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CALCULATING THE IMPACT OF TRADE ON ASPECTS OF HUMAN DEVELOPMENT IN CENTRAL EUROPE USING DATA ENVELOPMENT ANALYSIS

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Three equally weighted variables, material output, life expectancy and literacy, comprise the widely used comprehensive measure of development known as the Human Development Index (HDI). Although the level of development for a society is constrained by its resource endowment, traditional HDI calculations ignore this. Economic theory suggests that international trade leads to a more efficient use of resources and can contribute to economic development. This paper addresses the question of whether trade contributes only to material development, or whether it impacts life expectancy and literacy rates as well, taking into account differences in endowments and attitudes towards outcomes. The HDI values, with outcome flexibility, are calculated for a number of countries using data envelopment analysis, controlling for resource use. Then the impact of trade on different variables is considered. Economies in Central Europe or former Soviet republics, or both, are compared to the rest of the world to identify differences in performance and the influence, if any, of trade on performance. Relative to resource endowments, the subset of nations performs well relative to the rest of the world. Trade is seen to have varying influences in the two regions for certain performance variables.

Keywords: *economic development, human development index, data envelopment analysis, efficiency, openness*

Introduction

International trade is often promoted as a strategy for economic development. Specialization and trade enhance the efficient use of inputs and make possible the importation of items too costly to produce domestically. The result is a level of consumption unattainable in autarky and an increase in potential output over time as investment goods are imported. Trade is therefore seen as positively correlated with economic development. Development is, however, a multifaceted phenomenon. Trade may impact different development aspects differently, and there

may be differences as to the relative values of different aspects of development. Another question concerns the efficiency with which resources are used: will trade have similar effects on economies that are efficient as on those that are less efficient in the ways they use their endowments? To analyze the impact of trade on development meaningfully, a consistent metric of development is required which acknowledges that societies have varying priorities concerning aspects of development, and which attempts to measure achievements relative to an economy's use of resources. This paper is an attempt to do that by reconsidering a widely-used measure of development in a more flexible way, and then considering the impact of openness on trade of various aspects of that measure.

The Human Development Index (HDI) has long been used as a substitute for one-dimensional GDP per capita measurements to gauge social development that goes beyond purely material measures. The HDI is itself subject to criticisms, including, among others, those stemming from the equal weights assigned to the three components. Therefore, a country which emphasizes one component may be assigned a relatively low index number, but is reaching or even exceeding its social goals. The need to recognize and accommodate cultural differences is a central theme of the latest Human Development Report (Human Development Report, 2004). Likewise, a country which performs very well in one sector but poorly in the other two may record a low index number which hides its accomplishments in that one area. Along those same lines, countries which have very different profiles may record the same index value. In addition, no consideration is given of the resources used by the country in question. This leads to a situation where two nations may achieve the same index levels, but one of the nations uses far more resources than the other. The high-resource nation could have had a far better performance had it used them as economically as the resource-poor country.

To account for differing national priorities and resource use, this study reconsiders HDI values relative to labor, capital and energy usage, along with the impact of trade. The evaluation is based on Data Envelopment Analysis (DEA), a linear programming technique used to distinguish performance. DEA is capable of considering multiple outcome criteria (in this case, the three components of the HDI) relative to multiple inputs. DEA has the further advantage of not assigning *a priori* a functional form to the data, and to allow different performers to optimize the various outcomes with different priorities. The main disadvantage is that statistical noise is difficult to distinguish from poor performance, with the result that any performance observed to be relatively weaker than any other observation's is categorized as suboptimal. Parametric statistical techniques are available that can be used to undertake the same sort of study, but these are limited to a single dependent variable or composite (Coelli, Rao & Battese, 1998)). Since the primary object is to allow different nations to differ in their development profiles, DEA is the technique most suitable for this study.

The analysis concerns the countries in Central and Eastern Europe in a global context. The variables under consideration are the three components of HDI, labor force, capital stock, energy resources and the index of openness to international trade. The first three will be the outcomes to be considered. The next three are the resources or inputs used to achieve those outcomes. The last variable, the openness index, will be used to evaluate whether trade has a significant impact on performance for these countries. Data are available from the World Bank and the Human Development Report 2000. Countries will be categorized according to efficiency in

transforming available resources into outcomes, and according to apparent differences in priorities.

