CENTER FOR SOCIAL AND ECONOMIC RESEARCH

Khreschatik Str. 10B, #410
252001 Kyiv
Ukraine

Tel. (38-044) 228-8660/ 228-1349
Fax (38-044) 228-8660/ 228-1349
E-mail: case@case.kiev.ua

An Approach to Forecasting Ukrainian GDP from the Supply Side

by Alina Kudina

Kyiv,
Ukraine

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INTRODUCTION

The aim of this paper is to provide some insights on estimation and forecasting of Ukrainian GDP from the supply side. The aggregate output is modeled on the basis of aggregate production function that was estimated on the official data for 33 branches of the economy. Later the model was enhanced by allowing for some level of disaggregation. In this attempt production functions for major sectors (manufacturing, agriculture, services etc.) were estimated separately, that help to account for industry peculiarities.

Though theory underlying this study is rather straightforward, the Ukrainian ground on which it was applied assures a challenge for a researcher. The major difficulties are linked to the transitional state of the economy, which is characterized by structural breaks, considerable changes in statistical methodology, poor quality of data, very short time series, inconsistency of some indicators, lack of stable economic relationships and significant shadow economy.

THEORY & ASSUMPTIONS

The study is based on the neo-classical theory of production and distribution that invokes the principles of marginal productivity embodied in an aggregate production function for the economy as a whole.

Despite a criticism of simple functional forms that rarely provide a good representation of data, empirical models that fit the data well are often 'ad hoc' and may, at worse, violate the basic requirement of consistency with theory, and at best not fully exploit the information offered by theory. Therefore, one compromise between these two extremes is to base a model around a well-specified theoretical framework which is implemented through a set of functional forms that are sophisticated enough to provide a good representation of the data (Allen and Hall, 1997).

As for today there exists a wide range of functional forms having the properties economists favor (homogeneity, positive substitutability, positive but less than infinite complementarity between factors). All of them, however, embody the trade-off between simple functional forms and good representation of the data. This section explores the most popular functional forms, which have been discussed in the literature. [*]

1. The Cobb-Douglas production function.

This function was brought up by the observation that the share of labor in the US national income was a constant, at around 75%, despite wide fluctuations in the relative prices of labor and capital. Under constant returns to scale (homogeneous of degree one in factors)

[*] This part relies greatly on Allen, Chris and Hall, Stephen (1997). *Macroeconomic Modeling in a Changing World*. John Wiley & Sons.

and the pricing of factors at their marginal products, the only function compatible with this observation was

$$\mathbf{Y} = \mathbf{A*K^{a}*L^{b}} \qquad (1)$$

The properties of the function can be trivially derived:

1) *The returns to scale of the function are given by* $a+b$*;* usually it is equated to unity that expresses constant returns to scale (Allen and Hall, 1997);
2) a *and* b *parameters equal the value shares of inputs in the value of output* under certain assumptions:
   - competitive markets;
   - firms are profit maximizers that choose inputs such that marginal products equal real prices;
   - production technology followed the constant return to scale specification.

The second property is easily derived from the profit maximization problem. Given that marginal products of labor and capital must be equal to the real input prices, one can obtain:

$$MP_k = \frac{\partial Y}{\partial K} = A * a * \left(\frac{L}{K}\right)^{1-a} = \frac{P_k}{P} \qquad (2)$$

and

$$MP_l = \frac{\partial Y}{\partial L} = A * (1-a) * \left(\frac{K}{L}\right)^{a} = \frac{P_l}{P} \qquad (3)$$

After rearranging, this yields the relationships:

$$a = \frac{P_k * K}{P * Y} \quad \text{and} \quad b = 1 - a = \frac{P_l * L}{P * Y} \qquad (4)$$

3. Elasticity of substitution (s) *between capital and labor equals unity.*

Let's define the elasticity of substitution between capital and labor as

$$s = \frac{\partial \ln(K/L)}{\partial \ln(MP_l / MP_K)} \qquad (5)$$

Than solving for optimal K and L and substituting them into the equation above, one can easily show that for the case of Cobb-Douglas production function s always equals unity.

