E-LEARNING:
A Way to Solve the Human Capital Mismatch Problem in Transitional Economies in Central Europe?

A theoretical and computational study.

A revised grant proposal for the
CERGE-EI/World Bank research competition

by

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Abstract

E-learning -- the online delivery of content that allows students to see, hear, and speak to professors and fellow students without ever having to leave local learning centers, or even their home or office -- is rapidly establishing itself in the USA as well as in other countries as a viable alternative to more traditional delivery modes of education. Within the last two years more than a dozen e-learning enablers and content providers have gone public in the USA, with literally dozens in the wings waiting for their turn. Building on our previous research, we propose to study the likelihood of these "mutants" making inroads in Central European transition economies and whether such a development would be advantageous for those economies (albeit not necessarily for traditional providers to the tertiary sector.)

While our analysis will draw on an extensive review of the literature, the heart of the project is a genetic algorithm model of sellers (e-learning companies) and buyers (students and their employers). Specifically, we will set up a general equilibrium endogenous growth model with finitely lived, boundedly rational and heterogeneous agents who maximize their objective function by way of a hill-climbing trial-and-error process. Our approach lends itself well to comparative statics analysis, robustness tests, and studies of transitional dynamics. Our proposed research would integrate several literatures such as the economics of education and matching processes, industrial organization, development and growth, and agent-based economics. While the research proposed here is mostly theoretical, our research interests are motivated by human capital mismatch problems in the Czech Republic and other Central and East European transition economies. This first, primarily theoretical stage of our project is therefore designed to build a solid foundation for a second, more policy-oriented stage. Our theoretical results will have, however, obvious and immediate policy implications.

Table of Contents

1. Previous work by the principal investigators:

Building on earlier work on traditional (non-profit) higher education in the USA (e.g., Ortmann 1996; see also Ortmann & Paalandi 2000, Ortmann 2000, 2000a, 2000b, and Ortmann & Squire 2000), Ortmann (1997) sketched a number of rapidly emerging trends in "post-secondary" or "tertiary" education[1], namely the emergence of a for-profit education segment that has benefitted greatly from the slow responses of traditional providers to changing educational needs and possibilities offered by modern information technologies. The author also predicted that e-learning would play an ever increasing role and that a dramatic shift in the conception of the university was upon us: No longer would many students come to the university; soon the university would have to come to local learning centers, and even students' homes or workplaces (see above Noam 1995).

[1] In the following, we use these terms interchangeably.

Developments in higher education, have closely tracked these predictions. Ortmann (2000 (first draft: 1998); see also Ortmann 2000a[2]) is a detailed "cases study" (Eisenhardt 1989) that documents the emergence of the currently one dozen for-profit providers of post-secondary education operating in the USA; it distills ten common characteristics and suggests why most of these companies are likely to maintain a growth-rate for the foreseeable future that is three-to-five fold that of traditional providers. Ortmann & Nordberg (2000) formalize the cases study in Ortmann (2000) by way of a genetic algorithm model of post-secondary education in the USA. Their model generalizes genetic algorithm models of decentralized markets (e.g., Vriend 1995) to a decentralized market that matches stratified sets of sellers (universities) and buyers (students) (e.g., Roth & Xing 1994, 1997), complicating the conceptual and methodological difficulties significantly.[3] The Ortmann-Nordberg model thus integrates literatures on education and matching processes, industrial organization, and "agent-based" economics.[4] We are not aware of any closely related research.

Genetic algorithms, while not unproblematic (e.g., Mitchell 1996 for limitations), are quite useful in contexts such as Ortmann & Nordberg (2000) and the one proposed here, as they allow us to model the interactions of *boundedly rational, heterogeneous* buyers (students of different abilities or preferences) and sellers (providers employing different technologies). Our computational approach makes possible comparative statics exercises that allow us to explore the likely penetration of "mutants" (such as e-learning companies), or the possibility of the co-existence of incumbent

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[2] Ortmann (2000a) is a detailed and complementary study; commissioned by the Sloan Foundation (by way of the Curry School of Education at the University of Virginia) it presents an investigation of the arguments investment houses use to sell to the public a product that -- on the surface -- seems to have major strikes against it: It cannot benefit from an impressive list of tax and regulatory breaks that accrue to private non-profits (Facchina, Showell, & Stone 1993) and it has to produce profits to satisfy share-holders.