I. Measuring development

Undertaking the task of measuring and comparing the economic development and standards of living of nations leads without failure to disappointment in the methods or reliability of the results. This is not surprising, given that one is measuring what is essentially an aggregation of subjective interpretations of individual degrees of satisfaction. If one further attempts to adjust the measurements for resources used in accomplishing whatever has been accomplished, the path is laid for further disappointments, as one is faced with questions about, for example, labor quality and the measurement of capital stocks. Given the interest in and importance of the issue, however, an attempt will be made to construct an acceptable system for measuring and comparing the relative states of various economies, taking into account the levels of (aggregated) inputs available and the results forthcoming.

An obvious measuring tool for such comparisons is Gross Domestic Product per capita (GDPpc). This is in fact a widely reported and used measure of relative economic well-being. It is not, however, without problems. First, comparing GDPpc's requires a common valuation. This can be accomplished in one of the two ways: using market exchange rates to translate various currencies into a single currency with which to evaluate the output (say, the U.S. dollar, the euro, or some composite currency), or determining relative values based on purchasing power parities (PPP). The first solution is attractive because of the availability of market exchange rates for most currencies, but it is unattractive when those exchange rates do a poor job reflecting the relative values of the currencies (due to fixed rates, or important components of the economy not being traded and therefore having no impact on exchange rates). Purchasing power parity measures are superior in that the probability of a one-to-one correspondence of calculated GDP values and actual output is higher, but they require additional analysis of micro-prices and levels of output for a large number of goods and services. It is safe to assume that, when available, international comparisons using PPP are preferred to those based on market exchange rates.

There are, of course, additional problems involved with GDPpc-based comparisons. The main criticism stems from the focus on material well-being, while in fact the well-being of a citizen depends on more than just material goods and services. Some proposed indices have left material output out altogether: Drewnowski and Scott's Level of Living Index focuses on nutrition, literacy, shelter and health (Drewnowski & Scott, 1966), while Morris's Physical Quality of Life Index focuses on literacy and longevity (Morris, 1979). Recognizing the importance of various aspects of human existence, researchers at the United Nations Development Program developed a more comprehensive method designed to measure the level of development, the Human Development Index.

The Human Development Index (HDI) was developed to summarize succinctly achievement in three areas: living standards, life expectancy at birth and literacy. Living standards are measured in terms of GDPpc based on purchasing power parity expressed in U.S. dollars, and literacy is measured by combining the adult literacy rate (with a two-thirds weight) and gross enrolment ratios. Countries are assigned scores in each area based on performance relative to the best and worst performers in each area, and then a composite score is calculated by adding the

three sub-scores (an issue which is addressed further below). A new Index is published every year. Since the methodology may be somewhat inconsistent over time, inter-temporal comparisons should be considered less meaningful than interspatial comparisons.

The HDI approach came under criticism from the beginning (McGillivray, 1991). Foremost is the objection that reducing the complexity of human development to a single index value is highly questionable (Sen, 1999). Another criticism is that the criteria used are arbitrary, and that other measures of development might be more appropriate. Hicks (1997) suggested incorporating Gini coefficients in the measurements of all three components. Despite these criticisms, the HDI is widely accepted and preferred by many to the alternatives. On the other hand, these criticisms have not been ignored, and various changes in the computation of the index have occurred over the years. These changes are explained as they occur in each new issue of the Human Development Report.

Another criticism of particular concern here is that the equal weights given the three sub-categories is arbitrary as well, and that cultural or other differences among countries may cause them to pursue, or achieve, different aspects of development more vigorously than others. Weighting each category equally may then lead to a situation in which different levels of performance in the three categories may lead to a higher index value, but result in a lower level of welfare in the country as a high-priority aspect is sacrificed in favor of a category less important culturally, but more important perhaps to agents with disproportionate control of resources. This may be the case in a command economy or may arise in a market economy with extreme levels of market power. In any case, assigning weights to the three components will invariably reflect the values of the analyst.

To allow each country to record the highest possible index value, the three categories must be weighted in such a way that the weights correspond to the relative performance in each category. No arbitrary weighting system will accomplish this, but techniques are available with the required subtlety. Data Envelopment Analysis (DEA) is a linear programming technique proposed by Charnes, Cooper and Rhodes (1978) to address the problem of measuring efficiency as presented by Farrell (1957). Nilsson (2001) later applied these techniques to the HDI. He did not, however, include in his analysis data on the resources used by each observation. Arcelus, Sharma and Srinivasan (2003) extend the analysis by incorporating resource use into their reconsideration of HDI, although they maintained the equal weights for outcomes. Attempts to find previous data envelopment analyses of HDI that simultaneously incorporated both outcome flexibility and a consideration of resource use failed. Specifically, the question addressed here is, given that efficient operators can be identified, by how much could the inputs used [or output(s) produced] by an inefficient operator be reduced [increased] and achieve [use] the same level of output(s) [inputs]? DEA solves this problem by finding the efficiency values that maximize the score for each unit being observed. In short, the problem is to find the weights that maximize the ratio:

$$\text{Efficiency} = \text{weighted sum of outputs} / \text{weighted sum of inputs.}$$

DEA has an attractive feature of permitting multiple results or outputs to be considered simultaneously, with different weights assigned to each result as determined by the data. The main drawback of DEA is that any perceived shortfall in performance is attributed to inefficiency, with no facility to take into account the measurement

error. However, given the need to analyze multiple aspects of development, DEA is the most useful technique for this analysis.

