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Determinants and wage effects of computer adoption in Eastern Europe

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Determinants and wage effects of computer adoption in Eastern Europe

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ABSTRACT

A large body of work has been published about the impact of computers and related technologies in more advanced economies, but much less is known about the role and impact of these technologies in the former communist countries of Central and Eastern Europe. Data from the Intermedia national survey of nine Central and Eastern European countries collected in the year 2000 was analyzed to identify the determinants of computer adoption and consequent effects on income. The method of two stage least squares was used in the process, with a probit equation in the first stage, and an Ordinary least squares regression in the second stage. The digital divide in this region of the world was also examined by means of the Even and Macpherson Decomposition.

This thesis establishes the importance of human capital, age, language skills and infrastructure as determinants of computer adoption in these economies, which is quite similar to developed country findings. It also finds that there is an increase in productivity, measured by wages, as a result of computer use, and the computer premium ranges from 21 to 24 percent. In terms of the digital divide, while there is a statistically significant difference in adoption rates between Russia and other groups of countries, it is due to differences in coefficients, not characteristics.

CHAPTER ONE

INTRODUCTION

In the 1990s, the economy of the United States grew at a phenomenal rate. Between 1995 and 2000, the economy grew at about 4 percent per year (Oliner and Sichel, 2000). Average labor productivity also increased dramatically, growing at 2.4 percent per year during 1995-1998, more than a percentage point faster than 1990-1995, after a twenty-year slowdown (Jorgensen and Stiroh, 2000).

Most of this growth, which was considered almost miraculous, was attributed to the impact of the information technology (IT) revolution, comprised mainly of computers and related technologies, and the term " New Economy" developed. The IT revolution was supposed to have changed the economy by greatly increasing productivity, which dramatically increased incomes and wealth. Real wages also grew dramatically during the period, and the level of consumerism soared as spending increased dramatically, and net savings dropped. The net result of all this was that the economy boomed. (Gordon, 2002) These results generated a flurry of studies on the use of information and communication technologies (ICT) and their impacts on national economies, mostly in the United States and in Western Europe.

Oliner and Sichel (2000) estimated that the use of information technology and the production of computers accounted for about two-thirds of the productivity growth that occurred in the United States in the late 1990s.

Colecchia and Schreyer (2001), in their paper compared the impact of ICT capital accumulation on output growth in Australia, Canada, Finland, France, Germany, Italy, Japan, the United Kingdom and the United States. They found that ICT also had a positive impact on all these economies as the sector contributed 0.3 to 0.9 percentage points per year to economic growth during the second half of the 1990s, up from the between 0.2 and 0.5 percentage points per year depending on the country, in the previous two decades. While the performance of these countries was not as fantastic as that of the United States during the same period of time, these other countries also benefited from the positive effects of ICT capital investment on economic growth. Thus, the same growth stimulating impacts have also been recorded in other OECD countries.

Information technology adoption has been proven to have such a positive impact on industrialized economies, but its impact on less developed countries has not been established. It is important to study the factors that determine adoption of technology and to investigate its impact on labor productivity in other economies as well. In particular, it is important to establish whether information technologies offer broad based benefits to economies at all stages of development or if the benefits are restricted to economies with already established information and telecommunications infrastructure.

While "the new economy" has had positive effects on developed country economies, there is a darker side to it. The term "digital divide' was coined to capture the situation whereby certain groups of people, or countries do not have access to, or the capability to productively utilize modern information and communication technologies.

> The network society is creating parallel communications systems: one for those with income, education and—literally —connections, giving plentiful information at low cost and high speed; the other for those without connections, blocked by high barriers of time, cost and uncertainty and dependent on outdated information. With people in these two systems living and competing side by side, the advantages of connection are overpowering. The voices and concerns of people already living in human poverty—lacking incomes, education and access to public institutions—are being increasingly marginalized. Determined efforts are needed to bring developing countries—and poor people everywhere—into the global conversation. UNDP (1999)

There are two forms of the digital divide. The first is the divide within a country. As will be shown in chapter 4, the access to and gains from ICTs within the developed countries have not been evenly distributed. Access has been limited by income; race, sex, age and location just to mention a few. For instance in the United States, urban households with incomes of $75,000 and higher were more than twenty times more likely to have access to the Internet than rural households at the lowest income levels, and more than nine times as likely to have a computer at home in 1998. Between 1997 and 1998, the divide between those at the highest and lowest income levels grew 29 percent (NTIA, 1999).

The other form is the divide between information rich and information poor countries. The international digital divide is based largely on the vast economic disparities between the wealthier, industrialized nations and the poorer, developing nations. For example, high-income countries with 16 percent of the world's population have 90 percent of the world's Internet hosts. The United States has more computers than the rest of the world combined. (Carveth and Kretchmer, 2002)

This thesis is a study of 7 former Soviet Union republics (Armenia, Belarus, Georgia, Moldova, Russia, Ukraine and Uzbekistan), as well as Bulgaria and Romania, all emerging economies in Eastern Europe. The countries span a range of population sizes and economic activity and are thus representative of other transitional economies, so that results obtained can be generalized for all the others. All of these countries were formerly communist countries, and only after the fall of the Soviet Union in the 1990s have they started to democratize, open up their economies, and adopt capitalism. Their quest for economic growth and prosperity for their citizenry has not been without pitfalls, as they have had to develop new types of economic institutions and social attitudes. However, with more openness after years of isolation, they have started to adopt not only the economic systems of the West, but also their technology. Many of the governments of these countries, as they strive to develop and grow, are also making efforts to fully develop the IT industry and encourage mass adoption of computer technology. (Danielyan, 2001).

As earlier noted, technology adoption is commendable if it will jumpstart their economies and help them to catch up with their more technologically advanced Western European neighbors. However, if the pattern of adoption will also lead to a digital divide within and among these countries, then it has the potential to create a different set of problems.

As will be further developed in chapter 2, the prospect of catching up with more developed countries is rather low at the moment. This is because the rate of computer penetration is low due perhaps to the communist heritage of these economies which has bequeathed them with a high level of regulation, low incomes, high level of income stratification, domination of state ownership in nearly all sectors of economy, insignificant country investments, risky environment for foreign investments and a host of other factors. These have contributed to the underdeveloped IT sectors in these countries. (Babicki, 2002). These factors are important because they have implications for the level of infrastructural development of these countries, which determines the cost of technology adoption. As will be further developed in chapter 3, the low levels of income within these economies (another bequest of communism) are also a major barrier, as income determines basic access to technology in terms of affordability.

This study has three major objectives, which are to

- uncover the profile of the adopter of computer technology in these economies with a view to discovering whether it's the same as that in more developed countries
- investigate the impact of adoption on wages, and to find whether ICTs have the capacity to increase productivity and consequently income as it is believed to have done in other developed economies.
- explore the existence and nature of the digital divide in this region of the world.

The rest of the thesis is organized as follows:

Chapter 2 contains a survey of the infrastructural and socioeconomic development of the countries in the region, particularly since the 1990s when they abandoned communism. This chapter is important because it provides a proper context within which to understand the findings of the study. The third chapter contains the analytical framework within which the analysis is done as well as an exhaustive literature review, while the fourth presents the data, the methods of analysis and the results. Finally, the fifth chapter presents the summary and conclusions as well as policy implications of the results.

CHAPTER TWO

ECONOMIC AND INFRASTRUCTURAL BACKGROUND BY REGION AND COUNTRY

2.1 THE REGION: EASTERN AND CENTRAL EUROPE, SOUTH WEST ASIA.

The countries of interest in this study include two post communist Central European countries, namely Romania and Bulgaria, and seven other countries that emerged as independent republics after the fall of the Soviet Union. Three of these countries, Armenia, Georgia and Uzbekistan, are found in Asia, while the other four, Belarus, Moldova, Ukraine and Russia are also located in Eastern Europe, although Russia has also been placed in Northern Asia (CIA, 2002). Wherever they are located on the map however, communism was a common political and economic ideology shared by these countries. The Soviet Union fell in the early 1990s, and with it the communist philosophy, but these countries have since struggled with the political and economic transitions to a democratic and free market economy. Most of their economic institutions were dominated by the state, and in many cases, this did not change for many years after independence. In a few cases, the state still reigns supreme. This tight control extended to everything, including the telecommunications sector.

The broadcasting and telecom infrastructures inherited from the Soviet era were underdeveloped and tightly controlled with inefficient and moribund technology. The reluctance in some of these countries to privatize state monopolies and liberalize the telecommunications market has led to a substandard telecommunications sector that cannot fully respond to the demands of a modern economy in several ways which include low levels of teledensity, which are far lower than those in Western European neighbors, and poor technology that makes it impossible for the system to cope with growing demand for data and information services. (UNESCO, 1999).

Telecommunications Infrastructure and Penetration:

While the level of development differs from country to country, the problems are comparable and the consequences for the telecommunications sectors are similar. Tables 2.1 and 2.2 below display the level of Internet, computer and telecommunications penetration in each of these nine countries, and then compares these to a few developed countries in Western Europe and the United States. Clearly, the United States has the highest rate of telecom infrastructure and penetration, as it has more Internet hosts and users per 10,000 inhabitants than all of Europe combined. When the level of infrastructure available in each of the countries under scrutiny is compared to the average for all Europe, or even to the individual Western European countries or the United States, it is clear that there is a huge gap between these countries in terms of infrastructure. Bulgaria, with 42.28 has the highest number of Internet hosts* per 10,000 inhabitants, but that does not even begin to compare with the average for all of Europe of 229.65, or almost 4000 for the United States. Uzbekistan has 0.09 hosts per 10,000 inhabitants, a very minute number indeed. While there are 62.5 personal computers per hundred people in the United States, and about 20 per hundred people in all of Europe combined, the figures for the nine countries in question range from 0.92 per hundred inhabitants in Armenia, to 8.87 in Russia. While there was a marked increase in cellular mobile subscribers between 1995 and 2002 for all countries, the level of penetration was still insignificant. The number of cellular mobile subscribers ranged from 0.74 in Uzbekistan per 100 inhabitants to 19.12 per 100 inhabitants in Bulgaria, quite inconsequential when compared to about 50 for both the United States, and all of Europe, and whopping 85 subscriptions per 100 inhabitants in the United Kingdom.

There was a slight improvement over the previous statistics in the teledensity level, which is the number of phone lines per 100 people, as it ranged from 6.66 in Uzbekistan to 29.94 in Belarus. Bulgaria with 37.46 was quite close to the average for all Europe of 40.93, but still far removed from The United States with 65.89 or Switzerland with 73.27. In addition, none of the nine countries has more than 40 telephone subscriptions per 100 inhabitants, with the exception of Bulgaria with 55. All of Europe combined had about 90 subscriptions and none of the individual Western European countries or the United States had

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* An Internet host is the number of units linked to the global network.

less than 100 subscriptions per 100 people. In fact, Switzerland topped the list with 152 subscriptions. The positive impact of information and communications technologies in the more advanced Western European countries and the United States spoken of in the previous chapter were perhaps only possible because of the quality and deep penetration of relevant infrastructure within those economies.

The information just analyzed shows serious gaps in infrastructure between these more advanced countries and the countries under scrutiny. The socioeconomic and policy environment that created this state of affairs is examined in the sections that follow. It is important, however, to note that the number of Internet Service Providers (ISPs) is examined in each country as one of the rough measures of Internet penetration, but this may not mean much. There is a huge disparity in the number operating in each country due to how recently deregulation came about, and also depending on the country's maturity and the level of concentration. If deregulation is recent or ongoing in a country, then there are generally many ISPs competing for the market. In contrast, in a more mature market, there is usually more consolidation in the industry, such that there are fewer ISPs competing. Thus, a low number of ISPs in a country could be a sign of low Internet penetration, or a sign of high level of consolidation within the industry (Chaillou, 2002). The number of users within the country combined with the number of ISPs could be a more reliable indicator of how developed the Internet market is.

Table 2.1 Internet and Personal computer Penetration: Eastern Europe and Selected countries

Country	Internet				Estimated PCs	
	Hosts Total 2002	Hosts per 10,000 inhabitants 2002	Users (k) 2002	Users per 10,000 inhabitants 2002	Total (k) 2002	Per 100 inhabitants 2002
Armenia	2850	7.50	70	184.12	35	0.92
Belarus	4025	4.06	808	815.84	-	-
Bulgaria	32986	42.28	605	746.27	270	3.46
Georgia	3032	6.15	74	148.97	156	3.16
Moldova	1756	4.00	60	136.67	70	1.59
Romania	40971	18.35	1800	806.09	800	3.57
Russia	402229	27.92	6000	409.32	13000	8.87
Ukraine	71691	14.30	600	119.29	920	1.83
Uzbekistan	213	0.09	275	108.74	-	-
United States	**106,193,339**	**3728.74**	**155,000**	**5375.06**	**178,000**	**62.5**
France	1,388,681	232.86	18716	3138.32	20700	34.7
Germany	2,549,323	314.08	35000	4237.29	35921	43.49
Switzerland	560,902	770.34	2375	3261.79	3900	58.83
United Kingdom	2,865,930	485.03	24000	4061.74	22000	36.62
Europe	**18,363,144**	**229.65**	**166,386.5**	**2079**	**156,896**	**20.01**

Source: ITU (2003)

Table 2.2 Telecommunications Penetration and Infrastructure: Eastern Europe and Selected countries

Country	Cellular Mobile subscribers				As percent of Telephone subscribers	Phone lines Per 100 inhabitants	Total telephone subscribers	
	k		Per 100 inhabitants	percent Digital			Total (k)	Per 100 inhabitants
	1995	2002	2002	2002	2002	2002	2002	2002
Armenia	-	44.3	1.17	100	7.7	13.98	557.0	14.65
Belarus	5.9	465.2	4.69	96.3	13.6	29.94	3432.4	34.63
Bulgaria	20.9	1550.0	19.12	-	34.7	37.46	4463.9	55.06
Georgia	0.1	503.6	10.21	97.4	43.7	13.14	1152.1	23.35
Moldova	-	225.0	5.13	-	26.0	14.56	864.2	19.68
Romania	9.1	3845.1	17.17	43.4	48.3	18.38	7961.1	35.56
Russia	88.5	17668.1	12.05	-	33.2	24.22	53168.1	36.27
Ukraine	14.0	2224.6	4.42	-	17.3	21.21	12894.2	25.64
Uzbekistan	3.7	186.9	0.74	-	25.5	6.66	1725.7	6.91
United States	**33,785.7**	**140,766.0**	**48.81**	**89**	**42.6**	**65.89**	**330,767**	**114.7**
France	1302.5	38585.3	64.7	100	53.2	56.89	72514	121.59
Germany	3725.0	59200.0	71.67	100	52.4	65.04	112920	136.71
Switzerland	447.2	5734.0	78.75	100	51.8	73.27	11069	152.02
United Kingdom	5735.8	49921.0	84.89	100	58.6	58.74	81572	135.78
Europe	**24,081.3**	**401,715.4**	**50.21**	**55.4**	**55.1**	**40.93**	**719,143**	**89.83**

Source: ITU (2003)

2.2 BACKGROUND BY COUNTRY

This section draws heavily from information provided by the CIA World Fact Book (2002) and the report by the Center for Democracy and Technology on Internet Access in Central and Eastern Europe (CDT, 2001). The information presented is from these two sources unless otherwise noted.