[3] Ortmann & Nordberg intend to ultimately parameterize their genetic algorithm model through the real-world data base underlying the CyberCampus simulation project (see www.virtual-u.org) for which Ortmann was beta-tester (see also Ortmann 1998).

[4] This so-called Agent-based economics uses various modeling approaches such as genetic algorithms or simulated annealing; common to all of them is a bottom-up approach of first defining the action spaces of heterogeneous agents (such as the production and signaling tuplets for firms or the decision of students to stay with a provider or switch to another one). Next, agents are programmed to interact repeatedly. Successful action choices get stochastically re-inforced until an equilibrium is found.
For several good survey articles on agent-based economics see http://www.econ.iastate.edu/tesfatsi/ace.htm

providers and new providers under various parameter constellations.

Last summer, the Center for the Privatization of Higher Education at Columbia University commissioned one of us to write a paper on US-based e-learning companies (Ortmann 2000b). This research will result in a detailed cases study whose purpose is to understand that particular market segment of the post-secondary education market. (More on the issue of e-learning below.)

Jeong and Kejak (2000) study theoretically and empirically the problem of "human capital mismatch" in Central European transition economies, i.e. the well-documented fact that the composition of human capital stock inherited from socialism, is inadequate in light of the requirements of a modern market economy. Their project is guided by two key questions: (1) what has been the effect of the "human capital mismatch" on the growth experience of four Central European economies that are scheduled to access the EU; (2) how fast will the composition of the human capital stock and the levels of per capita income of these "accessing economies" converge to those of EU countries. The effect of human capital allocation on growth in a static and partial equilibrium framework is analyzed in Judson (1998).

In related work, Kejak (forthcoming) proposes a model of stages of growth in economic development which is based on the standard assumptions of such classic models as Lucas (1988), Azariadis and Drazen (1990), and Zilibotti (1995). Specifically, he assumes that there is a frontier of "theoretical knowledge" that is given exogenously and represents large advances in knowledge such as those produced by an industrial revolution. In contrast to Zilibotti's model, Kejak's model makes human capital the engine of growth. Furthermore, the growth engine does not have to be started through a structural one-off shock. Most importantly, and in contrast to most papers on endogenous growth, his model provides both a mathematical analysis of the steady state(s) and the transitional dynamics.

While most models of endogenous growth are limited to steady state analysis, and while the analysis of transitional dynamics is an important step forward, the underlying Lucas-Uzawa framework suffers from heroic assumptions such as all agents being endowed with perfect foresight with respect to future wages, interest rates, and the technology underlying knowledge production, or all workers having the same skill level and devoting the same fraction of their (non-leisure) time to current production, with the remaining fraction being spent on human capital accumulation.

As mentioned, genetic algorithms are an alternative approach that employs adaptive (= boundedly rational), heterogeneous agents and their interactions. A genetic algorithm makes possible numerous comparative statics exercises and a detailed study of the transitional dynamics. The recent use of genetic algorithms in the macroeconomic literature has produced promising results. For example, Arifovic (1996) successfully employs a genetic algorithm model to explain persistent fluctuations in exchange rates - an empirical fact observed in actual economies but not yet successfully modelled theoretically. Of particular relevance in the current context, growth models with human capital and learning are presented in Arifovic (1997) and Galor and Tsiddon (1997). The first paper shows learning as an equilibrium selection device in models with multiple equilibria and with empirically relevant transition dynamics between them. Both papers are able to model the transition from stagnation to economic growth as a very long endogenous process.

2. The issues to be investigated (and working hypotheses):

There is consensus (e.g., *White Paper on Tertiary Education in the Czech Republic* 2000; Koucky & Kovarovic et al., 1999) that something has to be done in the Central European transition economies to reduce the mismatch of supply and demand of those skills that are at a premium in a modern market economy. That consensus notwithstanding, the literature on the status of Czech post-secondary education suggests that the current state of affairs is actually worsening.[5] To wit, the "structure of work places (occupations) is changing faster than the work force and human resources." (Koucky et al., p. 31) In other words, the frontier of theoretical knowledge[6] is moving out faster than the actual knowledge. In other words, the skills gap is worsening, especially in those areas that represent skills idiosyncratic for the New Economy (IT, various business-related skills.) [It will be part of our work in the exploratory phase to better understand empirically the relevant facts.]