2. Constant elasticity of substitution (CES) production function.

The first major theoretical advance on the Cobb-Douglas production function was discovered independently by Arrow and Sollow and published in Arrow et al. (1961). This introduced the constant elasticity of substitution production function. Again this was prompted by empirical observation: running regressions of labor productivity on real wages on an international cross-sectional data set resulted in an intermediate case between the unitary coefficient on the real wage (as would have been expected from Cobb-Douglas production function) and the zero coefficient, which would have been expected from Leontief technology. Arrow et al. noted that such a property would be obtained from the derived demands from a production function which had the form of the mathematical function of a mean of order ρ (Ibid.):

$$Y = A*(\partial * K^{-r} + (1-\partial) * L^{-r})^{-n/r} \qquad (6)$$

CES function exhibits the following properties:

1) the returns to scale is given by ν;
2) the elasticity of substitution σ is equal 1/(1+ρ);
3) CES is reduced to the Cobb-Douglas production function when ρ = 0:
4) CES is reduced to the Leontief production function when $\rho \to \propto$.

Therefore the CES production function could be seen as the generalization of both Cobb-Douglas and Leontief production functions. Furthermore, Arrow et al. showed that maintaining positive linear homogeneity, any two-factor production function with constant elasticity of substitution was either Cobb-Douglas or ?ES function. (Ibid.)

The Cobb-Douglas or ?ES production functions together make up an important class of production functions. Samuelson (1965) proved the following representation in the consumer context. Any linearly homogeneous function is strongly separable (or 'additive') if and only if it can be represented as either Cobb-Douglas or ?ES production function (Blaug, 1996).

3. Diewert's generalized Leontief function.

The conceptual breakthrough that allowed the derivation of true flexible functional forms for more than two variables came about as a result of duality theory. The problem of developing flexible functional forms with three or more inputs, which were less restrictive than the Cobb-Douglas or CES functions, was solved by Edwin Diewert (1971). He made use of two properties of duality theory. The first was Shephard's duality theorem, which states that technology may be equivalently represented by a production function satisfying certain regularity conditions, or by a cost function satisfying a second set of regularity conditions. Secondly, Diewert used what has become known as Shephard's lemma, namely if a cost function is at least once differentiable with respect to input prices, then the optimal factor demands are given by the derivative of the cost function with respect to own factor price (Allen and Hall, 1997).

Therefore, one may take an arbitrary differentiable cost function, which obeys a set of regularity conditions, and then use Shephard's lemma to straightforwardly derive a set of factor demand functions from it.

However, since the goal of this paper is to explore production functions, let us move to the translog specification of production and cost function.

4. The translog production and cost function.

Almost simultaneous with the work of Diewert, a second flexible functional form was proposed, namely the transcendental logarithmic or translog. It had its origins in Kmenta's (1967) log-linearization of the CES production function which can be written in the form (Ibid.):

$$\log Y = \log g - \frac{n}{r}\log(dK^{-r} + (1-d)L^{-r}) \qquad (7)$$

Kmenta used a second-order Taylor series to approximate the CES production function around (ρ = 0) as a quadratic function of logarithms:

$$\log Y = \log g + nd\log K + n(1-d)\log L - \tfrac{1}{2}rnd(1-d)(\log(K/L))^2 \qquad (8)$$

The resulting function is linear in variables and could therefore be estimated by ordinary least squares (OLS) (Ibid.).

The generalization of Kmenta's work became estimation of a production function as a general, unrestricted quadratic function of logarithms. Christensen, Jorgenson and Lau used transcendental function of the logarithms of the functions arguments. For instance, take the aggregate production frontier

$$F(C, I; L, K) = 0 \qquad (9)$$

where C and I are outputs of consumption and investment goods, respectively, and Land K are inputs of labor and capital. We can approximate the logarithm of the production frontier (plus unity) by a quadratic function of inputs and outputs: (Ibid.)

$$\begin{aligned}
&\ln(f+1) = a_0 + a_c \ln C + a_i \ln I + a_l \ln L + a_k \ln K \\
&+ \ln C * (\tfrac{1}{2} b_{cc} \ln C + b_{ci} \ln I + b_{cl} \ln L + b_{ck} \ln K) \\
&+ \ln L * (\tfrac{1}{2} b_{ii} \ln I + b_{il} \ln L + b_{ik} \ln K) \\
&+ \ln L * (\tfrac{1}{2} b_{ll} \ln L + b_{lk} \ln K) \\
&+ \ln K * (\tfrac{1}{2} b_{kk} \ln K) \qquad (10)
\end{aligned}$$