2.2.1 Armenia

2.2.1.1 Political and socio-economic issues

Armenia is a landlocked country located in Southwestern Asia, just East of Turkey, with a population of about 3 million (July 2002 estimates) but its population declined at the rate of 0.15 percent in 2002. The country was formerly a part of the Soviet Union, and it developed a modern industrial system, supplying machine tools, textiles and other manufactured goods to sister republics in exchange for raw materials and energy. It gained independence from the USSR in 1991, and has since become a small-scale agrarian state, with very small mineral deposits. Armenia, with a GDP per capita of $3,350 (purchasing power parity), is categorized as a low-income country by the World Bank, though the economy was estimated to have grown at the impressive rate of 9.6 percent in 2001. It was estimated that about 55 percent of the population lived below the poverty line as at 2001, and it had an unemployment rate of about 20 percent during the same period. The major language, Armenian, is spoken by about 96 percent of the population, and the population is almost 100 percent literate* The governments since independence from the Soviet Union have made concerted efforts to modernize the country and stimulate economic growth, including privatization of industry and striving to reduce inflation among other measures, but there is still a lot to be done for Armenia to join the rank of fully developed nations.

2.2.1.2 Levels of institutional development and impact on infrastructure

Telecommunications services are run by a monopoly, Armentel, which is the only provider of domestic commercial landline-based and mobile services, as well as international connectivity, and its monopoly extends even to services that regularly enjoy competition in other countries, including the provision of long distance service and mobile phone services

* defined as people over age 15 who can read and write.

(ECA, 2001). The phone system is assessed as being inadequate to meet the country's needs, although it is undergoing modernization and expansion. Most of the telephone networks (landlines) are highly depreciated analogue systems that give poor quality service, and the best service is only available in the capital Yerevan. Outside the capital, access to telephones is much more difficult (ITG, 2001).

While the market for the Internet is relatively more competitive, as the country has nine ISPs, the existence of a monopoly on international communications constantly creates problems mainly related to price issues between the ISPs and the monopoly. It is difficult to provide affordable Internet services, given the administrative structure, in a country with over half the citizenry living below the poverty line. Consequently, it is estimated that only about 30,000 Internet users existed in the country in the year 2001.

2.2.2 Belarus

2.2.2.1 Political and socio-economic issues

Another landlocked country found in Eastern Europe, Belarus is located to the east of Poland, with a population of over 10 million people which declined at the rate of 0.14 percent in 2002. Languages spoken are Belarusian and Russian, and literacy for the total population is 98 percent. While the country obtained its independence from the USSR in 1991, it has embarked on very few structural reforms, still clinging to the communist past. The country has maintained close ties to Russia since embarking on Market socialism in 1995, meaning that the state still has tight control over the running of the economy, and there isn't any real effort to adopt a capitalist economy. In 2001, the GDP per capita was $8200 (at purchasing power parity), with the economy estimated to be growing at 4.1 percent. About 40 percent lived under the poverty line in 2000 (UNDP, 2002) and while the official unemployment rate in 2000 was 2.1 percent, there were estimated to be a large number of underemployed workers.

2.2.2.2 Levels of institutional development and impact on infrastructure

The telecommunications sector is controlled by the Ministry of Telecommunications through a Beltelcom, the state carrier that is also a monopoly. Most of the infrastructure is outdated especially outside the capital of Minsk. While telephone exchanges are being digitized and new lines being added, the quantity is still grossly inadequate, as over half a million applications for phone services remained unsatisfied in 1996. Though the government controls on the sector are very rigid, the Internet has managed to grow in the country due largely to a joint effort among the national phone company and some international organizations. By 2002, the country had 23 ISPs and was estimated to have almost half a million Internet users.

2.2.3 Bulgaria

2.2.3.1 Political and socio-economic issues

Bulgaria is in Southeastern Europe, and it borders the Black Sea, between Romania and Turkey. It has a population of 7.6 million people, with the population declining at a rate of 1 percent per annum (2002 estimates). The major language spoken is Bulgarian, and literacy is almost 100 percent. Bulgaria adopted a new constitution in 1991, and since 1996, a more democratic system has been established with the fall of the then socialist government. The real growth rate of GDP was estimated at 3.4 percent, and GDP per capita was $6600 (at purchasing power parity). About 35 percent of the population live below the poverty line, and unemployment is high at about 18 percent.

2.2.3.2 Levels of institutional development and impact on infrastructure

From tables 2.1 and 2.2, it is clear that Bulgaria has among the highest telephone penetration in the region, but its telecom infrastructure is still far behind that of Western Europe's. The quality of phone service is still substandard, and the telecom infrastructure still antiquated. There is, as in most of the region, backlogged demand for land phones, and cellular phones are being increasingly used as substitutes.

The country initially had a monopoly in its telecom sector as The Bulgarian Telecommunications Company (BTC), was the State owned monopoly with exclusive rights to provide access to local, long distance and international conventional basic services.

However, with Bulgaria desiring to join the European Union, it has been forced to open up the telecom market to competition, the process of which has begun, and it is hoped that this will lead to modernization of the telecom infrastructure and services.

The Internet is spreading, slowly but surely. By 2001, the country had 200 ISPs, and over half a million Internet users.

2.2.4 Georgia

2.2.4.1 Political and socio-economic issues

This is a country in Southwestern Asia, bordering the Black Sea between Turkey and Russia, populated by about 5 million people, but with the population declining by about 0.5 percent per year (2002 estimates). About 70 percent of the population speaks Georgian, about 10 percent, Russian, and the others speak several other languages. Literacy is almost 100 percent.

Georgia was a former Soviet Republic and, like all others, gained independence from the Soviet Union in 1991. Democracy has since been installed, with a new constitution adopted in 1995. The country is now mainly an agricultural economy, but it also has a small industrial sector. It has a struggling economy due to civil strife, but has shown signs of recovery in recent times. The per capita GDP is $3100 (purchasing power parity), and GDP was estimated to grow at 4 percent in the year 2002. However, over half (54 percent) of the population lives below the poverty line, and income is very unevenly distributed, with the lowest 10 percent getting 2 percent of total consumption, while the highest 10 percent controls 28 percent.

2.2.4.2 Levels of institutional development and impact on infrastructure

The development of the telecom sector in Georgia has been very slow due to several limiting factors that include the archaic state of the country's telecom infrastructure, high cost of basic equipment and lack of qualified personnel, among several others. Like most other nations in the region, the telecom sector was run by monopolies: Sakartvelos Telecom, which handled international communications, and Sakartvelos Elektokavshir, which operated local and inter-municipal networks. However there is an ongoing effort to privatize the sector, which will hopefully lead to greater efficiency in the sector. Internet penetration has also been slow, with only six Internet service providers in 2000, and only 25000 estimated users in 2002.

2.2.5 Moldova

2.2.5.1 Political and socio-economic issues

Moldova is located in Eastern Europe, just Northeast of Romania with a population of about 4.5 million people, and a population growth rate of 0.09 percent (2002 estimates). The official languages are Moldovan (virtually the same as Romanian), and Russian. Literacy is almost universal. Moldova obtained independence from the USSR in August 27, 1991, and it adopted a new constitution in 1994. Democracy has since been entrenched, as it adopted the parliamentary system of government, with a president and prime minister.

Moldova is regarded as one of the poorest countries in Europe. It is now a predominantly agricultural economy with no major mineral deposits. However, with help from international financial institutions, the economy has begun to show some signs of growth. GDP per capita was $3000 in 2002 (purchasing power parity estimates), and real growth rate of GDP was estimated at 4 percent within the same period. However, 80 percent of the population are said to be below the poverty line, and income distribution is skewed, with the lowest 10 percent accounting for only 2 percent of consumption, while the highest 10 percent captured 31 percent of total consumption. Unemployment rate is relatively low at 8 percent.

2.2.5.2 Levels of institutional development and impact on infrastructure

The telecommunications sector in Moldova is woefully underdeveloped, but it is making slow but steady progress with the aid of the government and foreign organizations. Mold Telecom, the dominant telecommunications carrier, is 100 percent state owned, though there are efforts being made to privatize it. Most of the phone lines in the country are analog and not digital, with outdated equipment, and there is a major language difficulty. The preferred languages in science are largely Russian and Romanian and not English. In chapters 3 and 4, the importance of speaking major languages of commerce for the adoption of computer technology will be further expanded upon. The country has also had to depend on international funding, at least in this sector, making long range planning almost impossible. Internet penetration is extremely low. By 1999, there were only two ISPs, and an estimated 15,000 Internet users in 2000.

2.2.6 Romania

2.2.6.1 Political and socio-economic issues

Located in South Eastern Europe and bordering the Black Sea between Bulgaria and Ukraine, the country is one of the largest of the nine being studied. Population is over 22 million, though as at 2002, population was estimated to be declining at about 0.21 percent. Languages spoken are Romanian, Hungarian, German and literacy is almost universal. Like most other former communist economies, Romania adopted a new constitution in 1991, and has since adopted democracy. Per capita GDP was $6800 (2001 estimates), with a GDP growth rate of 4.8 percent in 2001. About 45 percent of the population were estimated to be below the poverty line in 2000. The unemployment rate, however, was lower than that of several other countries in this study, at about 9 percent.

2.2.6.2 Levels of institutional development and impact on infrastructure

The telecommunications sector here again is inadequate and poorly developed. In 1996, the waiting list for a telephone line was over a million people, and the average waiting time was 7 years. The dominant, formerly state owned telephone service provider, Rom Telecom, was partially privatized in 1998. Rom Telecom has a monopoly of over local wireline, long distance and international voice telephony services and network infrastructure. The government has taken steps to reduce the waiting lists for phone lines by installing more lines and updating equipment, but there is still a long way to go.

The Internet does seem to be catching on though. As at the year 2000, the country had 38 ISPs, and had an estimated one million users in 2002.

2.2.7 Russia

2.2.7.1 Political and socio-economic issues

The largest country in the survey, Russia is found in Northern Asia bordering the Arctic Ocean, between Europe and the North Pacific Ocean, and it has a population of over 144 million people, though with a negative population growth rate of 0.33 percent in 2002. The dominant language spoken is Russian, and literacy is about 100 percent.
Also a former Soviet republic, Russia obtained independence from the Soviet Union in 1991, and adopted a new constitution in 1993.

Since the demise of the USSR, Russia has been struggling to establish a modern market economy and modernize its institutions. The country is heavily dependent on the exports of commodities like oil, natural gas, metals and timber, which account for over 80 percent of exports. The country no longer has a strong industrial base, and is subject to swings in international prices for its exports. GDP per capita is $8800 (purchasing power parity), and GDP growth rate in 2002 was an estimated 4 percent. 40 percent of the population live below the poverty line, and income distribution is skewed: the lowest 10 percent accounted for just 2 percent of total consumption, while the highest 10 percent consumed 34 percent. Unemployment is 8 percent, though there is considerable underemployment as well.

2.2.7.2 Levels of institutional development and impact on infrastructure

Infrastructure is very poor, as almost all of Russia's phone lines are analog, not digital and, thus, there is slow data transmission and long delays. In 1996, the number of unsatisfied applications for telephone service was 8.8 million, and the waiting period for installation of a phone line was an estimated 10 years. Nearly 90 regional and metropolitan networks provide local exchange service, most of which have been partially privatized. However, the government still holds at least 51 percent ownership. Russia's economic problems in the early nineties as it struggled to recover from its communist past have overshadowed every aspect of life, including the telecommunications sector. However, there have been improvements in the telecommunications infrastructure with more rapid digitization, though the improvements are mostly confined to the urban areas. In the rural area, the services available are of very poor quality, and low density.

In terms of Internet penetration, Russia had only 35 ISPs as at 2000, which is grossly inadequate for a country of over 100 million. It also had 18 million Internet users by 2002, but the number was severely hampered by the poor telecommunications infrastructure. An explosion in number of Internet users is expected as telecommunication facilities improve.

2.2.8 Ukraine

2.2.8.1 Political and socio-economic issues

Ukraine is located in Eastern Europe, between the Black Sea, Poland and Russia. The population is over 48 million, though declining at 0.72 percent (2002 estimates). Languages spoken are Ukrainian, Russian, Romanian, Polish and Hungarian and literacy is almost 100 percent.

Ukraine obtained independence on the 24^{th} of August 1991, and a new constitution was adopted in June 1996. Democracy has since been installed. The second most important country in the former Soviet Union after Russia, Ukraine was a major source of agricultural output and heavy equipment. Since independence, it has struggled with attempts to liberalize prices and set up a framework for privatization. Its GDP per capita was $4200 in 2001 (purchasing power parity) and some of the efforts of the government seem to be paying off, as GDP grew at the rate of 9 percent in 2001. Also, living standards seem to be better relative to other countries in this study, as only 29 percent of the population lived below the poverty line. In terms of income distribution, the lowest 10 percent of the population accounted for 4 percent of consumption, while the highest 10 percent accounted for 23 percent of consumption, also relatively more equitable than other countries under scrutiny. The unemployment rate is also unusually low at 3.6 percent (officially registered), although there is a large number of unregistered or underemployed workers.

2.2.8.2 Levels of institutional development and impact on infrastructure

As of 1996, over 3 million people could not get a phone line in Ukraine, and the average waiting time was 6 years. Ukraine also has a State company Ukrtelecom that monopolizes the provision of telecommunications services. The company controls more than half of the international communications channels and practically all local telephone service. It is also 100 percent government owned. The long distance and international carrier, Utel, is 49 percent owned by a foreign consortium and 51 percent owned by Ukretelecom. While the phone system is still poor, there are improvements. Phone density is slowly increasing and the domestic trunk system is being improved, and mobile cellular phone system is also expanding at a high rate. Also, the Internet is expanding rapidly in terms of facilities and users. In 2001, the country had over 260 ISPs and 750,000 Internet users.

2.2.9 Uzbekistan

2.2.9.1 Political and socio-economic issues

One of the only two doubly landlocked countries in the world, Uzbekistan is found in Central Asia, North of Afghanistan. It has a population of about 25 million people, and Uzbek is the predominantly spoken language (74 percent). Literacy is almost 100 percent.

Uzbekistan obtained independence from the USSR on the 1st of September 1991 and adopted a new constitution in December 1992. The country is the world's largest exporter of cotton, and it also exports significant amounts of gold, oil, chemicals and machinery. Despite independence from the Soviet Union, however, the country still tries to run a Soviet style economy, as the state is a dominant force in the economy, with very little structural changes. Uzbekistan is the poorest country in the sample being studied, with a GDP per capita of about $2500 in 2001 (purchasing power parity estimates), and the economy grew at a disappointing 3 percent in 2001. The population living below the poverty line is unknown, but the lowest 10 percent of the population have access to 3 percent of household income, while the highest 10 percent control 25 percent. The unemployment rate is 10 percent, although an additional 20 percent were estimated to be underemployed in 1999.

2.2.9.1 Levels of institutional development and impact on infrastructure

Like every other country in being surveyed, the telecommunications sector is also controlled by monopolies: UzbekTelecom (telecommunications) and UzPAK (International Internet Connectivity). The issues are also similar to those found in other countries: outdated and inadequate infrastructure as well as cost of access are major problems in this country. The Internet is slowly catching on, with 42 ISPs in 2000 and 100,000 Internet users in 2002. However, connection is expensive as Internet tariffs are much higher than in the US or Western Europe.