II. The model

The efficiency scores referred to above are a weighted ratio of outcomes to inputs. Mathematically, this becomes

$$\begin{array}{lll} \text{Max}_{u,v} & u'y_i/v'x_i, & \\ \text{s.t.} & u'y_j/v'x_j \leq 1, & j=1,2,\ldots, \\ & u = 0, & \\ & v = 0, & \end{array}$$

where **u** and **v** are vectors of weights on outcomes and inputs respectively, **y** is a vector of quantifiable outcomes, and **x** is a vector of quantifiable resources or inputs. Relative to the most efficient of the *n* performers, assigned scores of 1, each of the performers will be assigned a score between 0 and 1.

In this analysis, the outcomes *y* are the three components of the HDI: GDPpc, life expectancy and literacy scores. The resources available to the economies to produce those outcomes are assumed to be the labor force, energy resources used and the capital stock. Nilsson's models included both unrestricted and restricted versions of DEA, wherein the restricted versions limit the values that can be assigned to the weights **u** and **v**. The model below will not impose restrictions on the weights, in order to produce the highest level of flexibility.

III. The data

The outcomes examined in this study consist of HDI results for 1998 (Human Development Report, 2000) Data on labor force, capital stock, energy use and openness to trade levels were drawn from the World Bank's World Development Indicators on-line database (The World Bank Group). These data represent the most recent year for which information on each variable for an acceptable number of countries in the focus area could be found. Suitable data were recovered for ninety-two countries, including seventeen in the focus region.

The World Bank uses the following definitions for its variables. The total labor force comprises people who meet the International Labour Organization's definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector. It must be kept in mind that the quality of labor is assumed to be consistent across the sample. Identification or consideration of differences in efficiency measures stemming from quality differences in labor, or other inputs, is beyond the scope of this paper.

The capital stock is estimated as the market capitalization of listed companies in current U.S. dollars. Market capitalization is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year. There are, of course, problems involved with using corporate values to estimate the capital stock of an economy. To the extent that capital is privately held and not incorporated, these values will underestimate the true productive capacity of the country. Stock values are also volatile as market forces change. True depreciation is virtually impossible to measure exactly, and the market value may not reflect the vintage of the capital. Recognizing the difficulties involved in developing a true measure of capital, the capital variable measured in market value will be assumed to reflect the present value of the expected returns over the life of the

asset (Hulton, 1990). A Perpetual Inventory Method, as used in the development of the Penn World Tables (Summer, Heston & Aten, 2001) and elsewhere, would be preferred, but comprehensive data are not available for the time period under consideration at this time.[1]

Energy use is expressed in kilotons of oil equivalent and refers to apparent consumption, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. Openness is expressed as the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars.

These data were analyzed with Frontier Analyst software developed by Banxia Software Ltd.[2] The vector of outcomes was, as indicated above, the three components of HDI: GDPpc, life expectancy at birth, and a literacy score. The inputs were the labor force, the capital stock, and net energy use. To control for the range of the size of economies, a variable returns to scale analysis was employed.

IV. Results

The model allows each observation to maximize the weight given to its best component of HDI, as opposed to a fixed weight of one-third. This means that scores cannot go down absolutely, but observations may change positions relative to other scores. For the discussion immediately below the HDI values were adjusted by dividing by the highest recorded value, so each score is relative to a high score of 100. Not surprisingly, there is a substantial correlation between the adjusted HDI values and the DEA HDI values, with a correlation coefficient of nearly .89 (see Table 1 below). The average change in scores was nearly 8.5, with a standard deviation of 6.8. The highest improvement was 32.4, from an adjusted level of 67.6 to 100. This observation was Namibia, and the calculated improvement was virtually entirely due to a *relatively* high education index component and low energy use and capital resource base. Considering Namibia's relatively poor scores in all three components of HDI [life expectancy of 50.1 years (HDI life expectancy index = .42), literacy rate of 80.8, enrolment of 84% (HDI education index = .66) and a GDPpc of US$5,176 (GDP index = .51)], the increase in its DEA HDI score was certainly due to its extremely meager resource levels.