Relative factor demands can be derived from the condition that under profit maximization the relative price ratio is equal to the marginal rate of transformation between any two commodities:

$$\frac{p_l L}{p_k K} = \frac{\partial \ln F / \partial \ln L}{\partial \ln F / \partial \ln K} = \frac{a_l + b_{cl} \ln C + b_{il} \ln L + b_{ll} \ln L + b_{kl} \ln K}{a_k + b_{kc} \ln C + b_{ki} \ln I + b_{kl} \ln L + b_{kk} \ln K} \qquad (11)$$

This is briefly the most popular functional forms applied to production analysis. Although more sophisticated functional forms could represent economic processes more fully, data limitations in Ukraine make the simplest one, i.e. Cobb-Douglas, the most appealing. Although Cobb-Douglas function is rather abstract and suffers from a number of drawbacks, F. M. Fisher discovered that "an aggregate Cobb-Douglas production function predicts labor's share quite successfully, provided that the share is held roughly constant over the time-period of the simulation exercise" (Blaug, 1996). Therefore, on the assumption that this condition holds true for Ukraine over 1995-98, this approach is expected to provide a meaningful estimation of inputs' shares in Ukraine's total value of output.

DATA & PROXIES.

The official data on value added, employment, average wage and gross capital accumulation for 1995 - 1998 were used while estimating the model, which employs yearly time series for 23 sectors of the economy. More precisely, the following data sources were among the most important:

1) Statistical yearbooks (both general and for sectors of the Ukrainian economy), Derzhcomstat;
2) "Input – output" tables, Derzhcomstat;
3) "Bulletin of Economic Conjuncture", Derzhcomstat.

There is a word to mention about quality of data. Besides common flaws of macroeconomic statistics, there is a bunch of country specific peculiarities that aggravate this problem in Ukraine. These drawbacks could be classified into 2 groups: first are common to all transition economies, while second are Ukraine specific. The former is connected to the transition from plan to market that is usually accompanied by following problems:[1]

- *The underreporting of output*. Many observers believe that the size of the decline in output in the early stages of the reforms may have been overstated by official statistics, and, conversely, that the strength of the subsequent recoveries is likely to be understated. This happens due to thorough reporting of decline in traditionally important sectors (industry, transport etc.) and underreporting of growth in private sector, which existing statistical tools fail to capture.
- *Index number biases.* Since the index of total real output requires the comparisons of the values of different physical outputs, the inconsistency in price settings (in the market economy prices reflect relative values, while under the plan they show relative production costs, that do not reflect relative scarcities) distorts value of index.

[1] This part is adapted from the IMF's *World Economic Outlook* (Washington: International Monetary Fund, 1994).

- *Changes in the type and quality of output.* Though the problem how to measure the value of new goods and services exists in all countries, it becomes extremely severe in countries in transition due to the large number of new goods coming there, end of shortages and more efficient investment. What is more, in the plan economy the output that could not be sold, was nevertheless considered as output, yet it had no true economic value, therefore its disappearance from the market (decline in production) should not have been counted as a reduction in output.

Ukraine specific flaws are stipulated by:

- *Inconsistent methodology* of calculation of some indicators. It is not rare that different statistical offices show different figures regarding the same indicator. It happens since methodology of Ministry of Economy does not coincide with that of Ministry of Finance, Statistics Committee or sectoral ministries and agencies. To understand which indicator is more reliable, one needs to know how these figures are calculated, and here comes the second flaw:

- *Lack of information about methodological principles.* It is very hard to find out what is behind a certain macroeconomic indicator. Numerous bulletins do not provide methodological information, thus the only way to obtain it is through personal contacts with persons responsible for its calculation (if they are willing to share it).

- *Significant shadow economy* that, if not considered, will question any result built on official data. Shadow economy spoils almost all indicators, from monetary and fiscal ones to those of the real sector. Though there are some approaches to estimation of shadow economy in countries in transition, all of them, though being rather complicated, do not provide powerful tools to overcome this problem.