In addition to these country specific factors, another major issue affecting adoption of the computer and related technologies in these countries is the cost. In most of these countries, wages are so low that the average citizen cannot afford to own a computer or hook up to the Internet. The poor state of infrastructure and poor management creates a situation whereby these services are basically out of reach of a vast majority of the population. In most countries, the costs of Internet tariffs are much higher than in the United States or Western Europe, so that usually, only corporate clients, banks or foreign representative offices can afford these services. Most times, these high prices are a result of a monopoly offering these services, which results in inefficiency in delivery. For instance, in Uzbekistan, the monopoly access of UzPAK to international services has led to high prices for Internet access. There is also no interconnection (peering) among local ISPs, which also increases the price of Internet access. While average dial-up connection costs between 800-1400 soums an hour during the day, and 375-650 soums an hour during the night, the average monthly salary is 13749 soums. Clearly, this is unaffordable for the average citizen.(Revin, 2001). However, in a country like Armenia, the high prices are a result of lack of demand due to the low level of business activity and the small size of the market. (ITG, 2001).

In summary, it is clear that all nine countries being studied have had a rough transition from communism to capitalism, while a few have found it difficult even to embark on any kind of structural changes. All have struggling economies, and inadequate institutions. These problems have also afflicted the telecommunications sector both in terms of management and infrastructure, as both are grossly inadequate and need urgent improvement if these countries are to reap the benefits of the information revolution, which has transformed more advanced economies.

CHAPTER THREE

ANALYTICAL FRAMEWORK AND LITERATURE REVIEW

3.1 THE FARM HOUSEHOLD MODEL

The farm household model Singh et al (1986) and Huffman (2001) is applied to model computer adoption, although this is a much simpler version.

Consider the model for total income:

$Y = wH_w + f(H_c, K_H) + V;$ (1)

Where: w = wage,

w= w(education, age, other demographic and human capital indicators);

H_w= hours of wage labor

H_C= Hours of computer use

K_H = Human capital accumulation

$f(H_c, K_H)$ = production function which translates H_c, K_H into income.

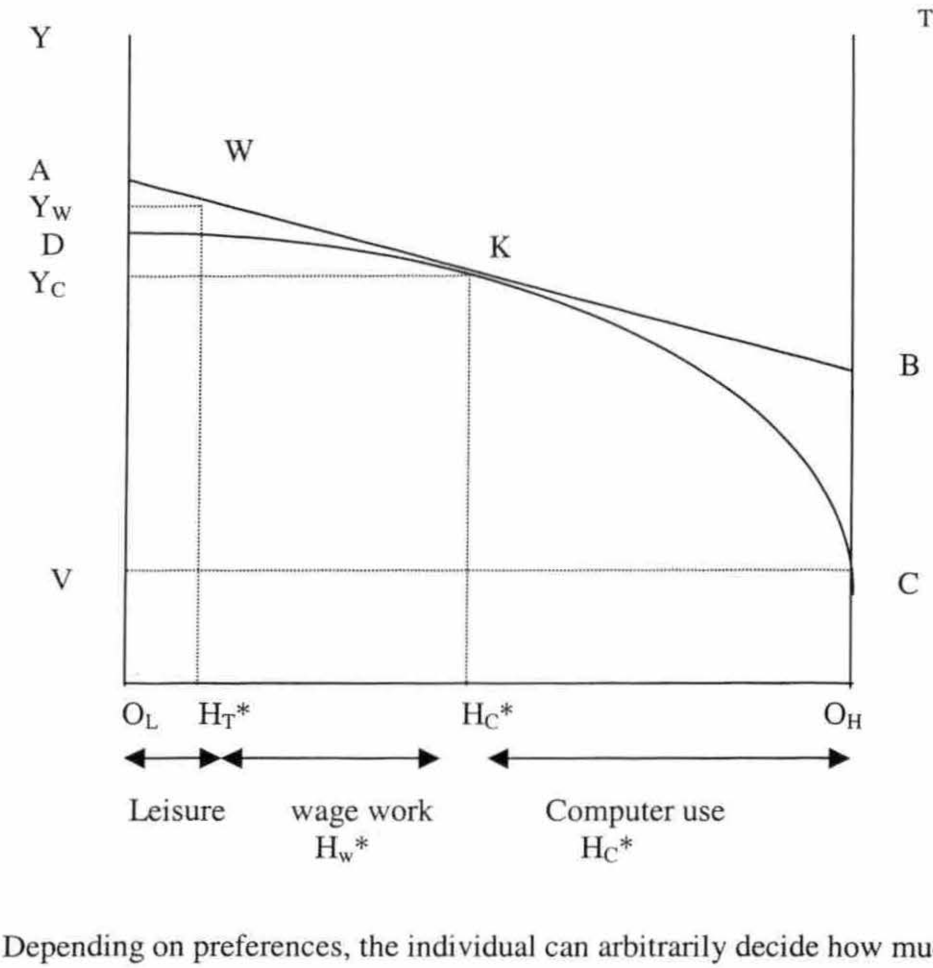
V = Non labor income.

From equation (1) above, there are three sources of income for the individual: wage work, returns to computer use, and non-labor income; this is presented graphically in figure 1 below. The individual is assumed to have a total time endowment T, which he can utilize in three ways: Working for a wage, using computers, or taking leisure. The amount of leisure taken runs from left to right on the horizontal axis, while the number of hours he chooses to work for a wage and /or on the computer is depicted as going from right to left on the horizontal axis. Therefore, the individual at point O_H takes all his time in leisure and does not work at all.

Let line AB be the line with slope (w) = wage rate, and the computer output production function is represented by the production function $DKCO_H$, and the slope of the production function is the marginal product of computer output, MP_{HC}. Also, O_L V represents non labor income. As long as the wage rate $dY/dH_L = w < dY/dH_c = MP_{HC}$, the individual chooses to work on a computer because the returns to the computer outweigh the returns to wage work (segment KB). Beyond point K, however, the returns to wage work outweigh the returns to working on a computer and, thus, the individual chooses to work for a wage rather than on a computer (segment AK).

There are a few simplifying assumptions made with respect to the technology utilized in production of computer output: the production function $f(H_c, K_H)$ is assumed to have positive but decreasing marginal product ; $f_i > 0$, $f_{ii} < 0$;

Figure 1 Decision on hours of wage work and hours of computer use.



Depending on preferences, the individual can arbitrarily decide how much of wage work and leisure he wants to take. Assuming the individual decides on point K as the limits to computer usage, then he works H_C* H_T* hours of wage work, and takes O_LH_T* in leisure. Total work done both for wages and on the computer is $H_T^* = H_C^* + H_W{}^*$

Thus, VY_C is the returns derivable from using computers, while Y_CY_W is the income derived from wage work.

This analysis thus gives an analytical framework for decomposing total measured income into non-labor income, income from computers, and wage income. This is not a perfect illustration. Computers add to productivity of wage work, and one hypothesis explored in another section is that using computers increases wages at work, which could ultimately affect the slope of the wage work line. However, this analysis assumes that we can separate out the different contributions of computers and wage work on total observed income.

In making the adoption decision, the individual examines the contribution of each component to income. If d_i is a dummy variable signifying adoption, then the individual makes a decision to adopt computers if the income from adopting computers is greater than the income from wage earnings alone.

More formally, $d_i = 1$ if $Y(w, V, H_L, H_c) > Y(w, V, H_L, 0)$

Else, $d_i = 0$

Where

$Y(w, V, H_L, H_c)$ = Income as a function of wages and hours worked, non-wage income, and hours of computer use.

$Y(w, V, H_L, 0)$ = Income as a function of wages, hours worked and non-wage income, with $H_c = 0$.

There are also other possibilities.

Figures 2 and 3 below depict alternative scenarios. In figure 2, the wage rate for wage work is higher than the returns to computer use at all $H_c > 0$. In this case, the household does not adopt computers, but only works for a wage, and the individual can be anywhere along line A. In figure 3, the returns to computer use are everywhere higher than the wage rate and, thus, the individual only uses the computer and never does any other kind of wage work.

Figure 2 Decision on hours of wage work and hours of computer use : No computer use

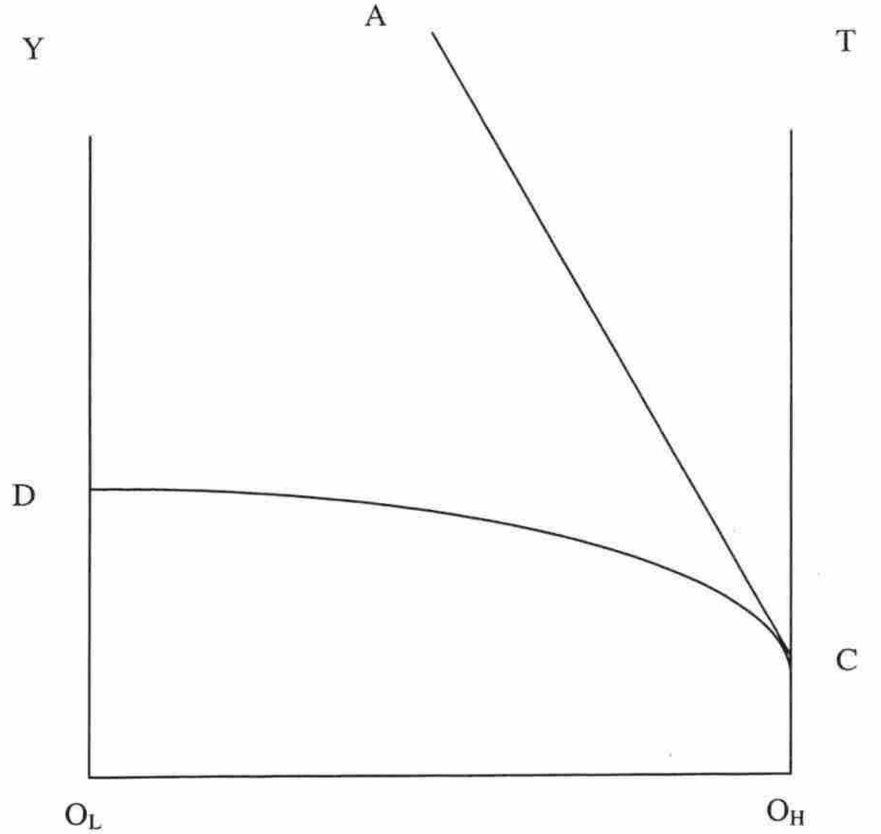
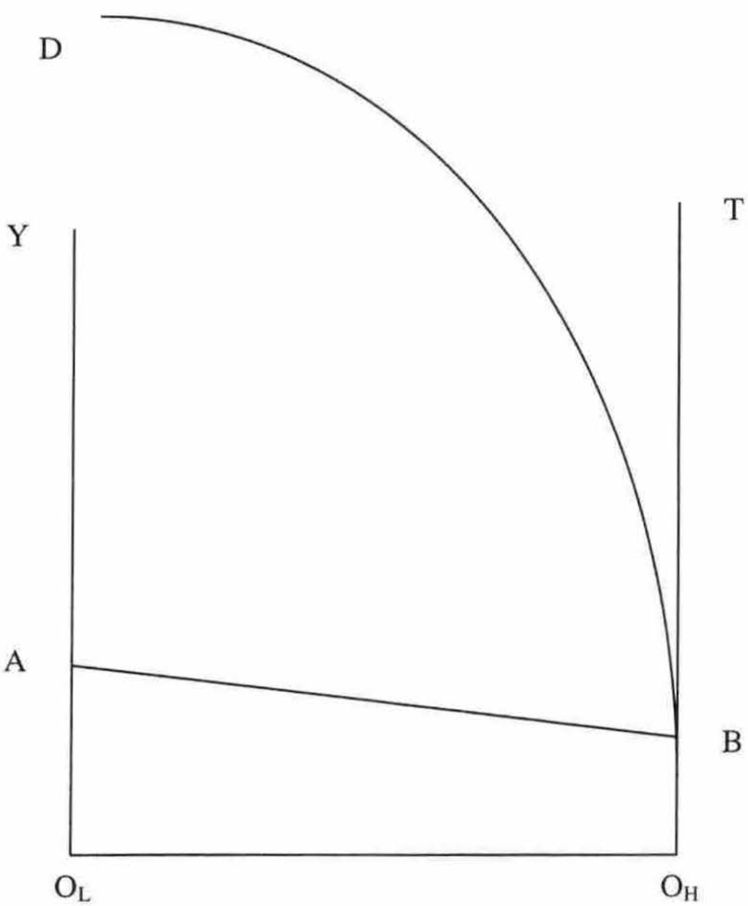
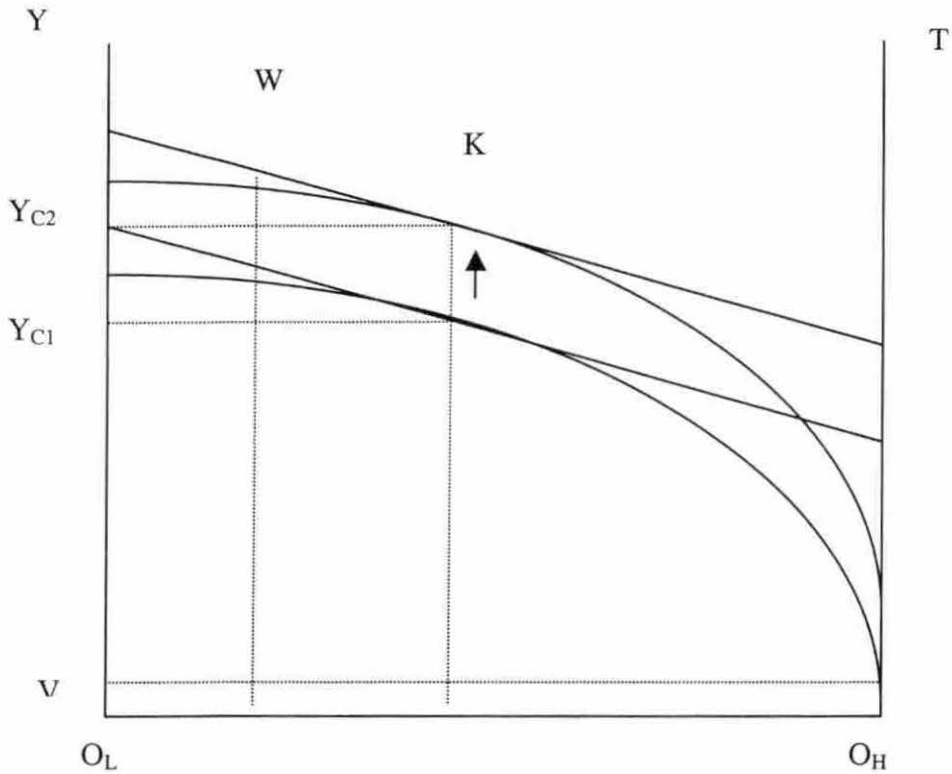


Figure 3 Decision on hours of wage work and hours of computer use: No wage work



In a subsequent chapter, a probit model incorporating human capital and other demographic variables, as well as other determinants of adoption, will be applied to the data from the nine eastern European countries to empirically evaluate the computer adoption decision. This specification, which will be thoroughly analyzed in the fourth chapter, includes exclusion variables which are added for identifiability of the system of equations. However, at this stage, these exclusion variables are only discussed within the context of the model.

