.020	0.964	0.689	0.390	-0.023
	b	*100.0*	*47.7*	*34.1*	*19.3*	*-1.1*
1951–1960	a	3.272	1.590	1.453	0.262	-0.033
	b	*100.0*	*48.6*	*44.4*	*8.0*	*-1.0*
1961–1970	a	3.123	1.465	1.106	0.587	-0.035
	b	*100.0*	*46.9*	*35.4*	*18.8*	*-1.1*
1971–1980	a	0.763	0.356	0.233	0.173	-0.009
	b	*100.0*	*46.7*	*30.5*	*24.0*	*-1.2*
1981–1990	a	0.921	0.452	0.257	0.221	-0.009
	b	*100.0*	*49.1*	*27.9*	*24.0*	*-1.0*

*a = average annual change; b = percentage distribution: $\Delta\ln(Y/gM) = 100$.

Empirical results concerning the *role of endogenous factors* in Soviet productivity growth are contained in Table 4. These results were obtained by putting the data on Soviet economy from the Appendix in relation (4'). What *main conclusions* can be drawn from these calculations?

1. The *efficiency of Soviet economy* was below the international standards, with a tendency of gradual worsening during the first three decades of the investigated period.

2. The relatively most important factor of productivity growth was the *immobile effect*. The magnitude of this pure form of embodied technical progress, reflecting primarily learning by doing, had long shown a diminishing trend. Its contribution significantly increased only in the last decade of the study period.

3. Next in importance was the *first component of the mobile effect*, depending on the equipment of workers with physical capital, which, however, made a continuously declining contribution to productivity rise.

4. The *second component of the mobile effect*, related to education and R&D, insured on average about a fifth of productivity growth. The share of this factor had been increasing until the early 1980s when its expansion came to a halt under the impact of a deepening crisis in the Soviet economy.

[6] See the list of these countries, including the USSR and the USA, in *Simon Sr.* (2000).

5. On the whole, it can be stated that in the period 1951–1990, productivity growth in the USSR was insured for two-thirds by human and for one-third by physical capital expansion.

3.2. The U.S. Economy

The United States of America had the world's largest economy in the investigated period, which decisively influenced the formation of post-war international order. The country's capital, Washington, D.C., accommodated such global economic institutions as the International Monetary Fund and the World Bank, while New York City was chosen as the seat of the United Nations. Moreover, the United States initiated the General Agreement on Trade and Tariffs (GATT) in 1948 that oversaw successive rounds of tariff-reducing negotiations and other moves to expand international trade (*Rosser* and *Rosser*, 2004: 117).

During the Cold War with the world socialist system led by the USSR (1946–1991), the concerns of Washington policymakers about Soviet influence underlay relatively high U.S. military spending, implementing the Marshall Plan to rebuild economically Western Europe, including West Germany, and the space race. The 1960s saw renewed increases in the role of government in the economy, with Keynesian fine-tuning of fiscal policies under President J. Kennedy and especially with the Great Society programs of President L. Johnson. Besides his War on Poverty, Johnson established the Medicare program, passed major civil rights legislation against racial segregation, extended voting rights, and increased various social programs for housing and welfare. Restrictions on immigration were relaxed, allowing for the greater diversity of immigrants, who substantially changed the nature of U.S. society in subsequent decades. At the same time, inflation was exacerbated by Johnson's rapid expansion of government spending on both the Great Society programs and the Vietnam War, without any increase in taxes to pay for them. During the 1970s, economic turmoil was marked by oil price shocks and stagflation (a combination of stagnation and inflation), after the Bretton Woods system of fixed exchange rates had been abandoned along with the remnants of the international gold standard. Presidents R. Nixon, G. Ford and J. Carter attempted to deal with these macroeconomic upheavals by a variety of ad hoc policies such as wage and price controls, and exhortations to restrain inflation that generally failed. The accelerating inflation finally brought on a strict monetarist anti-inflationary policy by the Federal Reserve under Chairman P. Volcker starting in 1979. But a decisive move to scale back Great Society programs and to deregulate the U.S. economy came only in the 1980s with the presidency of R. Reagan and his supply-side policies known as Reaganomics. This trend has continued through the subsequent presidency of G. Bush, Sr. (Ibid. 124–125).