- *Significant share of non-monetary transactions (barter, offsets, promissory notes)* tend to create an upward bias in value-added statistics and other price-based indicators. This bias occurs due to reporting of non-monetary transactions at their face value that frequently exceeds their true market value (evidenced in cash transactions). Fundamentally, these non-monetary transactions are essentially a survival device for many loss-making (i.e. value-destroying) enterprises, which by overstating their revenues still may report positive value added.

Besides above-mentioned shortcomings, the quality of data varies from indicator to indicator and from sector to sector. In the Ukrainian setting one can trust more gross investment figures than gross profit and salaries counterparts. As for sectors, agriculture provides the weakest figures since it naturally suffers from shadow activities and for the time being official statistics covers less than 50% of the total activity. On the other hand, non-monetary transactions are also higher than average in the sector.

The data for industry are better owing to more severe financial/accounting discipline. However, they are vulnerable to political pressures, which make them upward biased.

Besides, there is a noticeable variability across sectors in significance of non-monetary transactions (high in heavy industries and lower in consumer and export oriented counterparts).

In contrast, the sector of services provides the most reliable data owing to its quite severe financial discipline, low weight of non-monetary transactions and lack of political pressure that distort industrial indicators.

Despite above-mentioned drawbacks, the attempt to model supply side of the Ukrainian economy appears to be rather promising and could be enhanced, if we manage to incorporate our knowledge about the data.

Now let us go on with the description of the estimates. The nominal value added and adjusted employment were chosen as standard proxies for output and labor. As it was mentioned above, indicator of value added is vulnerable to distortions from shadow activities, political pressures and non-monetary transactions, therefore adjustment for these drawbacks in data and incorporation of shadow sector indicate possible ways of model enhancement.

The inaccuracy of series on capital originates not in the poor quality of data on capital stock, but in their total absence. Therefore, I have no other option but to fill this gap with own estimates. The capital series were calculated according to the following rule:

$$\mathbf{K_t = K_{t-1} + I - d*K_{t-1}} \qquad (12)$$

where K_t - capital,
I - gross capital accumulation (Derzhcomstat data),
δ - depreciation rate.

The basic stock of capital was calculated as share of yearly value added, by assigning weights from 2 – 10 % (for the heaviest branches the share was 10%, descending to 2% for the lightiest counterpart). Those rates are derived from observed patterns in comparable economies (mostly Poland), while the depreciation rate is estimated on the Ukrainian ground. As a rule, it was taken at about 5% for light industries descending to 2% for heavy counterparts.

THE MODEL

1. Estimation

Since historical period consists of only 4 observations, time series approach cannot be of use due to insufficient number of records. Therefore, the model was estimated using panel data approach (annual time series and cross-section data on 33 branches of the economy). Like cross-section data, panel data describe each sector of the economy. Like time-series data, they describe changes through time. By blending characteristics of both cross-section and time-series data, more reliable empirical results can be obtained owing

to significant increase in degrees of freedom that provides more robust hypothesis testing. What is more, panel data help to disregard heterogeneity among different groups (sectors) in the sample.

Still the model was built on data for only 23 branches since for 10 other some indicators were unavailable. Therefore the final panel consist of 92 observations that is sufficient for robust econometric analysis.

As it was mentioned above, the standard Cobb-Douglas production function in double-log form can be written as following:

$$\mathbf{ln\ Y = ln\ A} + a\mathbf{ln\ K} + b\mathbf{ln\ L} \qquad (13)$$

(where Y stands for output, α and β are relative shares of inputs (capital (K) and labor (L) respectively, and A is the hypothetical level of technology).
Using assumption of constant returns to scale ($\alpha+\beta = 1$), it is easy to obtain the following specification

$$\mathbf{ln\ (Y/L) = ln\ A} + a\mathbf{ln\ (K/L)} \qquad (14)$$

Though it is assumed that all branches have equal shares of inputs in the value of output, the differences among branches are captured by constant term, i.e. level of technology or so-called fixed effects. The estimated equation is given below with t-statistics in parentheses (Generalized Least Squares (GLS) procedure was used in estimation).

$$\mathbf{ln\ (Y/L) = C + \underset{(2.\ 31)}{0.0773}\ ln\ (K/L)} \qquad (15)$$

$$\mathbf{R^2 = 0.999103}$$
$$\mathbf{DW = 1.657}$$

For more detailed information (values of fixed effects) please look at the Appendix 1.