Figure 4 Increase in levels of infrastructure or language skills.



As will be further expanded in the fourth chapter, it is important that the instruments chosen are outside the control of the individual (exogenous variables), but that they also affect the adoption decision without affecting wages. Within the model, it is also possible to examine how these instruments affect the adoption decision.

The computer adoption equation empirically analyzed in the next chapter is specified as a function of several variables: $f(K_H, D, K_L, K_I, K_F, C)$

Where

K_H = Human capital

D = Vector of demographic variables

K_L = Vector of variables showing language skills

K_I = Level of infrastructure

K_F = Vector of variables signifying interest in information.

C = Country characteristics.

The level of infrastructure and language skills will shift the production function upwards or downwards (depending on whether they increase or decrease), because they affect the ability of the individual to produce with a computer. Figure 4 shows a simple picture of what happens in this situation. Assuming a parallel shift of the production function, to keep matters simple, the maximum amount of time that a rational individual spends on the computer before switching to wage work remains unchanged at point k. However, using a computer is more profitable than previously, as the income derivable from computer use increases from Y_{C1} to Y_{C2}. Assuming also, that the individual decides to take exactly the same amount of time in wage work and leisure, the total income accruing to the individual is increased because of the increase in income derivable from computers.

Interest in information will affect the preferences of the individual. This will affect the position of point W and K in figures 1 and 4, and will determine how much of the computer the individual decides to utilize.

Also, in this specification, wages are a function of demographic and human capital indicators. A wage function will also be empirically analyzed in a later section, using a Mincerian earnings function.

3.2 LITERATURE REVIEW

3.2.1 Determinants of Technology Adoption

The literature on technology adoption is very wide and varied. Most of the determinants of technology adoption identified are demographic in nature both for individuals and, in relevant cases, firms. Many of the factors are interrelated, but will be discussed separately as much as is possible. The variables that determine adoption also point to the digital divide. Within countries, and within regions, these factors consistently determine the haves and have-nots of technology. UNDP (1999), in examining global use of the internet and access to computers and supporting infrastructure, provided some facts and figures that provides an idea of the global face of the digital divide. NTIA (1999) also provides some of the same information for the United States. The discussion also includes some facts from around the world related to the digital divide with information provided mainly from the two sources above, unless otherwise stated.

Human Capital (years of schooling)

There has been a decrease in relative demand for less educated workers in most OECD countries despite their increasing relative scarcity. The preferred explanation for this phenomenon by labor economists is skill biased technological change, which refers to the fact that recent technological change has created jobs that demand people with high skills. (Katz and Autor, 1999; Autor et al, 1998). This change has occurred as technology (especially computers) has diffused through the work place. Subsequently, routine tasks are more easily computerized and less skilled workers become less important in the scheme of things as they can be directly substituted for by more advanced technologies. Skilled job activities become more important and in this way, adoption of the computer or other advanced technologies induces an upward shift in skill requirements for computerized jobs. Thus, physical capital and new technologies appear to be relative complements with more-skilled workers, and are considered to be complimentary inputs
(Borghans and Weels, 2002; Katz and Autor, 1999; Autor et al.,1998).

There is plenty in the literature on technology adoption to corroborate the existence of the skill/education- technology complementarity that spans different types of technology, disciplines and economies (both developed and developing). Bartel and Lichtenberg (1987) found that educated workers have comparative advantage with respect to the adjustment to and implementation of new technologies. More specifically, Doms, Dunne and Troske(1997), demonstrated that the adoption of new factory automation technologies is more likely to occur in plants with skilled workforces. This positive correlation between human capital and technology adoption was found in the adoption of a variety of new technologies across several disciplines in the U.S including medical technology in the form of drugs newly approved by the Food and Drug Administeration (FDA) (Lleras-Muney and Lichtenberg, 2002), Genetic Engineering (GE) technologies (Fernandez-Cornejo and McBride, 2002), new cattle feeding technologies (Rumensin) in Iowa (Wozniak,1984, 1993) and also in computer technology (Autor et al., 1998). Autor et al. (1998) explored the role of skill biased technological change in the growth of the relative demand for more skilled workers from 1960 to 1990 by linking data from multiple sources on industry workforce composition, physical capital intensity, research and development expenditures, computer investments, and trade penetration and foreign outsourcing variables (for manufacturing industries). They found for both manufacturing and non-manufacturing industries that increases in the utilization of more skilled workers are greater in the most computer-intensive industries, although they warn that it is not clear whether a causal interpretation of these relationships is appropriate.

A similar trend exists in other OECD countries. Sabourin (2001), in examining the impact of skill shortages on adoption of advanced technologies in Canada, found that the most technologically advanced establishments were more likely to report a greater need for skilled labor, though they resolved the skill shortage problem by efficiently utilizing all the resources at their disposal to make the best use of the skilled labor that they did have. Machin and Van Reneen (1998) compared the changing skill structure of wage bills and employment in the United States with six other OECD countries (Denmark, France, Germany, Japan, Sweden, and the United Kingdom). They investigated the linkage between a directly observed measure of technical change (R&D intensity) and the growth in the importance of more highly skilled workers, which had occurred in all countries. They uncovered evidence of a significant association between skill upgrading and R&D intensity in all seven countries and concluded that skill-biased technical change is an international phenomenon that has had a clear effect of increasing the relative demand for skilled workers and that important skill-technology complementarities exist across all countries.

A similar situation was also found to exist in other cultures as several studies found a positive and significant relationship between schooling and technology adoption in developing countries. For instance, human capital in terms of schooling was found to be positively related to adoption of cross breeding technology in Tanzania (Abdulai and Huffman, 2003) as well as hybrid rice in China (Lin, 1990). In examining gender differences in agricultural productivity for both men and women in a sample of developing countries, (Quisumbing, 1995), found that education was the most important determinant of whether farmers adopted new technology, among both male and female farmers.

Evidence in the literature thus points to the fact that technology and higher education/skills are complements, and therefore, the better educated have greater incentives to adopt new technologies because they can be more productive with it.
Gloy and Akridge (2000), in examining the internet adoption by farmers present an explanation for the importance of education "The education variable most likely represents different ability and eagerness to learn to use new technologies as well as the overall ability to make the information gathered from the Internet useful". These theoretical findings are confirmed by survey results both within the United States and worldwide. Globally, 30 percent of Internet users have at least one university degree—in the United Kingdom it is 50 percent, in China almost 60 percent, in Mexico 67 percent and in Ireland almost 70 percent.

In the United States, seventy-eight percent of adults with a bachelor's degree or more had access to a computer at home, compared with 46 percent of those holding only a high school diploma (U.S. Census Bureau, 2001).

Age

In addition to human capital, another very important determinant of adoption is age as most studies have found that in addition to being better educated, new technology adopters are also younger. Huffman (2001) stated that "The decision to adopt new technologies is an investment decision because significant costs are incurred in obtaining information and learning about the performance characteristics of one or more new technologies and the returns are distributed over time."

When technology adoption is viewed as an investment with streams of returns over time, then it is more likely that younger individuals who have more time to recoup their investment will adopt it.

Huffman and Mercier (1991) explored the farmers' decisions on the joint adoption of microcomputer technologies. Using a multivariate logit model, they found that schooling and age were the most important factors determining adoption, as younger and better-educated farmers were more likely to adopt the new technology. Gloy and Akridge (2000) in examining the factors that led farmers to adopt the internet also found that age and education were important factors, with individuals over 65 years being 27 percent less likely to use the internet than those under 35; and significant differences in the probability of internet adoption only emerging when the individual reaches masters (and above) level, all other things being equal, with greater levels of education being required to see the value of the internet. Weinberg (2002) further elaborated on the association among age, education and technology adoption. He found from his study that computer use is higher among college graduates (including those with additional education), than with high school graduates, and is highest at the beginning of the career, falling considerably by older ages. Among high school graduates, however, computer use is most prevalent among experienced workers, peaking among workers with between 20 and 30 years of experience.

Surveys done worldwide have found that most users of Internet and computer technologies are young. The average age of users in the United States is 36, while in China and the United Kingdom it is under 30 years.

Income/Wealth

Borghans and Weel (2002), in a study in Britain also examined the complimentarity between technology and skills, but they concluded that the barrier to adoption by lower skilled workers was not skills but wages. They found that a high percentage of computer use among skilled workers was mainly explained by high wages, and that lower computer use among relatively unskilled workers was not due to skill deficiencies, but determined by the relatively high costs of adopting computer equipment. Thus, they claimed that as computers get cheaper, skill biased technological change would occur at lower ends of the labor market. Schirmer and Goetz (1997) in their Kentucky study, found that technology adopters were younger, better educated and wealthier. Baliamoune (2002), using data from several developing countries, found income to be a major determinant of diffusion of information and communication technologies (ICT), as it was found to influence both ICT infrastructure (causing higher use of personal computers and internet hosts), and access to ICT.

Quisumbing (1995) found that farmers with larger plots and higher values of tools were found to be more likely to adopt new technology than those with fewer resources. Studies of internet adoption in Macao, China and India all found that adopters of this new technology were in the higher socioeconomic brackets of their respective societies, and resided in urban areas (Kshetri, 2002; Cheong, 2002).

The next section will review some studies that emphasize the importance of race on adoption. Fairlie (2002) examined the digital divide across racial groups in the United States, and estimated logit regressions for the probability of having a home computer and the probability of using the Internet at home conditional on having a home computer. He found that education, income and occupation were important determinants of computer ownership and Internet use, like most of the earlier studies. Using a special non-linear decomposition technique, he also found that racial differences in these factors contributed substantially to the black/white and Mexican-American/white gaps in home computer and Internet use rates but that income was the most important explanatory factor, as it explained 25.1 to 31.0 percent of the black/white gap in home computer rates and roughly a quarter of the Mexican-American/white gap. In his study, racial differences in income explained roughly one tenth of the gaps in Internet use conditional on having a home computer.

The main issue here is that income is important because it determines access. Technology will only be adopted if people can afford to adopt it. Some facts and figures both for the United States and other economies also bear this out. Income buys access to technology, and consistently around the world, only those on the higher end of the socioeconomic ladder have access. The average South African user (of the internet) had an income seven times the National average income, and 90 percent of users in Latin America came from upper-income groups. More than 30 percent of users in the United Kingdom had salaries above $60,000. Buying a computer would cost the average Bangladeshi more than eight years' income, compared with just one month's wage for the average American. In the United States, Eighty-seven percent of related adults living in family households with incomes of $75,000 or more had a computer, compared with 28 percent of adults living in family households with incomes less than $25,000. Two-thirds (67 percent) of related adults living in the wealthiest family households used the Internet at home, compared with 14 percent of those living in households with the lowest family incomes. U.S. Census Bureau, (2001)

Other Factors

There are several other determinants of adoption, but there is little consensus about the effects of most of them on technology adoption. Schirmer and Goetz (1997) determined that sex and employment status were important for determining computer adoption, but race was not. They stated that women were 7 percent more likely to use a computer somewhere; and also that employed people used Information technology twice as frequently as the unemployed. Traditionally, however, men have been perceived to have the advantage in technology adoption. Women accounted for 38 percent of users in the United States, 25 percent in Brazil, 17 percent in Japan and South Africa, 16 percent in Russia, only 7 percent in China and a mere 4 percent in the Arab States. The trend starts early: in the United States five times as many boys as girls use computers at home, and parents spend twice as much on technology products for their sons as they do for their daughters.

Hoffman and Novak (1998), contrary to Schirmer and Goetz's findings, argued that race was a very important determinant of adoption. They examined the impact of race on access to computers and internet use in America and found that race had a significant impact on both access to a computer at home and at work, and also on internet use, even among students. While income explained the differences in home computer ownership and education explained the differences in work computer access, education could not explain race differences in home computer ownership, and income could not explain race differences in access to a work computer, and thus there was still a significant race effect.

NSF (2001) also found that there were racial differences in access to computers in the US, which could not be explained mainly by affluence as black households lag white households substantially in their adoption of home computers and linkage to the Internet. They also found that income, levels of education and sex were also important determinants of adoption, as males were more likely to adopt a home computer than females.

Fairlie (2002) reported significant racial differences in rates of adoption of home computers and the internet, although he found that income was an important factor in explaining these differences. However, he also pointed out another important determinant of adoption, namely language. He found that Mexican-Americans in Spanish speaking households were much less likely to have a home computer and use the Internet at home conditional on having a home computer than other Mexican-Americans, all else equal. Relative to whites, these Mexican-Americans had a probability of computer use rate that was 0.3233 less than whites and a probability of conditional Internet use rate that was 0.3471 less than whites. Thus, even after controlling for income and education, Mexican-Americans in Spanish-speaking households were roughly half as likely as whites to own a computer or use the Internet. He found that language made a large difference. There is certainly a large digital divide worldwide that is language related. English is used in almost 80 percent of Websites and in the common user interfaces—the graphics and instructions. Yet less than 1 in 10 people worldwide speak the language.

Several studies also identify location as another important factor. Living in urban areas has been found to be important for determining technology adoption probably because the bulk of the infrastructure that supports these technologies is found in these areas. This occurs often because it is more profitable for providers of infrastructure to supply to the "more lucrative" urban dwellers (Schirmer and Goetz, 1997; Kshetri, 2002; Cheong, 2002, UNDP, 1999).

Location has been found to be very important both locally and globally.

Globally, living in the more advanced OECD countries dramatically increases the probability of adoption. In mid-1998 industrial countries—home to less than 15 percent of people—had 88 percent of Internet users. North America alone—with less than 5 percent of all people—had more than 50 percent of Internet users. By contrast, South Asia is home to over 20 percent of all people but had less than 1 percent of the world's Internet users. Thailand has more cellular phones than the whole of Africa. There are more Internet hosts in Bulgaria than in Sub-Saharan Africa (excluding South Africa). The United States has more computers than the rest of the world combined, and more computers per capita than any other country. Just 55 countries account for 99 percent of global spending on information technology.

Location also matters a lot within individual countries. As earlier noted, it is unlikely to have access to technology in rural areas in most countries around the world. Most telephones in developing countries are in the capital city, although most people live in rural areas. For instance, in 1995, the number of main telephone lines per 100 residents in urban Russia was 20, while the corresponding figure for rural areas was a mere 8. This divide appears throughout the Central and Eastern European region: In Georgia, there were 18 main telephone lines for every 100 urban inhabitants, and 3 per 100 rural inhabitants; in Ukraine, the split was 21 versus 7; in Moldova, 23 versus 6; in Slovakia, 28 versus 11; in Albania, 3 versus 2 (CDT, 2001). In parts of Asia and Africa, rural phone density is a fifth that in the largest cities (World bank, 1999). Even in the most technologically advanced nation, the United States, the situation is the same. Regardless of income level, Americans living in rural areas are lagging behind in Internet access. Indeed, at the lowest income levels, those in urban areas are more than twice as likely to have Internet access than those earning the same income in rural areas.