Table 5: **Some Supply-Side Characteristics of U.S. Economic Growth, 1950–1990**

Year	*Y*	*Y/M**	*K/Y*
1950	1169	19.24	6.37
1960	1643	23.98	5.90
1970	2474	30.17	5.33
1980	3396	33.43	5.17
1990	4658	38.46	5.07
Period	Average annual change (%)		
1951–1960	3.46	2.23	-0.76
1961–1970	4.18	2.32	-1.01
1971–1980	3.22	1.03	-0.30
1981–1990	3.21	1.41	-0.20
1951–1990	*3.52*	*1.75*	*-0.57*

*Thousand dollars per working year.

Note. *Y* is GDP, *M* is the number of working years and *K* is gross fixed capital (*Y* and *K* are in billion dollars of 1985).

The main *characteristics of U.S. economic growth* between 1950 and 1990 considering its *supply-side determinants* (Table 5) were as follows.

1. The rate of economic growth in the United States speeded up to the epoch change in the world economy, but later began to slow down. Overall, the rise in productivity insured less than half of the growth rate achieved in the investigated period.

2. Productivity grew slower than output, following a similar trend. The only difference from output was that productivity growth somewhat accelerated after 1980.

3. The capital-output ratio (*K/Y*) was continuously decreasing due to a wide use of capital-saving technologies.

The relatively rapid economic growth in the 1960s and early 1970s dramatically slowed down following the first oil price shock in 1973. Inflation began to grow in the mid-1960s. It jumped sharply after 1973 and peaked following the second oil price shock in 1979, gradually contracting afterward, especially in response to the stricter Fed policy (*Rosser* and *Rosser*, 2004: 125).

Table 6: **Productivity Growth and *TFP* in the U.S. Economy**

Period	*Number of observations*	Average annual growth (%)*				In percentage of productivity growth		
		GDP per person employed	Embodied technical progress	TFP	ε	Embodied technical progress	TFP	ε
1951–1990	40	1.732	0.386	1.091 (0.968)	0.255	22.3	63.0	14.7
1951–1960	10	2.202	0.480	1.594 (0,917)	0.128	21.8	72.4	5.8
1961–1970	10	2.296	0.421	1.049 (0.945)	0.826	18.3	45.7	36.0
1971–1980	10	1.026	0.243	0.524 (0.985)	0.259	23.7	51.1	25.2
1981–1990	10	1.402	0.400	0.935 (0.953)	0.067	28.5	66.7	4.8

* Logarithmic values.
Note. In parentheses is the coefficient of determination R^2.

How did productivity and *TFP* change in the U.S. economy over the study period?

Data in Table 8 show that the relevant results obtained with the neoclassical growth model are significant, with relatively high coefficients of determination. There was an unbroken predominance of *TFP* to the end of the investigated period. This means that the neoclassical model can indicate a concrete cause (embodied technical progress) for *less than a third* of productivity growth in the case of the United States, with a volatile error percentage (ε) (see Table 6).

Table 7: **The Role of Endogenous Factors in U.S. Productivity Growth**

Period	*Indicator**	$\Delta\ln(Y/gM)$	$\Delta F_K G_I$	$\Delta F_K G_M$	$\Delta F_K G_{HR}$	$\Delta\varepsilon$
1951–1990	a	1.732	1.098	0.421	0.218	-0.005
	b	*100.0*	*63.4*	*24.3*	*12.6*	*-0.3*
1951–1960	a	2.203	1.493	0.549	0.170	-0.009
	b	*100.0*	*67.8*	*24.9*	*7.7*	*-0.4*
1961–1970	a	2.297	1.461	0.544	0.301	-0.009
	b	*100.0*	*63.6*	*23.7*	*13.1*	*-0.4*
1971–1980	a	1.024	0.641	0.249	0.137	-0.003
	b	*100.0*	*62.6*	*24.3*	*13.4*	*-0.3*
1981–1990	a	1.404	0.844	0.340	0.224	-0.004
	b	*100.0*	*60.1*	*24.2*	*16.0*	*-0.3*

*a = average annual change; b = percentage distribution: $\Delta\ln(Y/gM) = 100$.

