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## 196

**Alina Kudina**

**An Approach to Forecasting Ukrainian GDP
from the Supply Side**

# Contents

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Alina Kudina has been working at CASE since October 1998, being mainly involved in macroeconomic modeling and analysis. Her major areas of interest lie in the real sector (analysis and forecast of GDP) and behavior of foreign direct investors in Ukraine. Regarding the first topic she is developing the quarterly model of the Ukrainian GDP from the supply side, whereas foreign investors' behavior is explored by surveying.

# Abstract

The aim of this paper is to provide some insights on the estimation and forecasting of Ukrainian GDP from the supply side. The aggregate output is modeled on the basis of the aggregate production function estimated from official data on 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 to help account for industry peculiarities.

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

## 1. Theory and 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 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 or, 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 substitution, positive but less than infinite complementarity between factors). All of them, however, embody the trade-off between simple functional forms and good representation of data. This section explores the most popular functional forms which have been discussed in the literature. *

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

$$Y = A*K^{\alpha}*L^{\beta} \tag{1}$$

The properties of the function can be trivially derived:

1) The returns to scale of the function are given by $\alpha+\beta$; usually it is equated to unity that expresses constant returns to scale [Allen and Hall, 1997],

2) $\alpha$ and $\beta$ parameters equal the value shares of inputs in the value of output under certain assumptions:

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

 – 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:

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

and

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

After rearranging, this yields the relationships:

$$\alpha = \frac{P_k * K}{P * Y} \qquad \text{and} \qquad \beta = 1 - \alpha = \frac{P_l * L}{P * Y} \tag{4}$$

3) Elasticity of substitution ($\sigma$) between capital and labor equals unity.

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

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

Then 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 $\sigma$ always equals unity.

## 1.2. 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 in 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 $\rho$ (Ibid.):

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

CES function exhibits the following properties:
1) the returns to scale is given by $\nu$;
2) the elasticity of substitution s is equal $1/(1+\rho)$;
3) CES is reduced to the Cobb-Douglas production function when $\rho = 0$;
4) CES is reduced to the Leontief production function when $\rho \to \infty$.

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 CES function (Ibid.).

The Cobb-Douglas or CES 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 CES production function [Blaug, 1996].

## 1.3. 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.

### 1.4. The translog production and cost function

Parallel to 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.):

$$logY = log\gamma - \frac{v}{\rho}log(\delta K^{-\rho} + (1-\delta)L^{-\rho})$$
(7)

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

$$logY = log\gamma + v\delta logK + v(1-\delta)logL - \frac{1}{2}\rho v\delta(1-\delta)(log(K/L))^2$$
(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

$$F(C, I; L, K) = 0$$
(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.):

$$ln(f+1) = \alpha_0 + \alpha_c lnC + \alpha_i lnI + \alpha_l lnL + \alpha_k lnK$$
$$+ lnC * (\tfrac{1}{2}\beta_{cc}lnC + \beta_{ci}lnI + \beta_{cl}lnL + \beta_{ck}lnK)$$
$$+ lnL * (\tfrac{1}{2}\beta_{ii}lnI + \beta_{il}lnL + \beta_{ik}lnK)$$
$$+ lnL * (\tfrac{1}{2}\beta_{ll}lnL + \beta_{lk}lnK) + lnK * (\tfrac{1}{2}\beta_{kk}lnK) .$$
(10)

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:

$$\frac{p_l L}{p_k K} = \frac{\partial lnF \, / \, \partial lnL}{\partial lnF \, / \, \partial lnK} = \frac{\alpha_l + \beta_{cl} lnC + \beta_{il} lnL + \beta_{ll} lnL + \beta_{kl} lnK}{\alpha_k + \beta_{kc} lnC + \beta_{ki} lnI + \beta_{kl} lnL + \beta_{kk} lnK} \quad . \tag{11}$$

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 1995–1998, this approach is expected to provide a meaningful estimation of inputs' shares in Ukraine's total value of output.

## 2. Data and 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.

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

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

– 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 overreporting of the decline in traditionally important sectors (industry, transport etc.) and underreporting of growth in the 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 the value of the index.

– 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 arriving, the end of shortages and more efficient investment. What is more, in the planned 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 be 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. This happens since the methodology of the Ministry of Economy does not coincide with that of Ministry of Finance, Statistics Committee or the various sectoral ministries and agencies. To understand which indicator is more reliable, one needs to know how these figures are calculated, and therein lies the second flaw.

– Lack of information about methodological principles. It is very hard to find out what lies 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 that is.

– Significant shadow economy that, if not factored in, will question any analysis derived from official data. The shadow economy spoils almost all indicators, from monetary and fiscal ones to those of the real sector. Though there are some approaches to the estimation of the 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 the above-mentioned shortcomings, the quality of data varies from indicator to indicator and from sector to sector. In the Ukrainian setting, one can trust gross investment figures more than their 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 cover less than 50% of total economic activity. On the other hand, non-monetary transactions are also higher than average in the sector.