Dimitrova (2003) identified several interesting determinants that are relevant to post communist societies. She investigated the variations in Internet use across the 28 post-communist countries and found that economic, political, and infrastructural factors were very important while cultural factors had only partial impact. She suggested that the traditional country-level indicators of economic wealth and technological infrastructure remained important determinants of Internet use in the countries of Eastern Europe and the former Soviet Union. The most significant determinant, however, was level of democratization. The results of the multiple regression analysis reported in her study indicated that democratization – measured by the level of civil liberties, teledensity, and GNP per capita were the three most important factors positively related to Internet use in the post-communist countries. Religion was another factor she identified. She found that being predominantly Muslim had a negative effect on Internet use while being Western Christian (Protestant or Catholic) seemed unrelated to Internet adoption. The omitted category was Eastern Orthodox Christianity. However, she did not find any significant impact of length of telecommunications privatization or college education.

The UCLA (2000) Internet report provides a summary of the most important determinants of technology adoption identified in the literature. In a nationwide survey in the United States, they found that higher education, higher incomes, sex (men used more overall, though in some age ranges women used more than men – ages 12-15), and age (use increased steadily with age between ages 12 and 35 and declined thereafter) were the most important determinants of adoption. The UNDP Human Development Report (1999) also painted the profile of a typical adopter of technology, "The typical Internet user worldwide is male, under 35 years old, with a college education and high income, urban-based and English-speaking—a member of a very elite minority worldwide"

3.2.2 Effects of Income on computer use.

The existence of skill biased technological change which was discussed in an earlier section clearly leads to an increase in demand for more highly skilled workers, which may change the wage structure.

Wage inequality has grown dramatically in the US since the 1970s (Handel, 1999; Katz, 1999), but there is a strong debate as to why this has occurred. One school of thought states that the growth in wage inequality has been driven by the information technology revolution. Information technology is said to have contributed to rising skill requirements across most occupations and it is estimated that the number of workers using computers at work in the US has increased from 24.2 million in 1984 to almost 64 million in 1997, an average annual increase of about 7.8 percent per year. (U.S DoC, 2002). As a result of the increase in use of computers in the US, and other highly developed countries, there have been increases in demand for skilled workers, and consequently a high return to computer use at work (US DoC, 2002; Katz, 1999).

While the evidence is clear in developed economies that skill biased technological change has really occurred, there is less of a consensus in the literature as to whether there is a return to technology usage or not.

Several studies have been done over time to investigate the existence and the size of this premium associated with computer use. One of the most influential papers on the subject is by Krueger (1993). Using U.S data and experimenting with several different specifications, he concluded that the wage premium from using a computer at work ranged from between 10 to 15 percent. Also, because more highly educated workers were more likely to use computers on the job, he found that increased use of computers accounted for between one-third and one-half of the increase in the rate of return to education observed between 1984 and 1989. Thus technological change is believed to have contributed significantly to changes in the US wage structure. In a later study, using current population study (CPS) data, Autor et al (1998) estimated that the wage premiums were 18.5 percent in 1984, 20.7 percent in 1989 and 22.5 percent in 1993. Other studies were also done in other countries that corroborated these findings.

Arabshiebani and Marin (2000), in their UK study, found a return to computer use of 19.1 percent. They found that computers raise the productivity of those who use them even after controlling for industry, occupation and firm size, and this results in higher wages. Also, Reilly (1995) in his study in Canada found a 13 percent return to computer use.

Several other studies, however, question the existence of a computer wage differential. DiNardo and Pischke (1997) carried out a similar study in Germany and while they found that the wage differential for computers was 11.2 percent in 1979, 15.7 percent in 1985-1986 and 17.1 percent in 1991-1992, results which are similar to the American survey by Krueger; they also measured large differentials for the on-the–job use of calculators, telephones, pens or pencils and working while sitting. Although the computer effect remained the largest when all job characteristics were entered into a wage equation, they concluded that it was unlikely that there was a wage premium associated with technology use, but instead, that these variables were picking up unobserved heterogeneity in human capital or occupational position.

Entorf and Kramarz (1997) responded to Krueger's paper using the French labor force survey, and utilizing a greater range of technology, including robots and computer assisted machine tools. They found around a 10 percent advantage for a pooled sample (1985-1987) in France, and argued that computer-based new technologies are used by workers that were already better paid then their fellow workers before working on these machines. These workers also seem to become more productive when they get more experience on these new technologies. Thus, it seems that in France, the selectivity effect of computer-based new technologies goes along with an exclusion effect: some workers are abler than others, this ability gets compensated and such workers may be used to work on machines based on modern technologies.

Handel (1999) questioned Krueger's coefficients claiming that they were too big and was upwardly biased due to correlation with omitted human capital, occupational and firm characteristics. He added seven measures of non-computer job content which were associated with similarly high returns when entered individually into a standard wage equation (suggesting all share such bias) together with computer use and other human capital and structural variables to a wage equation and found that the returns to computer use measured dichotomously fell to .066, well below Krueger's .10-.15.

Chennels and Van Reenen (1999) " Overall, there seems evidence that the computer-wage correlation cannot be interpreted as simply the causal effect of technical change on individual or enterprise wages. More likely, it reflects the fact that the best technologies are likely to be used by the most able workers who are already earning higher wages."

While Katz and Autor (1999) do not resolve the issue, they do make the point that

> the existence of a positive computer wage differential is neither a necessary or sufficient condition for the diffusion of computers to have induced a shift in the relative demand for more-skilled workers and to have affected the wage structure. If computer technologies are more complementary with highly skilled than with less-skilled workers, a decline in computing costs and spread of computers could generate an increase in the relative demand for and relative wages of more-educated (and more skilled) workers. Labor market competition could require firms both with and without computer technologies to pay equal wages to attain equally able employees. In this case, a cross-section wage regression with sufficient controls for worker skills would yield no computer wage premium even though computers may have greatly raised the relative wages of the more skilled and widened the wage structure.
> Katz and Autor (1999).

The literature on computer adoption and subsequent income effects demonstrate that income is an important determinant of adoption, while there is also a strong argument that adoption of computer technology has an impact of wages. Thus, income and computer use are simultaneously determined, creating an endogeniety problem, which will be further explored in subsequent chapters.

3.2.3 Hypotheses to be tested

Computer adoption

From the literature, we can state the following hypothesis:

Computer users are likely to be male and live in urban areas, and use will most likely be negatively correlated with age, and positively correlated with income, employment status (employed more likely to adopt) and race (dominant race more likely to adopt because of greater access). In addition, due to the special nature of post-communist societies, (formerly closed, now opening up) a number of other possible interesting determinants of adoption can be identified. We hypothesize that interest in information (about capitalism, democracy and politics), as well as level of technological development of the country, which determines how much of computer technology is available for adoption, as hinted by Dimitrova (2003) would be important determinants of technology adoption in these economies. Also, it is expected that ability to communicate in a major language of commerce (which will likely affect how easily computer equipment can be used because of language of instructions and technical support issues, or just access to some internet web sites), as implied by Fairlie (2002), may also be important determinants. Thus, it is hypothesized that higher levels of infrastructural development and interest in information are positively correlated with adoption, while inability to speak or read a major language of the G7 countries would be negatively correlated with adoption of computer technologies.

Income effects

For the purposes of this study, it is assumed that a wage premium exists for computer usage, and this is tested empirically in a subsequent section.

CHAPTER FOUR

DATA , METHODS AND RESULTS

4.1 Description of Data

Data Sources

This study utilizes data collected by the Intermedia Survey Institute based in Washington D.C. The data was collected in the nine transitional economies in Eastern Europe in the year 2000 through face-to-face interviews done in concert with local agencies. The survey includes a wealth of information on access to and attitudes towards information, the media, democracy and politics. It also includes a variety of demographic information on the respondents that was very useful for this study in analyzing both computer adoption and wages. The data on teledensity was obtained from the International Telecommunications Union (ITU, 2001), while the data on GDP per capita was obtained from The CIA World Factbook 2002.

Data Description

Tables 2.1 – 2.4 below present the summary information for all variables utilized in the study. The dependent variables in the analysis were a binary variable on computer use and the log of income in dollars. Respondents were asked to indicate which income range applied to their household, denominated in local currency. Income was computed by taking the midpoints of the ranges and applying the exchange rate that existed in the year 2000, to convert to dollars. Mean rates of exposure to a computer ranged from 3 percent (Armenia) to 21 percent Russia. The overall average was 14 percent. The explanatory variables are subdivided into five categories: Demographic, Work Sector, Attitudes towards information, Language, and Infrastructure. Table 2.4, which contains information for all countries combined, also includes a category on country characteristics.

Demographics

The sample was 45 percent male. For individual countries, male share of the population ranged from 40 percent (Ukraine) to 48 percent (Romania and Uzbekistan). The survey participants were middle aged on average, as the overall mean age was about 45 years, though there was some variability within individual countries. The country with the youngest surveyed individuals on average was Uzbekistan (37 years), while the oldest was Bulgaria (49 years). On average, the individuals sampled had about 11 years of education, but the values ranged from 10.32 years (Moldova) to 13 years (Georgia).

Labor force participation rates also fluctuated a bit among the countries, ranging from 32 percent (Romania) to 55 percent (Belarus). The overall mean was 42 percent. There was also some fluctuation in household size (hhnum). The number of household members ranged from 2.6 to 5.5 and the overall mean was about 4 people per household. Also, the level of urbanization of respondents ranged from 38 percent in Moldova to 72 percent in Russia. The overall mean for all countries was 58 percent.

Most of the people surveyed belonged to the major ethnic group within their respective countries (85 percent overall mean), and most were married (66 percent overall mean). On average, most of the respondents described themselves as poor (able to afford food but not much else)- about 48 percent, while only about 3 percent on average could afford any luxuries. This is also confirmed by the average value of individual incomes in dollar terms. This had a value of only $90 a month on average, ranging from $20 in Moldova to $123 in Uzbekistan.

Work Sector Information:

The three employment sector categories examined in the analysis are agriculture, manufacturing, and sales and service sectors. The reference sector includes all other sectors (the government sector, armed forces, construction and education, among others). The agricultural and manufacturing sectors are more traditional sectors, with manufacturing being traditional to the countries in this region (Eastern and Central Europe). The sales and service sectors could signify the level of development of a country, as more developed countries are supposed to have a smaller percentage of their workforce in the more traditional sectors (because of increased productivity), but have more people employed in the sales and services sector (the more modern sectors).

For all countries combined, less than 30 percent of the people sampled worked in these 3 sectors with agriculture employing 7 percent of all respondents, manufacturing 8 percent, and sales and services 10 percent. However, when this can be explained by the fact that labor force participation rates of the sampled individuals was less than 50 percent overall, and that formerly communist economies are likely to have large levels of government employment.

Interest in Information

The survey contained several questions that captured a respondent's interests in both local and international politics, their national economies and the functioning of the market economy, as well as other cultures, both within and outside their countries.

Interest in these variables was just about average, meaning that the mean values were in the middle of the possible range of responses. On a scale of 1 to 3, with 1 signifying the least interest, total average of these variables was somewhere in the middle, with interest in Other cultures and economics being lowest on average (about 1.4), and interest in politics and science highest on average (about 1.8). Interest in politics was highest in Ukraine and Uzbekistan, with values greater than two, and lowest in Romania. There was not much interest in other cultures in most of the countries (most values less than 1.5), with the exception of Uzbekistan and Georgia, where interest was higher than average. There was relatively higher interest in economic issues, with the highest interest in Georgia (1.77). Interest in science fluctuated quite a bit. There was a lot of interest in science in Uzbekistan (2.28), and much lower interest in Bulgaria (1.47).

Language

Most individuals surveyed could not speak or read English (overall mean: 9 percent). The highest percentage of English speakers was in Romania (19 percent). Similar patterns also held for the languages of the other G7 countries, which could be regarded as important languages of commerce (French, German, Italian, Japanese). About 8 percent of the people surveyed could speak these languages. The notable exception was once again Romania (18 percent). However, most individuals spoke Russian (overall mean 61 percent) with the notable exceptions of Romania (3 percent) and Bulgaria (18 percent), perhaps due to the fact that they are the two countries in the sample that are not part of the former Soviet Union.

Infrastructure

The within country measure of infrastructure is a composite variable that indicates mean access to telecommunications infrastructure by location (urban/ rural). The indicators of infrastructure used in creating this variable are access to pay-per-view, cable TV, and a satellite dish (shared or personally owned).

Country characteristics

Teledensity (phone lines per 100 people) which is a national proxy for level of infrastructural development averaged 19 phone lines per 100 inhabitants in the year 2001. This is low compared to other developed countries. For instance, the United States had teledensity of about 70 phone lines, United Kingdom, about 60 phone lines, Sweden about 70 phone lines, France about 60 phonelines and Belgium, about 50 phone lines. (ITU, 2001). The average GDP per capita was about $5000 at purchasing parity levels. Armenia, Georgia, Moldova, Ukraine and Uzbekistan are categorized as low-income countries while Belarus, Bulgaria, Romania and Russian Republic are categorized as lower middle-income countries. (World Bank, 2003).