Canada had the highest original HDI score, producing a normalized value of 100. It also recorded a DEA generated score of 100, so there was no change in the adjusted HDI and the DEA results for that country. The HDI for the United Arab Emirates was .918, which when normalized to Canada's score became 98.2. The DEA score for the UAE was 92.8, a reduction of 5.4 points. This was the only observation to see a decline in the DEA score relative to the normalized HDI score.

Although adjusting for resource use produced highly correlated results, there were some dramatic shifts in the relative rankings of the economies (Table 2). Most of the observations changed little relative to one another, but five changed by at least forty ranks, four up and one down. Twenty-four observations moved between twenty and thirty ranks, twenty down and four

*Table 1. **Change in adjusted HDI vs. DEA HDI results***

r	.89
Mean	8.45
Standard Deviation	6.8
Minimum	-5.4
Maximum	32.4

[1] As a test of the usefulness of market capital values as a proxy for the perpetual inventory calculations of the capital stock, date from the same year were drawn for these two variables from the Penn World Tables and the World Bank. The correlation coefficient between the two variables was .92.

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Table 2: Changes in rank ordering HDI vs. DEA results

Rank change	No. of obs.
60	1
50	2
40	1
30	0
20	4
10	7
0	28
-10	28
-20	17
-30	3
-40	0
-50	1

up. The bulk of the data, sixty-three of the ninety-two observations, moved relatively little, fewer than ten ranks.

The distribution of the DEA results is given below (see Figures 1 & 2). Seventeen observations record an efficiency score of one hundred. As the Namibian example demonstrates, these are not necessarily countries wit development, but ones which ha vely well given their access to re one countries score between n hundred, twenty-one between e ty, six between seventy and eight sixty and seventy and two betwe ty.

Many of these countries had leading to the original HDI sc mewhat low. Mainly because ea ly high literacy rates, each sho ment when HDI was calculat (Table 3). In some cases the imp substantial. The average gain points, with the highest over tw Moldova. Three countries, Mol and Azerbaijan, climbed mor points, bringing them from d group of seventeen to the very t singly, these three also saw the

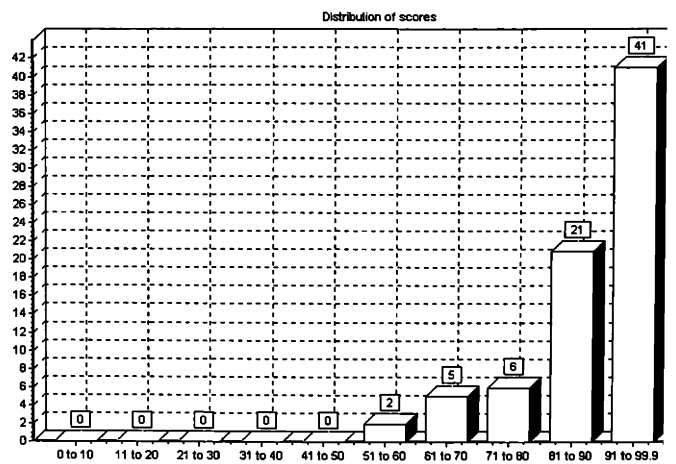

Fig. 1: DEA HDI results

Fig. 2: Geographic DEA HDI results

Table 3: CE17 HDI vs. DEA HDI changes

Country	Change in score	HDI rank	DEA HDI rank	Change in rank
Armenia	22.9	68	1	+67
Azerbaijan	22.8	66	1	+65
Bulgaria	13.4	46	42	+4
Croatia	6.6	41	56	-15
Czech Republic	3.8	28	46	-18
Estonia	14.3	39	1	+38
Hungary	6.4	36	47	-11
Kazakhstan	15.7	53	40	+13
Latvia	15	48	34	+14
Lithuania	12.5	43	38	+5
Moldova	23.6	73	27	+46
Poland	7.2	37	44	-7
Romania	11.4	51	48	+3
Russia	11.8	49	43	+6
Slovakia	9.5	33	30	+3
Slovenia	5.0	27	36	-9
Ukraine	17.8	58	35	+23

in rank from HDI to DEA HDI: Moldova, +46, Armenia, +67 and Azerbaijan, +65. The average change in rank for the CE17 countries was an increase of over thirteen spots in the rankings.

The relative contributions of the three components of the index are interesting in that they may provide an insight into the varying performance in different development aspects of different countries. In forty-one countries life expec-

Fig. 3: DEA HDI component dominance

tancy contributed more than education or GDP to the overall development index, in forty-five countries education was the main contributor, and in six countries material development as measured by GDP dominated the other categories (See Figure 3 below and Appendix 1 for details).