As one can notice, the equation is characterized by powerful statistics, i.e. T- statistic of 2.31 indicates sufficient significance of capital coefficient as it allows to reject hypothesis about no relationship between output and capital only at 2% level. The value of Durbin Watson statistics (DW) assures rejection of hypothesis about serial correlation in residuals at the 5% level, which is crucial in our case since it provides the means for neglecting doubts about the efficiency of forecast. R-square of 99.91% implies good fit of the model as 99.91% of dependent variable variation is explained by variation in the explanatory term.

Coming back to the initial form, one can obtain:

$$\mathbf{ln\ Y = C + 0.077\ ln\ K + 0.923\ ln\ L} \qquad (16)$$

From the equation above estimated elasticity of output with respect to capital is 0.077 and that with respect to labor is 0.923. Whereas values of estimated elasticities diverge from

habitual estimates (the elasticity with respect to labor or value share of labor in the value of output is quite large), there are grounds to believe that this pattern is very characteristic for Ukraine, considering its largely depreciated capital and low-cost labor that justifies labor-intensive technologies.

It is remarkable that equation yields negative values of fixed effects (see Appendix 1) that stay for the level of technology in the sectors. This pattern represents clearly the present situation in Ukraine that is characterized by continuous technological regress. The enterprises, lacking funds not only for investment and renovations but also for simple repairs, find themselves with more and more depreciated fixed assets, and, hence, with increasingly deteriorating level of technology.

2. Sectoral Estimates

Although estimation of aggregate production function provides overall understanding of production relationships in Ukraine, more precise estimates could be obtained by estimation of sector specific coefficients.

In this regard, 2 groups of rather homogeneous industries were identified:

1) **Manufacturing** (electric power, oil and gas, coal, ferrous metallurgy, non-ferrous metallurgy, chemical and petrochemical industry, machine-building and metal-workingindustry, wood-working, pulp and paper industry, construction material industry that includes glass and porcelain-faience industries, textiles/apparel, food).

2) **Services of productive type** (transport, communication, commerce and public catering, procurement, material and technical supply and distribution).

The identical estimation procedure was applied to these groups of industries and the following results were obtained:

Manufacturing:

$$\ln (Y/L) = C + \underset{(4.\ 22)}{0.239} \ln (K/L) \qquad (17)$$

$$R^2 = 0.998734$$

that implies

$$\ln Y = C + 0.239 \ln K + 0.761 \ln L \qquad (18)$$

Services of productive type:

$$\ln (Y/L) = C + \underset{(1.94)}{0.188} \ln (K/L) \qquad (19)$$

$$\mathbf{R^2 = 0.999351}$$

that implies

$$\mathbf{\ln Y = C + 0.188 \ln K + 0.812 \ln L} \qquad (20)$$

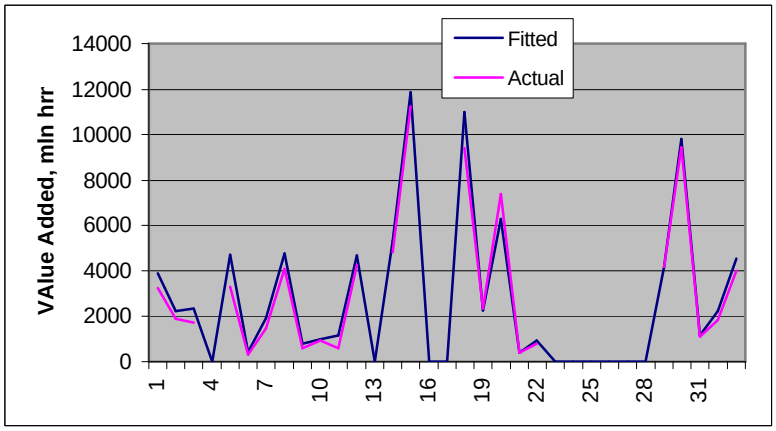
A remarkable feature of the estimated equations is much bigger share of capital in the value of output than that in the aggregated equation. For instance, in the manufacturing sector share of capital is about 23.9%, while in the sector of services of productive type the corresponding value is 18.8%, however in the whole economy the corresponding share is only 7.8%. Nevertheless, this pattern is not surprising, since it confirms the intuition behind the figures: the closer the branch is to heavy industry the higher the intensity of capital use.