Table 4.1.1 Summary statistics by country : Armenia, Belarus and Bulgaria

	Variable Title	Description	Country					
			Armenia(788)		Belarus(1648)		Bulgaria(1520)	
			mean	s.d	mean	s.d	mean	s.d
Dependent Variables	pcever	Ever used computer? (1=yes,0=no)	0.04	0.19	0.17	0.38	0.13	0.34
	logdollarincome	Log of dollar value of personal income.	3.32	0.99	4.51	0.66	4.53	0.76
Demographic variables	male	Gender (1=male,0=female)	0.45	0.50	0.47	0.50	0.47	0.50
	age	Age in years	43.10	16.40	44.44	17.38	49.36	18.28
	years_ed	No of years of education from 1yr(lowest) to 20 yrs(highest)	11.75	2.94	11.32	3.27	10.52	3.74
	working	Occupational status (1=working, 0 = not working)	0.38	0.49	0.55	0.50	0.38	0.49
	hhnum	Number of people per household	4.24	1.71	2.98	1.21	3.26	1.61
	hhmoinc	Income scale from 1(lowest) to 20 (highest)	3.77	2.05	6.24	3.75	5.53	3.48
	dollarincome	Income in dollars	42.13	38.43	110.43	69.15	119.69	89.31
	urban	Location (1=urban, 0=non urban)	0.70	0.46	0.66	0.47	0.69	0.46
	mainnatlity	Ethnic background (1 = main nationality; 0=minority)	0.99	0.09	0.80	0.40	0.85	0.35
	Marital Status dummies							
	married	Married (1=yes, 0 =no)	0.67	0.47	0.64	0.48	0.70	0.46
	divorced	Divorced (1=yes, 0=no)	0.03	0.17	0.07	0.25	0.04	0.19
	separated	Separated (1=yes, 0=no)	0.01	0.09	0.00	0.06	0.00	0.05
	widowed	Widowed (1=yes, 0=no)	0.09	0.29	0.11	0.31	0.13	0.33
	nevermarr	Never married (1=yes, 0=no)	0.19	0.40	0.16	0.37	0.13	0.33
	Financial Situation dummies							
	poor	Afford food, but no luxuries(1=yes,0=no)	0.33	0.47	0.60	0.49	0.42	0.49
	average	Afford food and some savings (1=yes,0=no)	0.07	0.26	0.20	0.40	0.10	0.30
	aboveaverage	Afford luxuries (1=yes, 0=no)	0.01	0.08	0.02	0.14	0.02	0.13
Work sector dummies:	agric	Agric sector (1=yes, 0=no)	0.09	0.29	0.08	0.28	0.03	0.16
	manuf	Manufacturing sector(1=yes,0=no)	0.04	0.19	0.13	0.34	0.08	0.27
	saleserv	Sales or service sector(1=yes,0=no)	0.09	0.28	0.12	0.32	0.14	0.34
Proxies for attitudes towards information	politics	Captures interest in local and international political developments. Ranges from 3(very interested) to 1 (not very interested).	1.51	0.86	1.82	0.76	1.68	0.86
	othercultures	Captures interest in other cultures. Ranges from 3(very interested) to 1 (not very interested).	1.37	0.72	1.13	0.56	1.14	0.71
	economics	Captures interest in economics and business. Ranges from 3(very interested) to 1 (not very interested).	1.58	0.85	1.29	0.76	1.24	0.86
	science	Captures interest in science and technology. Ranges from 3(very interested) to 1 (not very interested).	1.68	0.81	1.71	0.64	1.47	0.77
Language dummies	english	Can you speak/read English (1=yes, 0=no)	0.10	0.30	0.08	0.28	0.09	0.28
	commlang	Can you speak/read other major languages of commerce (languages of G7) (1=yes, 0=no)	0.05	0.21	0.07	0.25	0.09	0.29
	russian	Can you speak/read Russian (1=yes,0=no)	0.84	0.37	0.74	0.44	0.18	0.38
	infrastructure	Measures the availability of relevant infrastructure by location (continuous variable derived from other variables)	0.02	0.02	0.06	0.04	0.18	0.09

Table 4.1.2 Summary statistics by country: Georgia, Moldova and Romania

	Variable Title	Description	Country					
			Georgia(840)		Moldova(854)		Romania(2008)	
			mean	s.d	mean	s.d	mean	s.d
Dependent Variables	pcever	Ever used computer? (1=yes,0=no)	0.07	0.25	0.09	0.29	0.17	0.37
	logdollarincome	Log of dollar value of personal income.	3.56	1.13	2.47	0.97	4.16	1.05
Demographic variables	male	Gender (1=male,0=female)	0.42	0.49	0.47	0.50	0.48	0.50
	age	Age in years	41.41	16.52	46.23	16.58	45.46	19.59
	years_ed	No of years of education from 1yr(lowest) to 20 yrs(highest)	13.08	2.85	10.32	3.66	10.49	3.88
	working	Occupational status (1=working, 0 = not working)	0.33	0.47	0.37	0.48	0.32	0.47
	hhnum	Number of people per household	4.38	1.77	3.38	1.50	3.23	1.58
	hhmoinc	Income scale from 1(lowest) to 20 (highest)	3.82	2.97	2.87	2.83	9.18	4.66
	dollarincome	Income in dollars	64.64	87.94	20.42	33.30	99.11	88.22
	urban	Location (1=urban, 0=non urban)	0.55	0.50	0.38	0.49	0.52	0.50
	mainnatlity	Ethnic background (1 = main nationality; 0=minority)	0.93	0.25	0.79	0.41	0.91	0.29
	Marital Status dummies							
	married	Married (1=yes, 0 =no)	0.66	0.47	0.72	0.45	0.63	0.48
	divorced	Divorced (1=yes, 0=no)	0.03	0.16	0.02	0.13	0.03	0.17
	separated	Separated (1=yes, 0=no)	0.00	0.05	0.01	0.08	0.01	0.09
	widowed	Widowed (1=yes, 0=no)	0.07	0.26	0.15	0.36	0.12	0.32
	nevermarr	Never married (1=yes, 0=no)	0.23	0.42	0.10	0.30	0.20	0.40
	Financial Situation dummies							
	poor	Afford food, but no luxuries(1=yes,0=no)	0.43	0.50	0.41	0.49	0.46	0.50
	average	Afford food and some savings (1=yes,0=no)	0.11	0.32	0.09	0.29	0.19	0.39
	aboveaverage	Afford luxuries (1=yes, 0=no)	0.02	0.14	0.03	0.16	0.06	0.23
Work sector dummies	agric	Agric sector (1=yes, 0=no)	0.06	0.25	0.13	0.34	0.03	0.17
	manuf	Manufacturing sector(1=yes,0=no)	0.02	0.15	0.02	0.12	0.09	0.29
	saleserv	Sales or service sector(1=yes,0=no)	0.08	0.28	0.09	0.28	0.08	0.27
Proxies for attitudes towards information	politics	Captures interest in local and international political developments. Ranges from 3(very interested) to 1 (not very interested).	1.84	0.89	1.50	0.88	1.34	0.87
	othercultures	Captures interest in other cultures. Ranges from 3(very interested) to 1 (not very interested).	1.75	0.76	1.34	0.75	1.22	0.77
	economics	Captures interest in economics and business. Ranges from 3(very interested) to 1 (not very interested).	1.77	0.85	1.39	0.76	1.57	0.86
	science	Captures interest in science and technology. Ranges from 3(very interested) to 1 (not very interested).	2.14	0.68	1.63	0.74	1.65	0.77
Language dummies	english	Can you speak/read English (1=yes, 0=no)	0.12	0.33	0.04	0.20	0.19	0.39
	commlang	Can you speak/read other major languages of commerce (languages of G7) (1=yes, 0=no)	0.09	0.28	0.08	0.28	0.18	0.39
	russian	Can you speak/read Russian (1=yes,0=no)	0.79	0.41	0.91	0.29	0.03	0.17
	infrastructure	Measures the availability of relevant infrastructure by location (continuous variable derived from other variables)	0.06	0.07	0.06	0.08	0.23	0.16

Table 4.1.3: Summary statistics by country : Russia and Ukraine and Uzbekistan

	Variable Title	Description	Country					
			Russia(1659)		Ukraine(1786)		Uzbekistan(1692)	
			mean	s.d	mean	s.d	mean	s.d
Dependent Variables	pcever	Ever used computer? (1=yes,0=no)	0.21	0.41	0.16	0.36	0.09	0.29
	logdollarincome	Log of dollar value of personal income.	4.11	0.81	3.36	0.79	4.53	0.75
Demographic variables	male	Gender (1=male,0=female)	0.44	0.50	0.40	0.49	0.48	0.50
	age	Age in years	48.28	17.76	49.09	19.00	36.82	14.69
	years_ed	No of years of education from 1yr(lowest) to 20 yrs(highest)	11.16	3.53	11.38	3.57	11.03	2.78
	working	Occupational status (1=working, 0 = not working)	0.51	0.50	0.39	0.49	0.50	0.50
	hhnum	Number of people per household	2.64	1.26	3.23	1.57	5.56	2.53
	hhmoinc	Income scale from 1(lowest) to 20 (highest)	8.96	5.56	5.70	4.08	4.96	2.42
	dollarincome	Income in dollars	82.46	69.63	38.28	30.24	123.16	143.91
	urban	Location (1=urban, 0=non urban)	0.72	0.45	0.58	0.49	0.39	0.49
	mainnatlity	Ethnic background (1 = main nationality; 0=minority)	0.89	0.31	0.75	0.43	0.81	0.39
	Marital Status dummies							
	married	Married (1=yes, 0 =no)	0.56	0.50	0.64	0.48	0.73	0.45
	divorced	Divorced (1=yes, 0=no)	0.09	0.29	0.06	0.24	0.03	0.18
	separated	Separated (1=yes, 0=no)	0.03	0.17	0.01	0.10	0.01	0.12
	widowed	Widowed (1=yes, 0=no)	0.19	0.39	0.16	0.37	0.08	0.27
	nevermarr	Never married (1=yes, 0=no)	0.12	0.33	0.12	0.32	0.14	0.35
	Financial Situation dummies							
	poor	Afford food, but no luxuries(1=yes,0=no)	0.58	0.49	0.41	0.49	0.51	0.50
	average	Afford food and some savings (1=yes,0=no)	0.19	0.39	0.08	0.28	0.20	0.40
	aboveaverage	Afford luxuries (1=yes, 0=no)	0.05	0.23	0.02	0.14	0.04	0.19
Work sector dummies	agric	Agric sector (1=yes, 0=no)	0.05	0.21	0.04	0.21	0.16	0.37
	manuf	Manufacturing sector(1=yes,0=no)	0.14	0.34	0.08	0.28	0.05	0.22
	saleserv	Sales or service sector(1=yes,0=no)	0.14	0.35	0.10	0.30	0.09	0.29
Proxies for attitudes towards information	politics	Captures interest in local and international political developments. Ranges from 3(very interested) to 1 (not very interested).	1.81	0.76	2.00	0.78	2.20	0.73
	othercultures	Captures interest in other cultures. Ranges from 3(very interested) to 1 (not very interested).	1.23	0.68	1.40	0.69	1.75	0.80
	economics	Captures interest in economics and business. Ranges from 3(very interested) to 1 (not very interested).	1.17	0.74	1.44	0.76	1.66	0.93
	science	Captures interest in science and technology. Ranges from 3(very interested) to 1 (not very interested).	1.74	0.66	2.01	0.63	2.28	0.70
Language dummies	english	Can you speak/read English (1=yes, 0=no)	0.04	0.19	0.09	0.29	0.04	0.20
	commlang	Can you speak/read other major languages of commerce (languages of G7) (1=yes, 0=no)	0.03	0.17	0.08	0.27	0.02	0.14
	russian	Can you speak/read Russian (1=yes,0=no)	1.00	0.03	0.87	0.34	0.60	0.49
	infrastructure	Measures the availability of relevant infrastructure by location (continuous variable derived from other variables)	0.04	0.04	0.03	0.05	0.03	0.06

Table 4.1.4: Summary statistics : All countries

	Variable Title	Description	Total (12795)	
			mean	s.d
Dependent Variables	pcever	Ever used computer? (1=yes,0=no)	0.14	0.35
	logdollarincome	Log of dollar value of personal income.	3.98	1.05
Demographic variables	male	Gender (1=male,0=female)	0.45	0.50
	age	Age in years	45.16	18.09
	age2	Age squared	2367.05	1724.89
	years_ed	No of years of education from 1yr(lowest) to 20 yrs(highest)	11.12	3.49
	years_ed2	Years of education squared	135.86	77.29
	working	Occupational status (1=working, 0 = not working)	0.42	0.49
	hhnum	Number of people per household	3.58	1.90
	hhmoinc	Income scale from 1(lowest) to 20 (highest)	6.19	4.39
	dollarincome	Income in dollars	84.52	90.13
	urban	Location (1=urban, 0=non urban)	0.58	0.49
	mainnatlity	Ethnic background (1 = main nationality; 0=minority)	0.85	0.36
	Marital Status dummies			
	married	Married (1=yes, 0 =no)	0.66	0.48
	divorced	Divorced (1=yes, 0=no)	0.05	0.21
	separated	Separated (1=yes, 0=no)	0.01	0.10
	widowed	Widowed (1=yes, 0=no)	0.12	0.33
	nevermarr	Never married (1=yes, 0=no)	0.15	0.36
	Financial Situation dummies			
	poor	Afford food, but no luxuries(1=yes,0=no)	0.48	0.50
	average	Afford food and some savings (1=yes,0=no)	0.15	0.35
	aboveaverage	Afford luxuries (1=yes, 0=no)	0.03	0.18
Work sector dummies	agric	Agric sector (1=yes, 0=no)	0.07	0.26
	manuf	Manufacturing sector(1=yes,0=no)	0.08	0.27
	saleserv	Sales or service sector(1=yes,0=no)	0.10	0.30
Proxies for attitudes towards information	politics	Captures interest in local and international political developments. Ranges from 3(very interested) to 1 (not very interested).	1.76	0.86
	othercultures	Captures interest in other cultures. Ranges from 3(very interested) to 1 (not very interested).	1.35	0.75
	economics	Captures interest in economics and business. Ranges from 3(very interested) to 1 (not very interested).	1.44	0.84
	science	Captures interest in science and technology. Ranges from 3(very interested) to 1 (not very interested).	1.81	0.75
Language dummies	English	Can you speak/read English (1=yes, 0=no)	0.09	0.29
	Commlang	Can you speak/read other major languages of commerce (languages of G7) (1=yes, 0=no)	0.08	0.27
	Russian	Can you speak/read Russian (1=yes,0=no)	0.61	0.49
Infrastructure	infrastructure	Measures the availability of relevant infrastructure by location (continuous variable derived from other variables)	0.09	0.11
Country income and infrastructure characteristics	teledensity	Main telephone lines per 100 inhabitants (2001)	19.35	8.15
	gdppercap	GDP per capita (2001) US $	5432.94	2223.63

4.2 Methods of Analysis

4.2.1 Two stage Least Squares.

Simultaneity occurs when one or more of the explanatory variables are jointly determined with the dependent variable. In this case,

$$P_i^k = f(W_i^k, D_i^k, S_i^k, I_i^k, L_i^k, N_i^k, C_i^k) \quad (1)$$

$$W_i^k = \beta_0^k + \beta_1^k P_i^k + \beta_2 D_i^k + \beta_3 S_i^k + \beta_3 U_i^k + \upsilon \quad (2)$$

Where

P_i^k = Computer adoption by individual i in country k

W_i^k = Wage earned by individual i in country k

D_i^k = Vector of demographic variables

S_i^k = Vector of work sector variables

I_i^k = Vector of variables measuring interest in information

N_i^k = Variable measuring level of infrastructural development by location (urban/rural)

L_i^k = Vector of variables measuring language skills

C_i^k = Vector of country Characteristics.

U_i^k = Location of individual i in country k (urban or rural)

Since wage is a determinant of computer adoption, and computer adoption enters into the wage equation, both variables are jointly dependent. W will be correlated with μ, and P will be correlated with υ, violating one of the assumptions of the Classical OLS, and leading to inconsistent estimates when OLS is applied to these equations individually.

The first step in estimating these equations is first to ensure that they are identified, meaning that we ensure that the numerical estimates of the parameters of a structural equation can be obtained from the estimated reduced form coefficients. There are two conditions that need to be checked to do this, namely the Order condition, and the Rank condition, but usually, the order condition is sufficient to ensure identifiability (Gujarati, 2003).

The order condition requires that at least M-1 variables be excluded from an equation in a system of M simultaneous equations. In this case, M=2, and thus, at least one variable in the system must be excluded from the wage equation. The wage equation is over identified as it excludes several groups of exclusion variables, namely the variables that capture interest in information, infrastructure, language, as well as those that capture country characteristics.

One method of estimating the parameters in this system would be indirect least squares, but since we have an over identified equation, some of the reduced form coefficients may not be unique. Also, as the first stage utilizes the probit method of analysis, which is a nonlinear form of estimation, the method of indirect least squares is not useful here, and two stage least squares is used instead.