The geographic comparisons can be extended to the focal region in Central Europe. Seventeen countries in the data are either located in Central Europe or were formerly a Soviet Republic (or both): Armenia, Azerbaijan, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Slovakia, Slovenia, and Ukraine. These are referred to as CE17 below. Two Central European countries in the data, Austria and Finland, do not share the same economic history as these seventeen and are retained in the 'rest of the world' subset. Of the seventeen, only Armenia derived its main contribution to HDI from the life index; the rest had DEA results that assigned education at least a three- quarters weight.

Table 4 below summarizes the results of t-tests conducted to detect any significant differences in the use of inputs by region. The data were divided into the CE17 and the rest of the world (ROW). Each of the three input categories was examined. Measured as the calculated percentage reduction in the input required to achieve the best practice level observed, there were no statistically significant differences in the average efficiencies in the use of capital (%KROW vs. %KCE17), labor (%LROW vs.%LCE17) or energy (%EROW vs. %ECE17).

It should be noted here that the group of seventeen were observed to use capital extremely efficiently, so the percentage reduction needed for each for capital was zero, versus an average of 8% for the rest of the world. Since the true variances of these variables are not known, and since the variables themselves are not normally distributed, each variable was normalized around its mean and the tests were repeated. The results for the t-tests on the normalized variables were the same in each case, that is, there was no statistically significant difference at the 5% level.

Tests of the potential improvements in each category of HDI, given resources, for the seventeen-country subset against the rest of the world display more pronounced differences. These t-tests indicate that the CE17 subset of countries

Table 4: t-Tests of differences in efficiencies in input use

n	ROW *75*	CE17 *17*
	%KROW	%KCE17
Mean	-8.05	0
Variance	476	0
t	-1.51	
t Critical one-tail	1.66	
p(T<=t)	0.07	
	%LROW	%LCE17
Mean	-61.48	-60.84
Variance	1396	1459
t	-0.06	
t Critical one-tail	1.66	
p(T<=t)	0.47	
	%EROW	%ECE17
Mean	-43.95	-54.97
Variance	1340	1521
t	1.11	
t Critical one-tail	1.66	
p(T<=t) one-tail	0.14	

Table 5: Differences in DEA HDI outcomes

	Rest of World *75*	**Central Europe** *17*
	%LIFEROW	**%LIFECE17**
Mean	20.41	6.93
Variance	1122.1	48.7
t	1.64	
t Critical one-tail	1.66	
p(T<=t)	0.052	
	%LITROW	**%LITCE17**
Mean	21.9	3.8
Variance	882.1	7.3
t	2.50	
t Critical one-tail	1.66	
p(T<=t)	0.007	
	%GDPROW	**%GDPCE17**
Mean	30.5	12.92
Variance	1251	121
t	2.02	
t Critical one-tail	1.66	
p(T<=t) one-tail	0.02	

was, on average, accomplishing more in all three areas than would be expected given their resources. Achievement in all three areas was significantly closer to the estimated achievable level than world averages at a 5% alpha-level. The average shortfall from the highest levels in the life expectancy index was about 7% for the CE17, versus over 20% for the rest of the world. Education fell short an average of just under 4% versus almost 22% in the rest of the world, and GDP per capita fell short almost 13% versus over 30% in the rest of the world. These results are summarized in Table 5.

V. The impact of trade

There are many points of view concerning the impact of trade on development, as well as on what trade strategy is most appealing. Mainstream neoclassical theory suggests that international trade produces various positive effects: lower prices for consumers, productivity and efficiency improvements through specialization, greater access to technology and capital resources, and increased competition. As resources are freed from comparative disadvantage activities, there should conceivably be a positive impact on the development indices as GDP per capita rises, and opportunities arise to import goods and to a lesser extent services that may lead to improvements in health and literacy. There was no statistically significant difference in the openness levels of the two groups, although the CE17 level of openness was somewhat higher than the ROWs (44% vs. 37%). The importance of trade and its potential influence on development was examined by calculating correlation coefficients linking openness, defined as

exports of goods and services as a percentage of GDP, with each of the inputs and outcomes. The results are summarized in Table 6. The t-scores in parentheses are labeled t* or t** if significant at the 5% or 1% levels. Two variables, capital efficiency and the contribution of labor to DEA HDI, could not be analyzed in this way. Normalization was not possible in these two cases due to a measured zero-variance.