The most important result obtained with the neoclassical production function is that *TFP* in the United States has always been very important, though its significance somewhat diminished following the epoch change in the world economy. The neoclassical growth model, however, does not explain either the favorable average *TFP* values or the causes of the mentioned decline in the relative weight of total factor productivity.

Empirical results concerning the role of individual factors of the endogenous model in U.S. productivity growth are summarized in Table 7. They make it possible to draw the following *main conclusions*.

1. The *efficiency of American economy* was somewhat lower than the international level, but with a tendency of gradual improvement.

2. The pure form of embodied technical progress, related primarily to learning by doing, was the *absolutely dominant* factor of productivity growth in the United States to the end of the investigated period. However, the magnitude of this *immobile effect* was decreasing in time.

3. The *first component of the mobile effect*, depending on the equipment of workers with physical capital, contributed close to a quarter of productivity growth and showed a declining trend.

4. The *second component of the mobile effect*, related to education and R&D, insured on average more than a tenth of productivity rise and the share of this factor was continuously increasing.

5. On the whole, it can be stated that in the period 1951–1990, productivity growth in the USA was insured for three quarters by human and for one quarter by physical capital expansion.

3.3. Some International Comparisons

Now we can compare directly the economic performance of the Soviet Union and United States. Let us consider first the dynamics of economic growth. As seen from Table 8, overall the Soviet economy grew almost as rapidly as the American one. But if shorter time intervals are considered, the picture becomes more differentiated. It is visible that Soviet growth performance gradually worsened both in absolute and relative terms. Initially, the rate of economic growth of the USSR significantly surpassed the corresponding U.S. indicator, although the gap between the two superpowers was narrowing. With the epoch change in the world economy, the situation reversed to the advantage of America. Moreover, in the last decade of the existence of the USSR, American economic growth was nearly twice faster than the Soviet one.

Table 8: **Average Annual Growth Rate of GDP in the Soviet Union and the United States**
(in comparable prices of 1985, %)

Period	*USSR*	*USA*	*USSR / USA*
1951–1990	3.46	3.52	0.983
1951–1960	5.16	3.46	1.491
1961–1970	4.83	4.18	1.156
1971–1980	2.37	3.22	0.736
1981–1990	1.53	3.21	0.477

What characterized the *changes in living standard and productivity* which took place in the Soviet and American economies during the period under consideration?

The four-decade post-war development, despite a constant growth, has not yielded the ultimate result of bringing Soviet GDP per inhabitant closer to the analogous U.S. indicator.

During the first two decades following the post-war reconstruction of national economy, the Soviet Union managed to narrow substantially the gap that separated it from the United States in the given respect. Yet, subsequently, this gap began widening, and by the early 1990s, the relative living standard of the USSR fell back to the 1950 level. At the same time, in terms of productivity measured by GDP per person employed, the Soviet economy was able to achieve better results that brought it somewhat closer to the advanced American level. However, here too, the initial convergence lasted only to the early 1970s when a reverse trend prevailed (see Table 9).

Table 9: **GDP per Capita and per Person Employed in the Soviet Union and the United States**

Year	*GDP per inhabitant*			*GDP per person employed*		
	USSR	USA	USSR / USA	USSR	USA	USSR / USA
	in thousand dollars of 1985*		(%)	in thousand dollars of 1985*		(%)
1950	2.98	7.68	38.8	6.69	19.24	34.8
1960	4.14	9.09	45.5	9.28	23.98	38.7
1970	5.85	12.06	48.5	12.68	30.17	42.0
1980	6.74	14.91	45.2	13.69	33.43	41.0
1990	7.23	18.63	38.8	15.01	38.46	39.0

* At purchasing power parity (PPP): 1 dollar = 0.397 rubles.