The method of two stage least squares (Gujarati, 2003; Wooldridge,2000), first requires that P is regressed on all predetermined variables in the system to get rid of the correlation between P and υ.

$$P = \Pi_0 + \Pi_1 D + \Pi_2 S + \Pi_3 I + \Pi_4 L + \Pi_5 N + \Pi_6 C + \hat{\mu} \quad (3)$$

From which we obtain:

$$\hat{P} = \hat{\Pi}_0 + \hat{\Pi}_1 D + \hat{\Pi}_2 S + \hat{\Pi}_3 I + \hat{\Pi}_4 L + \hat{\Pi}_5 N + \hat{\Pi}_6 C \quad (4)$$

where $\hat{P}$ is the probability of computer adoption conditional upon all the fixed exogenous variables, and equation (3) is a reduced form equation,because it includes only exogenous variables as regressors.

Then the wage equation can be written as :

$$W = \beta_0 + \beta_1 \hat{P} + \beta_2 D + \beta_3 S + \beta_3 U + \upsilon^* \quad (5)$$

In this case, $\hat{P}$ is uncorrelated with υ^* asymptotically (as the sample size increases indefinitely). Thus OLS can be applied to equation (5), and consistent estimates of the parameters of the wage function can be derived.

Correcting the Standard errors

The standard errors from the two stage least squares process of estimation are not the estimates of the true standard errors. The standard errors are inefficient for a number of reason, including implicit restrictions on coefficients not imposed, sampling error in the first stage, and some parameters not taken into account in the second stage. Corrected standard errors are obtained for the wage equation by the process of bootstrapping.

4.2.1.1 First Stage : Probit

In the first stage, equation (1), we are interested in estimating the probability of computer adoption. The dependent variable is a binary variable, which takes the value 1 if the individual has ever used a computer, and 0 otherwise. There are several ways in which to estimate equations with a binary dependent variable. One of the earliest used initially was the linear probability model, which has diminished in popularity because it is characterized by several limitations, including non-normality of the errors, heteroscedasticity of the errors, possibility of the predicted values not lying between zero and one, and the generally lower R^2 values derived from this method of estimation. It also has the fundamental flaw of assuming the marginal or incremental effect of the independent variable is constant throughout, which is also unrealistic.

Correcting these problems requires a model that ensures that the probability of adoption increases with each independent variable, but does not exceed the interval between zero and one, and also a nonlinear relationship between the probability of adoption and each of the independent variables. The two major models used instead of the linear probability model are the Logit and Probit models, and the major difference between the two lies in the distribution of the errors. In this case, it is assumed that the errors are normally distributed, and thus the probit model is utilized in estimating the probability of computer adoption.

Probit model

In the first stage, we have the model of computer adoption:

$P^* = f(D, S, I, L, N, C)$

Only outcomes are observed, whether an individual uses a computer (P=1) or not (P=0). The probit model, as laid out by (Ramanathan, 1998) is based on the assumption that there is a response function of the form $P^* = \alpha + \beta X_i + \mu$ (6)

Where X_i is an observable explanatory variable

P^* is an unobservable variable.

What is generally observed is P, which takes the values

$P=1$ if $\alpha + \beta X_i + \mu > 0$

P=0 if $\alpha + \beta X_i + \mu \leq 0$

If the cumulative distribution function (CDF) of the normal distribution is denoted by F(z), i.e. $F(z) = Pr(Z \leq z)$, then,

$$Pr(P=1) = Pr(\mu > -\alpha - \beta X_i) = 1 - F\left(\frac{-\alpha - \beta X_i}{\sigma}\right)$$

$$Pr(P=0) = Pr(Pr(\mu \leq -\alpha - \beta X_i) = F\left(\frac{-\alpha - \beta X_i}{\sigma}\right)$$

The joint probability density function (likelihood function) of the sample of observations is then given by:

$$L = \prod_{p=0} F\left(\frac{-\alpha - \beta X_i}{\sigma}\right) \prod_{p=1} \left[1 - F\left(\frac{-\alpha - \beta X_i}{\sigma}\right) \right]$$

α and β are then estimated by maximizing the Likelihood function.

The numerical values of the βs in a probit regression have no simple interpretation. However, the signs of the coefficients give some indication as to the direction of the impact of the variable under consideration on computer adoption. A positive coefficient raises the probability of computer adoption, while a negative coefficient has the opposite effect.

4.2.1.2 Second Stage : Ordinary Least Squares

In the second stage, the regression takes the standard Mincerian form:

$$\ln W = \beta_0 + \beta_1 \hat{P} + \beta_2 D + \beta_3 S + \beta_3 U + \upsilon,$$

where lnW is the natural log of income. This Mincerian wage equation is augmented with the predicted probability of computer adoption ($\hat{P}$) from the first stage of the analysis.

4.2.2 Elasticities and Marginals

4.2.2.1 Computer adoption

P = $\alpha_0 + \alpha_1$ X_i

Where X_i = vector of explanatory variables

And elasticity $= \dfrac{\partial P(x)}{\partial X_i}\left(\dfrac{\overline{X}_i}{\overline{P}}\right)$

where

$P(x)$ = the cdf

$\dfrac{\partial P(x)}{\partial X_i}$ = the marginals of the cdf

$\overline{X}_i$ = mean value of the explanatory variable i

$\overline{P}$ = mean value of the dependent variable.

The elasticities express the percentage change in adoption for a small percentage change in each of the explanatory variables and they are estimated at the sample means.

Also, in addition to calculating the elasticities, the marginals for each explanatory variable, which are the numerical values of the increase in the predicted value of computer adoption brought about by increases in each explanatory variable, are also reported separately.

4.2.2.2 The Wage equation

Once again, the elasticities are estimated at the means.

The wage equation is :

lnW = $\beta_0 + \beta_1 \hat{P} + \beta_2 Q_i$

where Q_i is a vector of independent variables

and the elasticities are estimated as : $\dfrac{\partial \ln W}{dQ_i}\ \overline{Q}_i = \beta_i\ \overline{Q}_i$; where

$\dfrac{\partial \ln W}{dQ_i}$ = Estimated slope of each independent variable;

$\overline{Q}_i$ = Mean of each independent variable.

The elasticity can be defined in this way because the dependent variable is in log form, which means that the coefficient of each independent variable can be interpreted as semi elasticity.

4.3 Presentation of Empirical Results.

4.3.1 Two Stage Estimation

In this section, the data obtained from the nine countries surveyed is analyzed using two stage least squares as described in the previous section, and the results are presented below. However, the rate of computer use in Armenia was so low (about 4 percent in table 4.1.1), that it was impossible to get any statistically credible results. This resulted in Armenia being excluded from the individual country regressions, although the data from Armenia was utilized in the overall total where data from all countries were combined.

4.3.1.1 Computer Adoption.

In the first stage, using a probit model, the determinants of computer adoption are examined, and the results are presented in Table 4.3.1 where equation (4) from the previous section, the reduced form model that is a function only of exogenous variables is empirically analyzed. The dependent variable in the first stage is a dummy variable, P in the previous section that indicates whether or not an individual has ever used a computer.

As mentioned earlier in section 4.2.1.1, the coefficients obtained from the probit estimation do not have any easy interpretation. Therefore, to have an idea of the size of the impacts of the explanatory variables of interest on computer adoption, we resort to elasticities, as reported in table 4.3.2, which reveals how computer adoption would change with a percentage change in any explanatory variable.

In the third chapter, the farm household model was applied to the model of computer adoption and it was assumed that an individual would adopt computers if the returns to using a computer exceeded the returns to wage work and /or the value of leisure. The computer production function in that section was a function of hours of computer use and human capital (education), which implied that the allocation of time between wage work and computer use is affected by the level of human capital acquired by the individual. Also, the positive linkage between human capital investment and technology adoption (the skill-technology complementarity) and the negative relationship between technology adoption and age is documented in chapter three. Thus the human capital and age variables are theoretically important determinants of adoption. Their impacts on computer adoption are empirically investigated in this chapter, with the equation augmented by other demographic variables. Also, in carrying out the method of two stage least squares, it was important to have certain exclusion variables, which were related to computer adoption but not to wages, for identifiability of the system. These exclusion variables are in four categories: Attitudes towards information, Language, Infrastructure and country characteristics. The impacts of these variables on computer adoption are also shown in table 4.3.1.

Focus in this analysis is mainly on the total column in table 4.3.1, where data from all countries surveyed are combined. This is because of the large sample size (over 12,000), as well as the fact that it is possible to use cross country instruments in this equation, which leads to improved identification in the system of equations. The individual country regressions are reported for the reader's interest. They may just serve to reinforce the results in the total column. It is difficult to effectively scrutinize the country-by-country results because sample sizes are much smaller than in the total column, and thus the results may not be as robust.

The age variable has a negative effect on computer adoption as expected, which is in accordance with the theory. If technology adoption is viewed as an investment, younger individuals are more likely to adopt because it gives them more time to recoup their investment. Also, younger people are likely to have more interest in new technologies, as well as more ability and training. Age is negative and significant (at the one percent level of significance), and this result is also corroborated by the individual country regressions, where age has a negative and significant effect (and all at one percent). This effect is very strong, as can be seen from the elasticities in table 4.3.2. Once again, focusing on the total column for reasons mentioned earlier, we find that a 10 percentage increase in age decreases the probability of adopting a computer by about 10 percent.

The impact of human capital is just as strong and also conforms to theoretical expectations. The human capital variable is extremely important, and it is positive and statistically important (at 1 percent), suggesting the skill technology complementarity that was also found in OECD countries. Once again, the effect is large, as a ten percent change in years of education increases the probability of adopting computers by about ten percent.

The results are extremely interesting, because they are also confirmed by all the individual country results without exception. In all the countries, age has a negative effect on computer adoption, while education has a positive impact, and both these variables are significant at one percent. This result is in accord with human capital theory, and confirms the theory that implies technology adoption is significantly impacted by levels of human capital acquired by the individual, as more schooling enables the individual to be better able to acquire information about the new technology and better understand how to use it. The importance of schooling and age to the adoption process could have important policy implications as to which target group policy makers should aim to reach when making decisions with regards to technology.

The correlation between schooling and age may be of concern, and may lead to questions about the legitimacy of using them jointly as explanatory variables. The correlation between schooling and age was consequently estimated, and had a value of -0.3. The negative correlation is expected, since most schooling is done at young ages, but the value is not high enough to give any serious multicollinearity concerns.

The exclusion variables also reveal some very interesting results. Variables that capture interest in information in politics, economics, science and other cultures were included because computer technology aids information gathering and processing, which may likely motivate computer adoption. Of all the areas of interest in information, none had any significant impact on computer adoption with the exception of interest in economics, which had a positive coefficient (and was statistically significant at the 1 percent level of significance). This could perhaps imply the importance of computers in processing economic and financial information particularly in transitional economies just acquiring capitalist structures (the stock market, banking, etc). Interest in economics is positive and significant at least at the five percent level in most of the individual countries as well.

The infrastructure variable measures the existence of infrastructure by place of location (urban vs rural). This variable is extremely important because it indicates the impact the level of telecommunications infrastructure a country has on the ability of the citizenry to adopt new technologies. This variable has a positive coefficient and is statistically significant at the one percent level. Individuals in areas that have a higher level of telecommunications infrastructure (cable TV and satellite dishes) are more likely to adopt computer technology; which emphasizes the critical importance of infrastructure for the availability, adoption and productivity of computer technologies. Once again, even at the individual country level, this variable is extremely important, and is positive and statistically significant in almost all the individual countries.

Language seems to be an important determinant of adoption, meaning that speaking important languages of the internet, or of the major countries from which computers are likely to be imported and other major trade languages of the G7 countries seems to be very important for computer adoption. Speaking English in particular is very important, as that variable has a positive coefficient. The impact of speaking English is very strong not only in the total, but also in the individual country regressions, where all coefficients are positive. These variables increase the ability of individuals to productivity utilize computer technology, which was depicted in chapter three as an upward shift of the computer production function.

The cross-country exclusion variables, GDP per capita and telendensity are also important statistically. GDP per capita is a cross-country instrument that measures how wealthy a country is, and probably how easily a nation would be able to afford the infrastructure to make computer adoption easier. The hypothesis is that richer countries will have higher rates of computer adoption than poorer ones, and as expected, the sign is positive. Teledensity, measured as phone lines per hundred people, is a measure of the overall level of infrastructure in each country. This is also positive, and it is statistically significant at 5 percent.

The numerical changes in the probability of computer adoption brought about by changes in the exclusion variables are once again shown in table 4.3.2 and 4.3.3 where the elasticities and marginal effects of each explanatory variable are displayed. Table 4.3.2 shows that having an interest in information about economics raises the probability of computer adoption by 19 percent, while increases in infrastructure, and spoken English raise the probability by 7 and 5.7 percent, respectively. The impact of per capita GDP income is huge, increasing the probability of adoption by 39 percent, while teledensity increases adoption by 8 percent, which is a smaller, though appreciable effect. The marginals reveal that infrastructure increases the predicted value of adoption by 0.1, while ability to speak English increases it by 0.09. These were the variables with the largest marginal effects, with all other variables having significantly smaller marginal effects.

There are several other demographic variables included in the computer adoption equation. They include sex, working status of the individual, number in the household, whether the individual belongs to the dominant nationality or not, and several marital status variables. Neither sex nor marital status appear to be of much importance for computer adoption. Working has a positive coefficient and this is statistically significant at one percent, while belonging to the main nationality in the country has a negative impact on computer adoption. This latter effect is counter to the situation in the US, where minorities are less likely to have access to computer technologies. In terms of elasticities, these variables do not have much of an impact on the probability of adoption.

The overall pseudo R^2, which is similar to R^2 for the simple Ordinary least squares equation, and can thus be interpreted as a measure of the goodness of fit of the equation, is relatively high at 35 percent. For the individual countries, all the independent variables explain between 28 percent and 50 percent of the variation in the dependent variable, which is also quite reasonable.

In summary, the determinants of computer adoption in Eastern Europe are very similar to those in the more developed parts of the world. The average user of computer technologies could be of any sex, but he/she is younger, better educated, very well informed, speaks a major trade language and lives in an area with infrastructure that can support computer technology. It is imperative to once again note the importance of human capital (education) and skills (language) as well as the underlying infrastructure in the adoption decision.