Greater trade levels were associated with only slightly higher DEA HDI scores in the CE17, although the ROW benefits were higher and the correlation was significant at the 5% level. While this could be due to a small sample in the case CE17, it could also reasonably be interpreted as an indication that any impact trade may have on development levels as measured is less pronounced concerning the literacy index, the primary factor for CE17 HDI scores, than life expectancy or GDPpc.

Within the standard HDI calculations, the individual components displayed different correlations to trade. None of the individual components varied significantly between the two groups. The original life expectancy index value was significantly correlated with trade in the ROW but not in the CE17, although the r-values were very close to one another. The original literacy scores showed a significant correlation with trade in CE17, but less pronounced and not significant in the ROW. The original GDP component was significantly correlated with openness in both regions. In all three cases, the correlation between openness and HDI components was positive, if not consistently significant. It may be argued that the positive correlation in CE17 between literacy and trade suggests exploitation of a human-capital-based comparative advantage vis-a-vis ROW. There was no statistically significant difference in the HDI indices of literacy for the two groups, but CE17 relied more on literacy for its DEA HDI score. Along the same lines, ROW could rely on labor as a relatively abundant factor in its trade. As trade evolves, the advantages CE17 has in human-capital-intensive activities and the advantage elsewhere in labor-intensive activities leads each region to become more open while concentrating production on its relatively abundant input.

It should be noted that openness to trade was negatively correlated with the actual levels of use of each type of input, which is not surprising given the importance of trade for smaller economies, and positively correlated with the actual level of each outcome, which suggests a positive impact of trade on development. Although these results were not statistically significant, and therefore not reported in Table 6, they are consistent with the view that trade leads to more a productive use of inputs and higher levels of GDP per capita. The well-documented correlation between GDPpc on the one hand and, on the other, between GDP per capita and the other aspects of HDI can plausibly explain the positive results between trade, literacy and life expectancy (Rao, 1991).

There was no discernible capital inefficiency in the CE17. Input inefficiency was reported as the needed percentage change in a given input, ceteris paribus, to reach the best-practice levels. The values are non-positive, with a score of zero indicating efficient use of that input. Each of the CE17 scored zeros with respect to capital, which meant that a correlation between capital inefficiency and openness in the CE17 could not be calculated. Openness was associated in ROW with a decrease in the efficient use of capital, although the relationship was not significant at the 5% level. In both regions trade correlated positively with improvements in the efficient use of labor and energy, although this was significant only in ROW.

In the DEA analysis, the amount by which, considering other observations' performance, an observation should be able to increase each outcome given its inputs is estimated for each ob-

Table 6: Correlation coefficients between openness and selected DEA HDI results (based on normalized values)

	ROW	CE17
n	*75*	*17*
DEA HDI Score	0.28	0.09
	(2.51)**	(0.34)
HDI Life Index	0.23	0.21
	(2.09)*	(0.84)
HDI Literacy Index	0.17	0.51
	(1.53)	(2.30)*
HDI GDP Index	0.31	0.58
	(2.89)**	(2.76)*
DEA HDI K-Inefficiency	-0.19	ERR
	(-1.71)	
DEA HDI L-Inefficiency	0.30	0.12
	(2.74)**	(0.45)
DEA HDI E-Inefficiency	0.26	0.14
	(2.34)*	(0.56)
DEA HDI Life Outcome	-0.20	-0.17
	(-1.80)	(-0.67)
DEA HDI Education	-0.22	-0.09
Outcome	(-1.96)*	(-0.35)
DEA HDI GDP Outcome	-0.28	-0.29
	(-2.55)*	(-1.19)
DEA HDI Capital	-0.12	-0.06
Contribution	(-1.05)	(-0.24)
DEA HDI Labor	-0.07	ERR
Contribution	(-0.58)	
DEA HDI Energy	0.16	0.06
Contribution	(1.37)	(0.24)
DEA HDI Life	0.05	-0.41
Expectancy Contribution	(0.44)	(-1.74)
DEA HDI Literacy	-0.11	0.41
Contribution	(-0.94)	(1.73)
DEA HDI GDP Contribution	0.09	0.12
	(0.82)	(0.45)

servation. These scores are non-negative, with zero indicating no shortfall below the best practice. Openness was negatively correlated with each of these scores for the three HDI components for both CE17 and ROW. The ROW correlations for education and GDP were the only statistically significant results.

The contribution, based on the relative weight, of each input and each outcome to the overall DEA score was correlated with openness as well. In general, in CE17 there was a slight decrease in the importance of capital and more reliance on energy resources, which corresponded to the results in ROW. No correlation with the labor input for CE17 was possible, due to the limited contribution of labor relative to the other inputs in the overall DEA outcomes in that region. In no case were these results statistically significant at the 5% level. Regarding the outcomes, openness was somewhat associated with a shift in importance in CE17 from life expectancy to education and GDP. These results were not significant at the 5% level.