Notwithstanding the important insight that "the fundamental factor of production is the skill level of citizens ... only a society willing to invest in life-long learning for its members and in developing their potential will have long-term success in global economic competition" (Koucky et al., p. 27), little is said about the way toward the goal of transforming the Czech Republic into "a society of knowledge" (lit.cit.,p. 27) Specifically, the important question is not answered of how some of the most pressing needs such as IT or business-related skills (that are roughly reflected in the curricular offerings of for-profits in the USA, see Ortmann 2000, 2000a, 2000b; see also Koucky & Kovaric 1999, p. 30[7]), could be met. None of the proposals for successful implementation of lifelong

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[5] This is in parts a problem of primary and secondary education (Koucky et al, pp. 32 - 35) and in parts a problem of the high selectivity and (negative!) added value of secondary education (lit. cit., pp. 36 - 39), but it is even more a problem on the post-secondary level where people who can teach the required skills are a scarce resource.

[6] "Frontier of 'theoretical knowledge'" in the current context denotes those skills that are at a premium in industrialized nations, namely IT related skills in the broadest sense. It probably would be more appropriate to call it the "frontier of 'technological knowledge'". In this grant proposal we use these terms interchangeably.

[7] Most for-profit educational companies in the USA build their curricular offerings explicitly on those 20 or 25 industry segments that are predicted to have the highest growth rates, namely business and IT related areas and health care. The table in Koucky & Kovaric et al – although it

learning strategies that we are aware of, addresses the potential for e-learning to slow down, and possibly reverse, the continuing drifting apart of the frontier of "theoretical knowledge" and actual knowledge.

For example, the draft of the *White Paper on the Tertiary Educational Sector* currently circulating in the Czech Republic acknowledges the need for dramatic systemic reforms such as (more) professionally oriented programs on the bachelor and master level, modular study programs, and credit systems, but does not acknowledge the rapid emergence of e-learning as a highly viable business and pedagogic model. A major problem with the kind of strategies proposed in the *White Paper* or similar publications is their authors' assumption that systemic reforms can be engineered from within the system. The US American experience suggests strongly that that's not going to happen. Too strong is the inertia built into the incumbent system (see Ortmann & Squire 2000). Furthermore, even if such institutional reforms would succeed, they would have to rely on "bootstrapping", i.e. trainers/content providers that themselves first have to learn the requisite skills. This, to us, is a losing proposition.

compares percentage of employment in various sectors in the Czech Republic with average employment in EU states is an indication of the deep structural problems that Central European States face.)

It is here where e-learning comes in. E-learning -- the on-line delivery of content that allows students to see, hear, and speak to professors and fellow students without ever having to leave their local learning center, or even home or office -- can be conceptualized usefully as a subset of distance learning as well as a superset of online learning which itself can be conceptualized as a superset of computer-based learning (Urdan & Weggen 2000, p.9; see also Moe & Blodget 2000). E-learning is typically web-based.[8] In the present context, the most interesting aspect of e-learning is that it knows no borders.[9]

It is in the nature of the beast that proprietary data are hard to come by and in any case are rather puzzling as apparently most people seem to agree that interactive online courses are as, and sometimes even more expensive, than on-campus courses. The available evidence suggests e-learning companies are making inroads because cost savings -- an estimated one-half to two thirds of the costs that employers would have to incur were they to send their employees to traditional continuing education/training courses (Evans 2000; see also Moe & Blodget 2000 and Urdan & Weggen 2000) -- are dramatic. Much of the savings seem to come from travel-related and time costs. In addition, e-learning offers unprecedented flexibility for those learners that have competing demands on their time. Last but not least, for-profit providers have benefitted from the increasingly accepted view that the notion of a completed education (diploma etc.) is becoming quaint and that what really counts in many contexts are ever-expanding portfolios of certified skills (e.g., Evans 1999; Healey 1999;

[8] At this point, the pedagogic consequences of the shift from chalk-and-talk teaching and learning to this particular mode of distance learning, are unclear. However, by revealed preference it is clear that these new providers do fill important needs that they manage to provide at a cost that makes it worthwhile. The growth rate of the OnLine division of the University of Phoenix – by now the largest provider of post-secondary education in the USA – is currently above 50 percent, with more than 10,000 students being enrolled as of Fall of 1999.