Can the endogenous model really explain the growth performance of the Soviet and American economies? To answer this question, we used relation (4').

Regarding the whole study period, there is practically not even a tenth percent divergence between the actual and calculated rates of productivity growth, particularly in the case of the Soviet economy. It is also visible that the epoch change in the world economy brought about a not too significant (below two percent per annum) and decreasing negative balance for the USSR. On this basis, it can be asserted that the endogenous model explains with a good approximation the economic growth of both the USSR and USA, without using such an indicator as *TFP* (see Table 10).

Table 10: **Actual and Estimated Magnitude of Productivity Growth in the USSR and the USA**

$\Delta\ln(Y/L)$ (annual average, %)

Period	*USSR*	*USA*
1951–1990	2.0 (0.0)	1.8 (0.1)
1951–1960	3.3 (0.2)	2.2 (0.1)
1961–1970	3.2 (0.1)	2.3 (0.1)
1971–1980	0.8 (-1.5)	1.0 (0.1)
1981–1990	0.9 (-0.3)	1.4 (0.0)

* In parentheses is fact – estimate.

Table 11: **Actual and Estimated Magnitude of Productivity Difference**

(United States – Soviet Union)

Year	*Indicator*	$\Delta\ln(Y/L)$	$1/3\Delta\ln(K/L)$	ΔG
1950	Logarithm	2.530	1.578	2.482
	%	*100.0*	*62.4*	*98.1*
1960	Logarithm	2.688	1.605	2.629
	%	*100.0*	*59.7*	*97.8*
1970	Logarithm	2.862	1.613	2.802
	%	*100.0*	*56.4*	*97.9*
1980	Logarithm	2.983	1.578	2.894
	%	*100.0*	*52.9*	*97.0*
1990	Logarithm	3.155	1.537	3.048
	%	*100.0*	*48.7*	*96.6*

In order to analyze the differences in productivity between the USSR and USA, we used formulas (3) and (4'). In case of comparative analysis, component $\lambda\Delta t$ drops out of relation (3), as comparison is made for the same years. The empirical results are contained in Table 11. It can be ascertained that the neoclassical model considerably underestimates the productivity difference between the Soviet Union and the United States. From the cited data, it is also evident that with the endogenous model, one is able to estimate and explain substantially better the economic development level differences than with the neoclassical model.

Table 12: **Intensity Indicators of the Soviet and American Economies**

Indicator	Unit of measurement	Country	1950	1960	1970	1980	1990
K/L	thousand dollars* per person	USSR	8.37	17.70	33.77	58.51	93.78
		USA	122.56	141.58	160.65	172.81	194.86
		USSR/USA, %	*6.8*	*12.5*	*21.0*	*33.9*	*48.1*
H/L	schooling years per person	USSR	7.01	7.99	9.14	9.23	10.50
		USA	7.78	8.49	9.53	11.86	11.74
		USSR/USA, %	*90.1*	*94.1*	*95.9*	*77.8*	*89.4*
R_{t-2}/L	per mille	USSR	1.18	3.02	7.35	9.96	10.95
		USA	2.12	5.18	6.72	5.86	7.65
		USSR/USA, %	*55.7*	*58.3*	*109.4*	*170.0*	*143.1*
Z/L	hectares per person	USSR	2.81	2.50	2.08	1.77	1.65
		USA	3.18	2.69	2.33	1.88	1.55
		USSR/USA, %	*88.4*	*92.9*	*89.3*	*94.1*	*106.5*
O_{t-1}/L	oil tons per person	USSR	139.38	162.03	212.15	268.07	364.18
		USA	130.31	155.27	150.33	87.80	62.89
		USSR/USA, %	*107.0*	*104.4*	*141.1*	*305.3*	*579.1*

* In prices of year 1985.

How did the *intensity indicators* change in the Soviet economy relative to the American one?