The data for industry are much better owing to more severe financial/accounting disciplines. However, they are vulnerable to political pressures, resulting in upward biases. Besides, there is a notable variability across sectors in non-monetary transactions (high in heavy industries and lower in consumer and export oriented counterparts).

In contrast, the service sector provides the most reliable data owing to its strong financial discipline, low weight of non-monetary transactions and lack of political pressure which distorts industrial indicators.

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

Now, let us move on with the description of the estimates. The nominal value added and adjusted employment were chosen as standard proxies for output and labor. As mentioned above, the 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 my own estimates. The capital series were calculated according to the following rule:

$$K_t = K_{t-1} + I - \delta^* K_{t-1}$$

where: $K_t$ – capital,

$I$ – gross capital accumulation (Derzhcomstat data),

$\delta$ – depreciation rate.

The basic stock of capital was calculated as a 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.

## 3. The Model

### 3.1. Estimation

Since the historical period consists of only 4 observations, the time series approach cannot be of use due to the 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 describes each sector of the economy. Like time-series data, it describes 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 others some indicators were unavailable. Therefore the final panel consist of 92 observations that is sufficient for robust econometric analysis.

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

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L \tag{1}$$

where $Y$ stands for output, $\alpha$ and $\beta$ 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

$$\ln (Y/L) = \ln A + \alpha \ln (K/L) \ . \tag{2}$$

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).

$$ln\ (Y/L) =\ C +\ 0.0773\ ln\ (K/L) \tag{3}$$
$$(2.31)$$

$R^2 = 0.999103$

$DW = 1.657$

For more detailed information (values of fixed effects) please look at 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:

$$ln\ Y= C + 0.077\ ln\ K + 0.923\ ln\ L. \tag{4}$$

From the above equation, the 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 this equation yields negative values of fixed effects (see Appendix 1) that remain for the level of technology in the sectors. This pattern represents clearly the present situation in Ukraine that is characterized by continuous technological regression. 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 levels of technology.

## 3.2. Sectoral Estimates

Although the estimation of aggregate production functions provides an overall understanding of production relationships in Ukraine, more precise estimates could be obtained by estimating 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:**

$$\ln (Y/L) = C + 0.239 \ln (K/L) \tag{5}$$
$$(4.22)$$

$$R^2 = 0.998734$$

that implies

$$\ln Y = C + 0.239 \ln K + 0.761 \ln L \tag{6}$$

**Services of productive type:**

$$\ln (Y/L) = C + 0.188 \ln (K/L) \tag{7}$$
$$(1.94)$$

$$R^2 = 0.999351$$

that implies

$$\ln Y = C + 0.188 \ln K + 0.812 \ln L. \tag{8}$$

A remarkable feature of the estimated equations is the much bigger share of capital in the value of output than that in the aggregated equation. For instance, in the manufacturing sector, the share of capital is about 23.9% while in the service sector 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.

### 3.3. Extrapolation and 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 CASE's quarterly model of the Ukrainian economy. 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 changes in capital stock were 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.

**Graph 1. Value Added by Sectors, 1998**
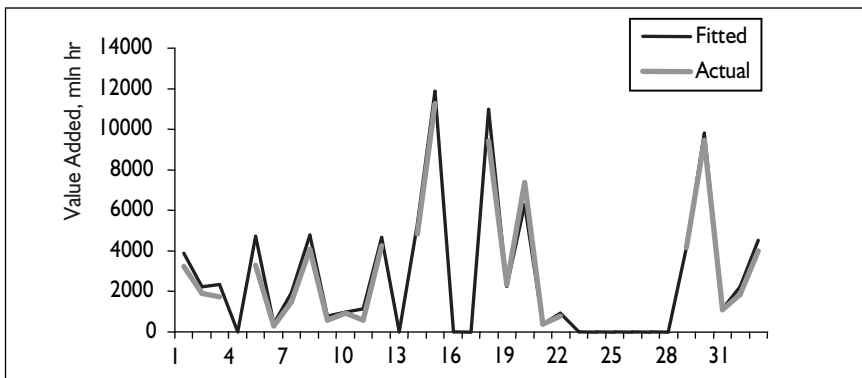


**Forecast Criteria**
**MAPE:** Mean Absolute Percentage Error 0.16835
**Theil** Inequality Coefficient:  0.0964
Bias proportion: 0.069
Variance proportion: 0.0086.
Covariance proportion: 0.984

The forecast was made for the first-half of 1999 (since 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 a 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 become available, thus offering more precise estimates.

## 4. Conclusions

In this paper an attempt to model the supply side of the Ukrainian economy was discussed. It was developed through an estimation of aggregate production functions in its simplest form, i.e. Cobb-Douglas. Although drawbacks in data – brought on by the transitional  state of the economy and shortness of time series – rendered 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. An 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 questions of disaggregation and length of time series can be ultimately overcome, the problem with the quality of data will persist in the near future. Despite improving quality, a low reliability of indicators will persist since the problems of widespread non-monetary transactions and significant shadow activities will not (and cannot) be resolved soon.

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## 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 II. 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 III. 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 | | | |
| **WeightedStatistics** | | | | |
| 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 | | | |
| **UnweightedStatistics** | | | | |
| 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 | | | |