[9] It therefore is immune to ill-advised restrictive immigration policies like those of the Czech Republic.

Urdan & Weggen 2000; Moe & Blodget 2000). This idea has become known as "lifelong learning".

Most importantly though, at least in the present context, is the fact that once a course offering is online, everyone can access it from everywhere – if they can pay for it.[10] That access is not restricted is the key point in our argument, as e-learning has the potential to overcome the "bootstrapping problem" that we identified as the major driver of the continuing drifting apart of the frontier of "theoretical knowledge" and actual knowledge.

Working hypotheses:

1) It is exactly those skills that e-learning companies offer which constitute the relevant frontier of technological knowledge and for which there is therefore an increasing demand in the Central European transition economies, both on the part of traditional and non-traditional students.

2) If one factors in the opportunity costs of going to school full-time and/or travel-related and time costs, e-learning is less expensive for the same reasons that it is less expensive in the USA (although much will depend on the price tag with which those courses will be offered in the Central European transition economies).

3) There is a clear trend away from learning and teaching skills "just in case" to learning and teaching skills "just in time". Consequently, Diplomas (= signifiers of a "completed education") are losing their authentication function quickly while portfolios of certifications of specific, and quickly

[10] This may well be a binding constraint although from reading publications such as *White Paper on Tertiary Education in the Czech Republic* or Koucky & Kovarovic et al. (1999), one gets the impression that it would not be a highly restrictive one in the Czech Republic.

changing, skills are gaining ground ever more rapidly. E-learning, while depending on it to some extent, will accelerate the shift away from diplomas to certification.

4) The skills required to reduce the human capital mismatch problem cannot be easily imparted in traditional ways because of the "bootstrapping problem" identified above. Specifically, the lack of appropriately trained teachers/content providers make it impossible for a typical transition economy to keep step with the advance of the theoretical knowledge frontier.

5) The skills required to reduce the human capital mismatch problem can best be imparted through e-learning companies because they free potential students/ trainees from both space and time constraints that otherwise would be binding.

6) E-learning will accelerate convergence to a human capital structure adequate for a modern market economy, i.e. it will reduce the mismatch problem faster than the alternatives currently discussed. This must be so, because – given roughly identical out-of-pocket expenses and factually lower costs --, e-learning overcomes the boot-strapping problem identified above, and therefore increases the choice set for consumers of skills that are relatively highly priced in the economy.

7) E-learning will accelerate economic growth and per capita income.

3. Proposed methodology:

We propose to extract and merge the key features of the models of Kejak (2000) and Ortman & Nordberg (2000). That is, we intend to follow Kejak's analysis of stages of growth in the face of an exogenous (and rapidly moving) frontier of technological knowledge. As in Kejak (2000), human capital will be the engine of growth in our model and this growth engine does not have to be started through a structural one-off shock. We will also study both the steady state(s) and the transitional dynamics.

We will set up a general equilibrium model economy where, in contrast to Kejak (2000), agents will be modelled as finitely lived, adaptive (boundedly rational), and heterogeneous and maximize their respective objective functions by way of a hill-climbing trial-and-error process. The overlapping-generation model will use, and fundamentally amend, some of the features at the exogenous growth model with education groups in Laitner (2000). In this we will follow Ortmann & Nordberg's model of higher education that employs heterogenous agents on both the buyer and seller side, including "mutants" (in their case "for-profits" endowed with economies of scale) that invade a incumbent population (of non-profit educational entities). In contrast to Ortmann & Nordberg (2000), and generalizing Kejak (2000), our buyers will choose between different ways of acquisition of human capital via traditional education entities or via e-learning providers. To address the problem of human capital mismatch, and to analyze the effect of human capital allocation on growth, in transition economies, our model needs to assume agents' heterogeneity in the human capital. The reason for the use of boundedly rational agents is two-fold. First, "Administrative Behavior" -- including that of educational institutions -- has long been acknowledged to be boundedly rational (e.g., Simon 1947, 1959, 1982; Cohen, March, Olsen 1997; see for a detailed review Ortmann & Squire 1996 [see paper 6 at