From data in Table 12, it is visible that Soviet capital intensity, starting from a strikingly low level, achieved less than a third of the U.S. level by the end of the investigated period, which testifies to a relatively backward technological base (at least as far as civilian production is concerned). At the same time, the Soviet Union significantly and increasingly surpassed the United States in terms of mineral resource intensity, while its relative land intensity became higher only on the eve of the dissolution of the Soviet state. By the early 1970s, the USSR had managed to outperform the USA in research intensity and, despite a setback during the 1980s, preserved its leadership to the end. Yet, the relatively high Soviet educational attainment never caught up with the American level.

Although the USSR and the USA had essentially different political and social models of state, the processes of scientific and technological progress proceeded there practically in a parallel direction. This additionally confirms that they had identical models of development. Both counties relied on the necessity to cover the next turn of scientific and technological progress at the expense of expanding markets, although their technologies of market use to cover expenditures were different. But this did not change the essence of the process of financing scientific and technological progress at the expense of consumers in the USA or through a centralized redistribution of social funds in the USSR (*Khazin*, 2008: 3).

3.4. The Issue of Military Spending

There is an opinion that excessive military spending was one of the causes that eventually led to the collapse of the USSR. Although some authors believe, as noted above, that this issue is not of crucial importance, it deserves a closer examination. It should be pointed out that the analysis of this problem is complicated by the fact that several different estimates have been made concerning the Soviet defense budget. Therefore below we will consider various comparisons of Soviet and American military expenditures and try to make a comparison of our own based on purchasing power parity.[7]

Table 13: **Comparative Military Expenditures of the USSR and the USA** (1960–1990)

Year	*Soviet Union*				*United States*			
	Military expenditure, billion rubles	Share of military expenditure in state budget, %	Military expenditure per inhabitant, rubles	Share of military expenditure in GNP, %	Military expenditure, billion rubles	Share of military expenditure in state budget, %	Military expenditure per inhabitant, rubles	Share of military expenditure in GNP, %
1960	15.3	20.9	75.4	7.5	48.1	45.0	251.0	8.2
1970	29.2	18.9	97.3	7.3	81.7	39.4	399.7	7.8
1980	48.9	16.6	180.7	7.4	141.6	22.5	590.0	5.0
1985	63.4	16.4	237.3	6.1	252.7	25.9	1056.0	6.2
1988	76.9	16.7	269.8	8.9	292.8	26.5	1200.0	5.9
1989	77.3	16.1	269.6	8.4	303.6	25.5	1224.2	5.7
1990	71.2	13.9	244.8	7.5	296.3	25.5	1204.5	5.4

Source: *Timoshenko* (2012).

As for available data, the relatively longest period seems to be covered by estimates for selected years between 1960 and 1990, presented by *Timoshenko* (2012). They show that in this period, Soviet military spending made up on average somewhat above a quarter of the corresponding American indicator in absolute terms. At the same time, the share of military expenditure in state budget in the USSR accounted for about three-fifths of the analogous share of the USA. Although the Soviet share of military spending in GNP was 1.2 times higher than the American one, military expenditure per inhabitant was more than four times higher in the United States than in the Soviet Union. However, these data should be treated with reserve, as comparisons here are made in rubles on the basis of official exchange rates, which may seriously distort the real picture (see Table 13).

Table 14: **Comparative Military Expenditures of the USSR and the USA** (1985–1991)

Year	*Military expenditure in billion dollars*		*GDP in billion dollars*		*Share of military expenditure in GDP, %*	
	USSR	USA	USSR	USA	USSR	USA
1985	277	258	2118	4054	13.1	6.4
1986	237	280	2250	4278	12.7	6.5
1987	303	288	2348	4544	12.9	6.3
1988	319	293	2507	4908	12.7	6.0
1989	303	304	2648	5267	11.5	5.8
1990	292	306	2660	5563	10.9	5.5
1991	260	280	2531	5741	10.3	4.9

Source: *Yanovsky* and *Deryugin* (1999: 99).