Where possible, tests were run to investigate whether CE17 differed in its response to trade levels from ROW. Only those variables for which there was some evidence of a linear relationship with openness in at least one region were further tested. For each variable from Table 6 which exhibited a possible linear relationship with openness, tests were conducted on the two regions' correlation coefficients. These are Z-tests on the test statistics:

$$Z = (Z_1 - Z_2)/\sigma,$$

where $Z_i = .5\ln[(1+r_i)/(1-r_i)]$ and $\sigma = [(1/n_1 - 3) + [(1/n_2 - 3)]$ (Kanji, 1993). Z is normally distributed with mean 0 and standard deviation 1. The results are reported in Table 7 for eight variables for which the correlation coefficients with openness were significant, along with two for which they were not. The latter two had significantly different correlation coefficients, although the results must be viewed as less robust since the Z-test assumes linearity.

For six of the variables (the DEA HDI score, the original HDI life expectancy index, energy inefficiency, and the DEA results for the each of the three HDI components) there was no significant difference in the impact of trade on the

Table 7: Tests of differences in correlations between selected variables and trade

Variable	Z-score
DEA HDI score	-1.82
Life index	-0.2
Education index	3.63**
GDP index	3.15**
Energy inefficiency	-1.13
DEA HDI life index	0.31
DEA HDI education index	1.23
DEA HDI GDP index	-0.12
Normalized IO life	-4.54**
Normalized IO literacy	5.04**

CE17 versus the ROW. Trade had a greater impact, with greater significance, on the education and GDPpc levels actually recorded for CE17 countries than for the ROW. When the linearity requirement was relaxed, there was evidence that greater openness meant the importance of life expectancy in the overall DEA HDI results decreased for CE17 and increased for the ROW. Education, on the other hand, increased for CE17 and declined in importance in the ROW. In both regions the importance of GDPpc rose.

Conclusions

When the Human Development Index is recomputed using data envelopment analysis, with consideration of the resources available, noticeable changes occur in the relative development rankings of countries. For countries in Central Europe and elsewhere with a shared command economy legacy, variable weighting of the outcomes in HDI generally, but not universally, improve their standing vis-a-vis other countries in the analysis. These countries, more so than the rest of the countries in the data set, tended to rely more on literacy, and to a lesser extent on life expectancy, in their overall development than on GDP per capita. There were no significant differences in efficiency in the use of capital, labor or energy between the two regions. The seventeen countries achieved significantly better results in literacy than the rest of the world, but significantly lower results in output per person. Performance in life expectancy was noticeably, but not statistically significantly, lower than the rest of the world. Taken alone, in the CE17 there was evidence of a positive impact of higher levels of trade on the DEA HDI scores and on each of the three components, although the impact was significant only for the education and GDPpc components. The latter two effects were significantly (at the 1% level) greater than in the rest of the world. Finally, the relative importance of life expectancy in an economy's DEA HDI score declines significantly more in the CE17, and the relative importance of literacy rises significantly (both at the 1% level).

It is not surprising that trade should be positively correlated with material output. Specialization and trade are clearly associated with a higher output, but the positive impact on the other two components, literacy and life expectancy, warrants further consideration. Is GDP growth leading to achievement in the other two indices indirectly, or is there a more direct impact? If so, how is trade bringing about gains in literacy and life expectancy?

Many other questions are beyond the scope of this paper, but address interesting issues. Why are there differences in the observed impact of trade on some variables in these countries versus the rest of the world? How would inclusion of other factors, for example, foreign direct investment, help us better understand the dynamics involved? How will entry of some countries into the European Union affect them and their nonmember neighbors? What pattern would an inter-temporal analysis uncover? Finally, there are the fundamental questions regarding the ways we try to measure development. Is the HDI the best way to address the issue, and how would results based on another method differ?