http://home.cerge.cuni.cz/Ortmann/recentWingPaps.html; this paper is a precursor of Ortmann & Squire and has a long section on the very issue of the appropriate modelling approach of decision making in educational institutions.] Second, as we are interested in the effects of human capital composition on the growth of transition economies, using genetic algorithms will be conceptually simpler than employing models with rational expectations.

Last but not least, while our primary purpose is to build a theoretical and computational model, we will use as template a scaled-down version of post-secondary education in the Czech Republic. Specifically, we intend to base our initializations and robustness tests on "reasonable" estimates such as e-learning's out-of-pocket expenses and other cost savings and measures of the mismatch of skills particularly relevant for the Czech Republic. This institutional analysis will be conducted in the exploratory phase of our project.

4. Qualifications of the principal investigators:

Relevant past research of the principal investigators are summarized under 1. above; for additional research interests and qualifications see the curricula vitae of Kejak and Ortmann. We believe that our respective skills and qualifications are both complementary and synergistic.

5. Match with World Bank agenda:

The proposed project addresses two topics that feature prominently on the agenda of the World Bank: Education and Transition Economies. Specifically, the World Bank has promoted for several years private sector involvement in education (e.g. its investment in EdInvest, see http://www.worldbank.org/edinvest/pubs.html). Most recently, as documented by Covington (2000), the World Bank has funded online-learning programs on various sites in South Africa.

Since the World Bank is interested in improving the quality of economic analysis in education project and sector work and in building a network of education economists, our project could be a stepping stone for more ambitious work on education by our team and other CERGE-EI researchers. We also note that most of the relevant work on education in the Central European countries is not done by economists. We believe that analyses like the one that we propose would bring important new insights to the discussion.

6. Conclusion

We propose to build an endogenous growth model with genetic algorithms analyzing the consequences of e-learning companies invading the tertiary education landscape of transitional economies. Our project integrates the economics of education and matching, modern industrial organization, models of endogenous growth, and agent-based economics in a theoretically novel and innovative way: we believe that the resultant papers will be published in reputable journals such as Journal of Economic Dynamics and Control, Journal Economic Behavior and Organization, and possibly even higher-ranked journals. Equally important, our project promises insights about the conditions under which e-learning may contribute to a reduction of the human capital mismatch problem in Central European economies. If e-learning does what we conjecture it might – that is allowing to overcome the "bootstrapping problem" --, then one obvious and immediate policy would be to subsidize those who are willing to engage in e-learning. (En passant, we point out that there are also interesting policy issues for international e-learning providers who may have incentives to provide initial "price discounts" to gain market share.)

Appendix 1: Bibliography of relevant literature

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Appendix 2: Detailed curricula vitae of principal investigators

Appendix 3: Budget proposal and time table

Exploratory phase: Spring 2001

During the Spring we will undertake a detailed data analysis of the human capital mismatch problem in Central European transitional economies. We will continue our study of the business models underlying e-learning (including production and cost parameters which will then help us to calibrate our model.) We anticipate that significant parts of the first task can be done -- with appropriate guidance -- by a research assistant during the Spring 2001.

Modeling phase: Spring and Summer 2001

We will build our genetic algorithm model during late Spring and the Summer of 2001. The basic model should be up and running within one month of full-time work but we assume that various refinements, robustness tests (i.e., the study of the effects of initial conditions), and comparative static exercises (i.e., study of long run behavior under different parameter regimes) will take another two months of concentrated work by the principal investigators.

Writing phase: Fall 2001

Modeling phase and writing phase will to some extent overlap but we anticipate circulating working papers by late Fall 2001. We estimate the net time necessary to write up these papers to be one month for each of the principal investigators. We anticipate submission to reputable journals by the end of 2001.