[77] All value data here are expressed in current prices. *Gy.S.*

More realistic data were presented earlier by *Yanovsky* and *Deryugin* (1999) for the perestroika years (1985–1991) (see Table 14). According to their estimates, the military budget of the USSR in absolute terms was on average almost as large as the military budget of the USA. However, the Soviet share of military expenditure in GDP surpassed twice the analogous American indicator. Thus, the Soviet economy seems to have been more burdened by defense spending than the American one. Although this comparison of the Soviet and American military expenditures was expressed in U.S. dollars, *Yanovsky* and *Deryugin* (1999) based the relevant estimates for the Soviet Union on the official exchange rates in a manner similar to the estimates cited by *Timoshenko* (2012) for the ruble value of the military budget of the United States.

By the early 1970s, the Soviet Union had become a superpower whose position determined the military equilibrium in the world. This makes justifiable to consider in more detail the changes in the Soviet and American defense expenditures in the period between 1970 and 1991. As seen from data based on PPP estimates cited in the Appendix, the American defense budget in that period was on average 1.5 times larger than the Soviet one. At the same time, the average share of defense spending accounted for 12.3% of the Soviet and 6.7% of the American GNP. Yet, in per capita terms, this spending made up 513 dollars in the USSR contrary to 898 dollars in the USA.

4. Conclusion

In this paper, we endeavored to define the main characteristics of Soviet-American economic competition at a macro level in the course of the four decades between 1950 and 1990. We wished to reveal what factors determined the growth rate differences in the Soviet Union and the United States, as well as the differences in the levels of income. The concrete subject of our investigation was the rise in macroeconomic productivity and its determinant factors, which also implied an investigation of the nature of technical progress. For that purpose, we used two growth models – a neoclassical and an endogenous one.

The empirical results on the whole corroborated our hypothesis that the USSR eventually lost to the USA the race of hegemony in the economic sphere primarily because of a lower efficiency of production.

The use of the *neoclassical production function* showed that *in the Soviet economy, productivity growth was decisively determined by embodied technical progress, whereas in the American economy, its main component was total factor productivity*. These findings are in total accordance with the results of research concerning the hypothesis of extensive Soviet economic growth driven primarily by input accumulation and reflecting relatively high capital-output ratios.

The applied *endogenous growth model* allowed us to ascertain that in both countries, *the most important factor of productivity growth was the immobile effect*, reflecting primarily learning by doing. *Human capital and creativity affected productivity increase in the Soviet Union to a smaller extent than in the United States*. Moreover, the Soviet economy, was burdened by a quite *high relative level of defense spending*.

APPENDIX

Main Macroeconomic Indicators of the Soviet Union

Year	Y^{*}	K^{**}	*L*	*H*	R_{t-2}	*Z*	O_{t-1}	*N*
1950	535	669	79.97	7.01	94	225	11146	179.6
1951	538	705	81.25	7.11	103	225	11317	182.7
1952	573	761	82.23	7.21	113	225	11496	185.9
1953	597	818	83.22	7.30	123	222	11714	189.0
1954	626	984	85.46	7.39	133	220	12069	192.2
1955	680	1076	86.14	7.49	145	220	12437	195.6
1956	745	1178	87.08	7.56	157	221	12896	199.1
1957	760	1296	88.56	7.66	183	227	13440	202.6
1958	817	1374	89.36	7.77	213	229	14175	206.2
1959	808	1543	93.14	7.88	248	230	14908	209.9
1960	885	1688	95.37	7.99	288	238	15453	213.8
1961	936	1842	97.16	8.09	336	240	15993	217.6
1962	961	2053	98.98	8.18	405	240	16551	221.2
1963	939	2244	100.8	8.28	446	239	17129	224.6
1964	1061	2427	102.7	8.38	490	237	17727	227.7
1965	1121	2631	104.6	8.48	539	237	18481	230.5
1966	1175	2822	106.1	8.61	593	234	18986	233.1
1967	1227	3014	107.5	8.74	665	234	19649	235.6
1968	1299	3241	108.9	8.87	712	233	20337	238.0
1969	1317	3483	110.4	9.00	770	233	21700	240.3
1970	1419	3779	111.9	9.14	823	233	23740	242.5
1971	1457	4080	113.7	9.17	883	233	21782	244.9
1972	1465	4420	115.6	9.19	928	233	23241	247.3
1973	1588	4759	117.4	9.22	1003	232	24821	249.7
1974	1634	5135	119.2	9.25	1056	233	26633	252.1
1975	1638	5515	121.3	9.27	1108	232	28098	254.5
1976	1716	5891	123.2	9.26	1170	233	29387	256.9
1977	1756	6353	125.1	9.25	1233	233	30735	259.2
1978	1800	6763	127.1	9.24	1256	232	32145	261.5
1979	1791	7177	129.1	9.23	1280	231	33619	263.8
1980	1793	7665	131.0	9.23	1305	232	35117	265.9
1981	1810	8125	132.1	9.34	1330	232	35231	268.1
1982	1854	8661	133.5	9.44	1373	232	35346	270.4
1983	1914	9197	134.4	9.54	1411	232	36419	272.7
1984	1938	9730	136.3	9.65	1432	232	37525	275.3
1985	1956	10265	136.3	9.77	1440	232	38665	277.8
1986	2036	10778	137.1	9.91	1464	232	40148	280.3
1987	2062	11291	137.8	10.06	1491	232	41689	282.7
1988	2106	11941	138.4	10.21	1501	232	43288	285.0
1989	2138	12523	139.1	10.36	1518	230	46811	286.5
1990	2086	13036	139.0	10.50	1522	229	50621	288.4