Appendix 1

Dominant DEA HDI Categories

Life Expectancy	Literacy	GDP per capita
Armenia	Argentina	Austria
Bahrain	Australia	Côte d'Ivoire
Bangladesh	Azerbaijan	Kuwait
Canada	Belgium	Qatar
Chile	Brazil	United States
China	Bulgaria	Uruguay
Costa Rica	Colombia	
Cyprus	Croatia	
Egypt	Czech Republic	
El Salvador	Denmark	
France	Ecuador	
Ghana	Estonia	
Greece	Finland	
Honduras	Germany	
Hong Kong	Hungary	
India	Iceland	
Iran	Indonesia	
Israel	Ireland	
Italy	Jordan	
Jamaica	Kazakhstan	
Japan	Kenya	
Luxembourg	South Korea	
Malaysia	Latvia	
Malta	Lebanon	
Mexico	Lithuania	
Morocco	Moldova	
Nepal	Namibia	
Oman	Netherlands	
Pakistan	New Zealand	
Panama	Nigeria	
Portugal	Norway	
Saudi Arabia	Paraguay	
Singapore	Peru	
Spain	Philippines	
Sri Lanka	Poland	
Switzerland	Romania	
Trinidad and Tobago	Russia	
Tunisia	Slovakia	
Turkey	Slovenia	
United Arab Emirates	South Africa	
Venezuela	Tanzania	
	Thailand	
	Ukraine	
	United Kingdom	
	Zambia	

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PREKYBOS POVEIKIO ŽMOGIŠKOSIOS PLĖTROS ASPEKTAMS VIDURIO EUROPOJE NUSTATYMAS NAUDOJANT DUOMENŲ GAUBIAMĄJĄ ANALIZĘ

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Santrauka

Dažnai teigiama, kad tarptautinė prekyba ekonominės plėtros strategija. Specializacija ir prekyba didina efektyvų išteklių naudojimą ir leidžia importuoti prekes, kurias per brangu gaminti šalies viduje. Rezultatas – uždarame ūkyje nepasiekiamas vartojimo lygis ir potencialių produktų per laiko tarpą padidėjimas, kai investicinės prekės yra importuojamos. Todėl pastebima teigiama prekybos ir ekonomikos plėtros koreliacija. Tačiau plėtra yra daugiaaspektis procesas. Trys vienodą svorį turintys kintamieji – medžiaginis produktas, tikėtina gyvenimo trukmė ir raštingumas yra plačiai naudojamas ir lengvai suprantamas plėtros matas, vadinamas žmogiškosios plėtros indeksu (ŽPI). Žmogiškosios plėtros indeksas ilgą laiką buvo naudojamas vienos dimensijos rodikliui, BVP žmogui, pakeisti, matuojant socialinę plėtrą, vykstančią už grynai materialinių matų ribų. ŽPI yra kritikuojamas, kaip ir kiti indeksai, kuriuos sudaro trys lygūs svertiniai komponentai. Todėl šalis, pabrėžianti vieną komponentą, gali turėti sąlygiškai žemą indeksą, tačiau būti siekianti ar netgi viršijanti savo socialinius tikslus. Poreikis atpažinti ir pritaikyti kultūros skirtybes yra pagrindinė Žmogiškosios plėtros ataskaitos tema. Nors visuomenės plėtros lygį riboja jos ištekliai, tradicinis ŽPI skaičiavimas tai ignoruoja. Ekonomikos teorija teigia, kad tarptautinė prekyba padeda efektyviau naudoti išteklius ir skatina ekonomikos plėtrą.

Šiame straipsnyje nagrinėjama, ar prekyba turi poveikį tik materialinei plėtrai, ar ir tikėtinai gyvenimo trukmei bei raštingumui, atsižvelgiant į indėlių skirtumus bei požiūrį į rezultatus. ŽPI vertės skaičiuojamos šalims naudojant gaubiamąją analizę, kontroliuojant išteklių naudojimą. Tada nagrinėjamas prekybos poveikis įvai-

riems kintamiesiems. Vidurio Europos ar buvusių sovietinių respublikų ekonomikos yra lyginamos su kitos pasaulio dalies siekiant nustatyti veiklos skirtumus ir prekybos įtaką veiklai, jeigu ji egzistuoja. Sprendžiant iš išteklių kai kurios šalys veikia gerai, palyginti su kita pasaulio dalimi. Stebima kintanti prekybos įtaka tam tikriems veiklos kintamiesiems dviejuose regionuose.

Kai žmogiškosios plėtros indeksas yra perskaičiuojamas naudojant gaubiamąją analizę, atsižvelgiant į esamus išteklius, pastebimi sąlyginės šalių plėtros pokyčiai. Vidurio Europos ir kitoms šalims, kur įteisinta komandinė ekonomika, žmogiškosios plėtros indekso svertiniai rezultatų kintamieji bendrai, bet ne visuotinai, pagerino savo poziciją, palyginti su kitomis šalimis. Šios šalys, labiau negu kitos atliekant analizę pasirinktos šalys, buvo linkusios pasikliauti raštingumu ir šiek tiek mažiau tikėtina gyvenimo trukme bendroje plėtroje nei BVP vienam žmogui.

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