3. Extrapolation & Forecast

The extrapolation was done on the basis of the equations above. The method of estimation is multi-step forecast, i.e. dynamic solution. The extrapolation was run on quarterly series (contrary to yearly estimates), since this model is aimed to be consistent with the CASE's quarterly model of the economy of Ukraine. Whereas quarterly labor series are easily available, series on the capital are still scarce, therefore they were obtained by distributing yearly data according to employment. Specifically, yearly change in capital stock was distributed by quarters and then added to the previous value.

The extrapolation resulted in quarterly series of the value added. To discuss how well they fit actual values, i.e. what the forecasting power of the model, one need to consider certain criteria. Since Root Mean Squared Error and Mean Absolute Error, which depend on the scale of dependent variable are helpful only while comparing different forecasts, I will discuss relative indicators, i.e. Mean Absolute Percentage Error and Theil Inequality Coefficient, which takes values from 0 to 1 (the closer value is to 0 – the better the fit). As one can notice from the table below, MAPE and Theil coefficient show quite powerful forecasting ability of the model.

The value of bias proportion of 0.069 tells us that the mean of forecast diverges from the mean of the actual series by 0.069, whereas the value of variance proportion of 0.0086 indicates that the variance of the forecasted series deviates from the variance of true series by 0.0086. The value of covariance proportion of 0.984 implies that major part of the forecasting bias is due to unsystematic forecasting errors. The forecasting ability of the model can be more visually seen from the graph below.

Value Added by Sectors, 1998	Forecast Criteria
	**MAPE:** Mean Absolute Percentage Error 0.16835 **Theil** Inequality Coefficient: 0.0964 Bias proportion: 0.069 Variance proportion: 0.0086. Covariance proportion: 0.984

The forecast was made for the first half of 1999 (since the labor and capital data are available for this period only). The forecasted value added constituted UAH 58881 mln, while the actual figure is UAH 55267 mln. The forecasted value added in the manufacturing sector (according to the sectoral equation) is UAH 17822 mln, whereas the actual value is UAH 16666 mln. This indicator for the sector of services of productive type constituted UAH 12128 mln comparing to actual figure of UAH 12046 mln.

Therefore, the model under discussion provides rather successful means of forecasting the nominal value added in Ukraine. However, its forecasting ability should grow with time as data on more historical periods will be available, thus more precise estimates could be obtained.

Conclusions

In this paper an attempt to model the supply side of the Ukrainian economy was discussed. It was approached through estimation of aggregate production function in its simplest form, i.e. Cobb-Douglas. Although drawbacks in data, brought by the transitional state of the economy and shortness of time series, made extrapolated and forecasted figures not as accurate as was aimed at the beginning, the final output seems to be rather encouraging and could be enhanced with the expansion of historical period. Other way of model improvement is seen in further disaggregation. The more homogeneous branches in the pool are, the more precise estimates one can obtain.

Although the questions of disaggregation and length of time series can be ultimately overcome, the problem with the quality of data will persist in the nearest future. Despite ameliorating quality, a low reliability of indicators is going to persist since the problems of widespread non-monetary transactions and significant shadow activities would not (and cannot) be resolved soon in Ukraine.

Works Cited

1. Allen, Chris and Hall, Stephen (1997). *Macroeconomic Modeling in a Changing World*. John Wiley & Sons.
2. Blaug, Mark (1996). *Economic Theory in Retrospect*. 5th edition. Cambridge. University Press.
3. Snowdon, Brian; Vane, Howard and Wynarczyk, Peter (1994). *A Modern Guide to Macroeconomics.* Edward Elgar.
4. Ramanathan, Ramu (1995). *Introductory Economterics with Applications.* 3d edition.The Dryden Press.
5. Berndt, Ernst (1996). *The Practice of Econometrics: Classic and Contemporary.* Addison-Wesley Publishing Company.
6. Abdessatar Ouanes and Subhash Thakur (1997). *Macroeconomic Accounting and Analysis in transition Economies.* IMF

Appendix 1.