*1 dollar = 0.397 rubles. - ** 1 dollar = 0.262 rubles.

Source: Народное хозяйство СССР, ЦСУ/Госкомстат, Москва; Statistical Yearbook, National Accounts Statistics, Energy Statistics Yearbook, UN, New York; Yearbook of Labour Statistics, ILO, Geneva; FAO Production Yearbook, Rome; UNESCO Statistical Yearbook, Paris, various volumes; *Heston* et al. (1995); *Hall* and *Jones* (1999); *Barro* and *Lee* (2000); *The Conference Board* (2013).

Main Macroeconomic Indicators of the United States

Year	*Y*	*K*	*L*	*H*	R_{t-2}	*Z*	O_{t-1}	*N*
1950	1169	7448	60.77	7.78	129	193	7919	152.3
1951	1258	7606	63.21	7.85	143	193	8392	154.9
1952	1304	7816	64.00	7.92	158	193	8356	157.6
1953	1364	8011	64.85	7.99	175	193	9016	160.2
1954	1356	8213	63.58	8.06	193	188	9106	163.0
1955	1451	8430	65.36	8.13	214	188	9546	165.9
1956	1479	8665	66.83	8.20	237	187	9856	168.9
1957	1507	8907	67.08	8.27	249	186	10046	172.0
1958	1492	9158	65.88	8.34	280	186	10263	174.9
1959	1603	9438	67.38	8.42	315	185	10627	177.8
1960	1643	9701	68.52	8.49	355	184	10639	180.7
1961	1681	9973	68.56	8.61	370	183	10760	183.7
1962	1783	10272	69.70	8.73	386	179	10851	186.5
1963	1860	10573	70.69	8.85	425	181	11024	189.2
1964	1967	10940	72.25	8.97	442	180	11012	191.9
1965	2092	11364	74.02	9.09	481	179	11191	194.3
1966	2230	11758	76.26	9.18	498	178	11272	196.6
1967	2286	12161	78.03	9.26	497	176	11350	198.7
1968	2394	12527	79.63	9.35	508	183	11186	200.7
1969	2470	12828	81.58	9.44	529	191	10681	202.7
1970	2474	13173	82.00	9.53	551	191	12327	205.1
1971	2551	13617	82.32	9.56	554	190	11857	207.7
1972	2686	14017	84.76	9.59	544	189	11367	209.9
1973	2839	14411	87.56	9.63	524	189	10837	211.9
1974	2831	14949	89.20	9.66	520	188	10384	213.9
1975	2823	15369	88.20	9.69	520	188	9956	216.0
1976	2971	15728	91.06	10.09	521	188	9424	218.0
1977	3105	16173	94.32	10.51	530	188	9101	220.2
1978	3283	16486	98.33	10.94	544	191	8662	222.6
1979	3394	16895	101.1	11.35	555	191	8863	225.1
1980	3396	17558	101.6	11.86	595	191	8920	227.7
1981	3480	18266	102.7	11.80	623	191	9118	230.0
1982	3415	18902	101.9	11.74	659	190	9297	232.2
1983	3558	19359	103.2	11.67	691	190	9261	234.3
1984	3817	19811	107.4	11.63	702	190	9617	236.3
1985	3965	20344	109.6	11.57	723	190	9460	238.5
1986	4101	20956	112.0	11.60	798	190	9306	240.7
1987	4264	21580	114.9	11.64	849	188	9155	242.8
1988	4425	22304	117.4	11.67	897	188	8610	245.0
1989	4578	23048	119.7	11.71	923	188	8096	247.3
1990	4658	23598	121.1	11.74	927	188	7616	250.1

Source: Statistical Abstract of the United States U.S. Department of Commerce, Bureau of the Census, Washington, D.C.; Statistical Yearbook, National Accounts Statistics, Energy Statistics Yearbook, UN, New York; Yearbook of Labour Statistics, ILO, Geneva; FAO Production Yearbook, Rome; UNESCO Statistical Yearbook, Paris, various volumes; U.S. Department of Commerce, Bureau of Economic Analysis; *Heston* et al. (1995); *Hall* and *Jones* (1999); *Barro* and *Lee* (2000); *The Conference Board* (2013).

Total Defense Burden of the USSR and the USA
(1970–1991)

Year	*Defense expenditure in billion current dollars* at purchasing power parity		*GNP in billion current dollars* at purchasing power parity		*Share of defense expenditure in GNP, %**		*Defense expenditure per inhabitant, USD at PPP**	
	USSR*	USA	USSR*	USA	USSR	USA	USSR	USA
1970	58.48	87.60	337.7	1044.7	17.3	8.4	241	427
1971	64.50	84.55	376.7	1134.4	17.1	7.5	263	407
1972	79.39	86.95	410.9	1246.4	19.3	7.0	321	414
1973	94.55	88.10	475.1	1394.9	19.9	6.3	379	416
1974	99.70	95.55	565.1	1515.0	17.6	6.3	395	447
1975	105.35	103.93	652.4	1650.7	16.1	6.3	414	481
1976	108.16	111.10	737.2	1841.4	14.7	6.0	421	510
1977	115.31	120.88	816.2	2050.4	14.1	5.9	445	549
1978	131.35	130.48	940.0	2315.3	14.0	5.6	502	586
1979	131.01	145.20	1066.1	2594.2	12.3	5.6	497	645
1980	136.12	167.95	1244.9	2822.3	10.9	6.0	512	738
1981	137.07	196.23	1416.5	3159.8	9.7	6.2	511	853
1982	139.42	225.88	1578.8	3289.7	8.8	6.9	516	973
1983	145.18	250.60	1707.3	3571.7	8.5	7.0	532	1070
1984	151.14	281.55	1832.5	3967.2	8.2	7.6	549	1191
1985	162.82	311.18	1957.2	4244.0	8.3	7.3	586	1305
1986	188.18	330.80	2042.2	4477.7	9.2	7.4	671	1375
1987	224.67	349.98	2165.4	4754.0	10.4	7.4	795	1441
1988	228.22	354.73	2365.9	5123.8	9.6	6.9	801	1448
1989	217.81	362.10	2524.9	5508.1	8.6	7.1	760	1464
1990	187.41	373.85	2318.3	5835.0	8.1	6.4	650	1495
1991	150.32	383.10	2064.1	6022.0	7.3	6.4	519	1511

* Author's calculations.
Source: *Steinberg* (1992: 262–263); *Heston* et al. (1995, 2002, 2006); *The Conference Board* (2013); Data 360; U.S. Department of Commerce, Bureau of Economic Analysis.

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