The Aggregated Production Function

Dependent Variable: LOG(VALC?)
Method: GLS (Cross Section Weights)
Date: 11/25/99 Time: 18:08
Sample: 1995 1998
Included observations: 4
Number of cross-sections used: 23
Total panel (balanced) observations: 92

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(K?/LC?)	0.077302	0.033439	2.311722	0.0238
Fixed Effects				
B1--C	-4.834252			
B2--C	-3.804568			
B3--C	-5.956014			
B5--C	-5.280756			
B6--C	-5.102592			
B7--C	-5.112967			
B8--C	-5.826458			
B9--C	-5.289890			
B10--C	-5.403854			
B11--C	-4.796462			
B12--C	-4.869397			
B14--C	-5.586033			
B15--C	-3.322545			
B18--C	-4.592483			
B19--C	-5.014689			
B20--C	-4.290859			
B21--C	-5.183709			
B22--C	-4.662166			
B29--C	-4.939439			
B30--C	-5.276102			
B31--C	-5.309408			
B32--C	-4.917587			
B33--C	-5.030140			

Weighted Statistics			
R-squared	0.999103	Mean dependent var	-12.66068
Adjusted R-squared	0.998799	S.D. dependent var	8.507955
S.E. of regression	0.294798	Sum squared resid	5.909580
Durbin-Watson stat	1.656951		

Unweighted Statistics			
R-squared	0.841466	Mean dependent var	-5.646566
Adjusted R-squared	0.787844	S.D. dependent var	0.642985
S.E. of regression	0.296162	Sum squared resid	5.964397
Durbin-Watson stat	1.587363		

Appendix 2.

The Manufacturing Production Function

Dependent Variable: LOG(VALC?)
Method: GLS (Cross Section Weights)
Date: 11/25/99 Time: 18:09
Sample: 1995 1998
Included observations: 4
Number of cross-sections used: 11
Total panel (balanced) observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(K?/LC?)	0.239080	0.056628	4.221966	0.0002
Fixed Effects				
B1--C	-3.383084			
B2--C	-2.654098			
B3--C	-4.474116			
B5--C	-3.915443			
B6--C	-3.726942			
B7--C	-3.754151			
B8--C	-5.001234			
B9--C	-4.324777			
B10--C	-3.953980			
B11--C	-3.162994			
B12--C	-3.262489			

Weighted Statistics			
R-squared	0.998734	Mean dependent var	-12.47817
Adjusted R-squared	0.998298	S.D. dependent var	8.892168
S.E. of regression	0.366801	Sum squared resid	4.305386
Durbin-Watson stat	1.517077		

Unweighted Statistics			
R-squared	0.743249	Mean dependent var	-5.753097
Adjusted R-squared	0.654991	S.D. dependent var	0.641607
S.E. of regression	0.376864	Sum squared resid	4.544839
Durbin-Watson stat	1.673107		

Appendix 3.

The Production Function for the Sector of Services of Productive Type:

Dependent Variable: LOG(VALC?)
Method: GLS (Cross Section Weights)
Date: 11/22/99 Time: 18:18
Sample: 1995 1998
Included observations: 4
Number of cross-sections used: 5
Total panel (balanced) observations: 20
Convergence achieved after 15 iteration(s)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(K?/LC?)	0.188330	0.096981	1.941930	0.0725
Fixed Effects				
B18--C	-3.589541			
B19--C	-3.950090			
B20--C	-3.269954			
B21--C	-4.055920			
B22--C	-3.597099			

Weighted Statistics			
R-squared	0.999351	Mean dependent var	-11.55948
Adjusted R-squared	0.999119	S.D. dependent var	8.803450
S.E. of regression	0.261278	Sum squared resid	0.955727
Durbin-Watson stat	1.806070		

Unweighted Statistics			
R-squared	0.694359	Mean dependent var	-5.484191
Adjusted R-squared	0.585202	S.D. dependent var	0.405703
S.E. of regression	0.261292	Sum squared resid	0.955829
Durbin-Watson stat	0.942919		