Table 4.3.1 Probit estimates of determinants of computer adoption by country

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
DEMOGRAPHIC VARIABLES									
male	0.18*	-0.14	0.15	0.00	0.04	0.01	-0.03	-0.18	-0.01
	(0.09)	(0.11)	(0.19)	(0.17)	(0.10)	(0.09)	(0.10)	(0.11)	(0.04)
age	-0.03**	-0.03**	-0.03**	-0.04**	-0.03**	-0.04**	-0.04**	-0.05**	-0.04**
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)
education	0.16**	0.14**	0.11**	0.13**	0.12**	0.20**	0.13**	0.15**	0.14**
	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)
working	0.01	-0.15	0.02	0.42*	-0.03	0.14	0.22	0.27	0.14**
	(0.13)	(0.16)	(0.25)	(0.21)	(0.13)	(0.12)	(0.12)	(0.14)	(0.05)
Household no.	0.06	0.04	-0.04	-0.03	-0.01	0.06	-0.02	-0.03	-0.02*
	(0.04)	(0.05)	(0.06)	(0.07)	(0.04)	(0.04)	(0.03)	(0.02)	(0.01)
Main race	-0.24*	0.80**	-0.20	-0.40*	0.12	-0.05	-0.20	-0.29*	-0.20**
	(0.11)	(0.29)	(0.34)	(0.19)	(0.18)	(0.15)	(0.10)	(0.14)	(0.05)
Marital status dummies									
married	-0.07	-0.37	0.06	0.64	-0.56	0.61	-0.37	-0.28	-0.07
	(0.37)	(0.45)	(0.99)	(0.89)	(0.37)	(0.39)	(0.38)	(0.40)	(0.14)
divorced	-0.17	-0.67	0.05	-	-0.74	0.71	-0.59	0.21	-0.06
	(0.41)	(0.54)	(1.10)	-	(0.44)	(0.41)	(0.41)	(0.46)	(0.16)
separated	1.89*	-	-	1.59	-0.40	0.77	0.02	0.32	0.33
	(0.90)	-	-	(1.18)	(0.59)	(0.45)	(0.58)	(0.51)	(0.20)
widowed	-0.22	-0.27	-	0.85	-0.60	0.89*	-0.38	-0.78	-0.02
	(0.48)	(0.53)	-	(0.98)	(0.46)	(0.43)	(0.46)	(0.62)	(0.17)
nevermarried	0.31	0.34	0.57	0.91	0.15	0.95*	0.19	0.21	0.36*
	(0.37)	(0.45)	(0.99)	(0.90)	(0.37)	(0.40)	(0.38)	(0.41)	(0.15)
WORK SECTOR DUMMIES									
Agriculture	-0.11	0.77*	-0.23	-0.36	-0.87	-0.49	-0.46	-0.32	-0.30**
	(0.22)	(0.34)	(0.62)	(0.30)	(0.54)	(0.27)	(0.27)	(0.20)	(0.09)
manufacturing	0.17	0.43*	-0.08	-	-0.45*	-0.01	0.01	-0.14	0.04
	(0.14)	(0.20)	(0.56)	-	(0.19)	(0.13)	(0.16)	(0.23)	(0.06)
Sales/services	-0.09	0.30	0.46	-0.11	-0.03	-0.11	-0.07	-0.03	0.05
	(0.15)	(0.17)	(0.33)	(0.28)	(0.17)	(0.13)	(0.15)	(0.18)	(0.06)
INTEREST IN INFORMATION									
politics	-0.10	0.01	0.03	0.21	-0.02	-0.10	-0.17*	0.04	0.05
	(0.08)	(0.10)	(0.14)	(0.11)	(0.07)	(0.07)	(0.08)	(0.10)	(0.03)
Othercultures	0.03	0.00	0.25	-0.13	-0.03	-0.10	0.11	0.06	-0.02
	(0.09)	(0.10)	(0.18)	(0.13)	(0.08)	(0.08)	(0.09)	(0.09)	(0.03)
economics	0.28**	0.21*	0.24	0.16	0.32**	0.38*	0.37**	0.12	0.20**
	(0.07)	(0.09)	(0.15)	(0.13)	(0.08)	(0.07)	(0.08)	(0.08)	(0.03)
science	-0.12	0.15	0.14	0.20	0.17*	-0.04	-0.06	0.06	0.05
	(0.08)	(0.10)	(0.16)	(0.14)	(0.07)	(0.07)	(0.09)	(0.10)	(0.03)
INFRASTRUCTURE									
infrastructure	4.98**	2.57**	0.78	-0.33	2.98**	1.29	3.78**	0.33	1.29**
	(1.52)	(0.97)	(1.25)	(1.03)	(0.39)	(1.20)	(0.88)	(0.85)	(0.18)
LANGUAGE									
english	0.59**	0.80**	0.93**	0.98**	0.73**	1.15**	0.62**	0.67**	0.63**
	(0.13)	(0.14)	(0.20)	(0.28)	(0.11)	(0.22)	(0.12)	(0.17)	(0.05)
commlang	0.33*	0.06	0.32	0.69**	0.46**	0.62**	-0.13	0.02	0.26**
	(0.15)	(0.15)	(0.23)	(0.20)	(0.11)	(0.22)	(0.15)	(0.29)	(0.05)
russian	0.25*	0.10	0.80	-	0.19	-	0.28	0.40**	0.44**
	(0.12)	(0.13)	(0.50)	-	(0.21)	-	(0.16)	(0.13)	(0.05)
COUNTRY CHARACTERISTICS									
gdppercapita	-	-	-	-	-	-	-	-	0.01**
(/100)	-	-	-	-	-	-	-	-	(0.00)
teledensity	-	-	-	-	-	-	-	-	0.01*
	-	-	-	-	-	-	-	-	(0.00)
constant	-2.45**	-3.66**	-4.43**	-2.71**	-3.13**	-2.90**	-1.54**	-1.92**	-3.10**
	(0.54)	(0.65)	(1.43)	(1.08)	(0.50)	(0.52)	(0.51)	(0.56)	(0.21)
loglikelihood	-512.15	-349.87	-129.92	-161.53	-459.67	-541.08	-480.58	-367.69	-3364.73
Pseudo R^2	0.37	0.41	0.36	0.37	0.5	0.36	0.38	0.28	0.35
No of obs	1648	1516	777	751	2008	1657	1786	1692	12795

Note : Standard errors given in parenthesis

** significantly different from zero at the 1 percent level

* signicantly different from zero at the 5 percent level

Table 4.3.2: Determinants of computer adoption elasticities

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
DEMOGRAPHIC VARIABLES									
male	0.059	-0.031	0.030	-0.001	0.007	0.002	-0.006	-0.052	-0.003
age	-1.050	-0.606	-0.601	-1.282	-0.477	-1.270	-1.073	-1.148	-1.027
education	1.233	0.689	0.674	0.945	0.474	1.650	0.880	1.021	0.980
working	0.003	-0.027	0.004	0.122	-0.003	0.054	0.054	0.083	0.040
Household no.	0.118	0.066	-0.081	-0.082	-0.018	0.112	-0.045	-0.112	-0.058
Main race	-0.147	0.202	-0.105	-0.274	0.038	-0.035	-0.097	-0.176	-0.122
Marital Status dummies									
married	-0.003	-0.143	0.017	0.247	-0.155	0.243	-0.158	-0.145	-0.030
divorced	-0.007	-0.007	0.001	0.000	-0.004	0.069	-0.015	0.005	-0.002
separated	0.010	0.000	0.000	0.022	-0.001	0.025	0.000	0.004	0.003
widowed	-0.014	-0.013	0.000	0.164	-0.018	0.174	-0.030	-0.020	-0.001
nevermarried	0.041	0.027	0.088	0.123	0.012	0.133	0.015	0.021	0.043
WORK SECTOR DUMMIES									
agriculture	-0.006	0.018	-0.006	-0.026	-0.005	-0.012	-0.009	-0.026	-0.011
manufacturing	0.018	0.023	-0.001	0.000	-0.010	-0.001	0.000	-0.004	0.002
Sales/services	-0.007	0.024	0.028	-0.006	-0.001	-0.011	-0.004	-0.002	0.003
INTEREST IN INFORMATION									
politics	-0.126	0.011	0.022	0.222	-0.010	-0.141	-0.202	0.049	0.055
othercultures	0.027	-0.002	0.207	-0.126	-0.015	-0.093	0.097	0.061	-0.019
economics	0.251	0.125	0.204	0.160	0.183	0.333	0.326	0.128	0.190
science	-0.005	0.108	0.142	0.231	0.103	-0.054	-0.069	0.082	0.064
INFRASTRUCTURE									
infrastructure	0.210	0.221	0.020	-0.014	0.255	0.040	0.063	0.007	0.073
LANGUAGE									
english	0.049	0.063	0.121	0.062	0.080	0.057	0.052	0.031	0.057
commlang	0.019	0.003	0.018	0.068	0.042	0.019	-0.005	0.000	0.016
russian	0.114	0.009	0.193	0.000	0.003	0.000	0.124	0.140	0.161
COUNTRY CHARACTERISTICS									
gdppercapita									0.392
teledensity									0.084

Table 4.3.3 Marginals for the computer adoption equation.

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
DEMOGRAPHIC VARIABLES									
male	0.022	-0.009	0.005	0.000	0.003	0.001	-0.002	-0.010	-0.001
age	-0.004	-0.002	-0.001	-0.003	-0.002	-0.006	-0.003	-0.003	-0.003
education	0.019	0.009	0.003	0.009	0.008	0.031	0.012	0.008	0.012
working	0.001	-0.009	0.001	0.031	-0.002	0.022	0.022	0.015	0.013
Household no.	0.007	0.003	-0.001	-0.002	-0.001	0.009	-0.002	-0.002	-0.002
Main race	-0.032	0.031	-0.008	-0.033	0.007	-0.008	-0.020	-0.019	-0.020
Marital Status dummies									
married	-0.009	-0.027	0.002	0.032	-0.041	0.092	-0.038	-0.018	-0.006
divorced	-0.018	-0.024	0.002	-	-0.024	0.159	-0.036	0.014	-0.005
separated	0.569	-	-	0.348	-0.017	0.184	0.002	0.024	0.038
widowed	-0.023	-0.014	-	0.102	-0.025	0.197	-0.029	-0.024	-0.001
nevermarried	0.044	0.028	0.026	0.116	0.010	0.226	0.020	0.014	0.040
WORK SECTOR DUMMIES									
agriculture	-0.012	0.095	-0.006	-0.019	-0.026	-0.056	-0.031	-0.014	-0.021
manufacturing	0.023	0.038	-0.002	-	-0.020	-0.001	0.001	-0.007	0.004
Sales/services	-0.010	0.024	0.023	-0.006	-0.002	-0.016	-0.006	-0.002	0.004
INTEREST IN INFORMATION									
politics	-0.012	0.001	0.001	0.014	-0.001	-0.016	-0.016	0.002	0.004
othercultures	0.004	0.000	0.008	-0.009	-0.002	-0.016	0.011	0.003	-0.002
economics	0.034	0.013	0.008	0.011	0.020	0.060	0.035	0.007	0.018
science	-0.014	0.010	0.005	0.013	0.010	-0.007	-0.005	0.003	0.005
INFRASTRUCTURE									
infrastructure	0.593	0.163	0.025	-0.022	0.185	0.201	0.357	0.018	0.115
LANGUAGE									
english	0.100	0.093	0.067	0.141	0.072	0.316	0.089	0.067	0.087
commlang	0.050	0.004	0.014	0.077	0.038	0.139	-0.011	0.001	0.028
russian	0.027	0.007	0.017	-	0.014	-	0.022	0.021	0.036
COUNTRY CHARACTERISTICS									
gdppercapita									0.001
teledensity									0.001

4.3.1.2 The Wage equation

In the second stage of the analysis, a Mincerian log earnings function supplemented by the predicted use of computers from the first stage is estimated. This equation contains the demographic variables and the predicted probability of adoption, while other variables included in the first stage are excluded to ensure that the equation is identified. While the Mincerian earnings function usually estimates the age and education variables as quadratics, a linear specification in age was found to be the best fit in this case. (Table 4.3.4 below presents the results.)

The predicted probability of computer use has a high rate of statistical significance, (at one percent level) in all eight countries and the total, implying that there is a return to personal computer use in each and all of these countries combined as Kruger found for the United States. The estimated returns are shown in table 4.3.5. The overall estimated return for all countries combined is about 24 percent, even higher than Krueger (1993)'s estimate of 10 to 15 percent. In the individual countries, the increase in wages due to computer use ranged from 7 percent in Bulgaria, to 19 percent in Moldova. This confirms the hypothesis that there is a positive wage premium associated with computer use, and this exists both in developed and transitional economies. One of the major problems in the literature with estimating the wage premium was that computer use was treated as an exogenous variable, instead of being regarded as endogenously determined. This problem has been resolved in this case.

Table 4.3.6 presents the estimated elasticities when computer use is treated as exogenous. The returns to computer use are overestimated in this case. For all countries combined, the return to computer use is 48 percent (exactly twice the corrected effect), ranging from 22 percent to a huge 85 percent in the individual countries. It is clear that the two-stage estimation has been successful in correcting for the bias in the estimates that would otherwise exist without the procedure.

Demographic variables are also important for predicting wages earned. In most countries, you are most likely to earn higher wages if you are male, older (signifying experience), more educated (significant in every country at 1 percent), have more than one (probably working) person in the household, live in the urban areas and work in the manufacturing or sales and services sectors. The evidence is mixed for the agricultural sector. (Associated with lower wages in Belarus, Romania, Russia, Ukraine and Uzbekistan) and overall, the coefficient is negative but not significant. Marital status, does not seem to have much impact, the coefficients are also inconsistent, and do not display much in terms of statistical significance.

Table 4.3.4 OLS Regression on natural log of income for the entire household

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
Pred.									
Computer use	0.69**	0.54**	1.67**	1.85**	0.82**	0.87**	0.94**	1.21**	1.71**
	(0.14)	(0.13)	(0.31)	(0.26)	(0.13)	(0.12)	(0.16)	(0.22)	(0.10)
DEMOGRAPHIC VARIABLES									
male	0.05*	0.07*	-0.06	0.11	-0.01	0.11**	0.08*	0.00	0.08**
	(0.03)	(0.03)	(0.09)	(0.07)	(0.04)	(0.04)	(0.03)	(0.04)	(0.02)
age	0.004**	0.00	-0.01**	-0.0008	0.005**	0.01**	0.01**	0.01**	0.01**
	(0.001)	(0.00)	(0.00)	(0.003)	(0.002)	(0.00)	(0.00)	(0.00)	(0.00)
education	0.03**	0.06**	0.05**	0.03**	0.10**	0.02**	0.03**	0.04**	0.02**
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)
Household no.	0.16**	0.13**	0.11**	0.06*	0.09**	0.19**	0.10**	0.10**	0.13**
	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
urban	0.26**	0.02	0.34**	0.38**	0.36**	0.29**	0.31**	0.23**	0.34**
	(0.03)	(0.04)	(0.08)	(0.08)	(0.04)	(0.04)	(0.03)	(0.04)	(0.02)
Main race	0.07*	0.42**	0.22	-0.02	-0.08	0.11*	-0.04	0.13**	0.10**
	(0.03)	(0.06)	(0.17)	(0.08)	(0.07)	(0.05)	(0.04)	(0.05)	(0.02)
Marital status dummies									
married	0.37*	0.25	0.52	0.09	0.21	-0.04	-0.13	0.04	0.12
	(0.17)	(0.18)	(0.44)	(0.22)	(0.17)	(0.15)	(0.15)	(0.25)	(0.09)
divorced	0.08	-0.13	0.45	-	-0.25	-0.47**	-0.47**	-0.12	-0.16
	(0.17)	(0.20)	(0.48)	-	(0.20)	(0.17)	(0.17)	(0.27)	(0.10)
separated	-0.12	--	-	-0.64	-0.51	-0.33	-0.43*	0.08	-0.29*
	(0.24)	-	-	(0.50)	(0.29)	(0.19)	(0.21)	(0.35)	(0.12)
widowed	-0.04	0.03	-	-0.29	-0.25	-0.44**	-0.45**	-0.04	-0.24**
	(0.17)	(0.18)	-	(0.26)	(0.18)	(0.16)	(0.16)	(0.20)	(0.09)
nevermarried	0.26	0.23	0.51	-0.26	0.04	-0.19	-0.29	0.15	-0.10
	(0.16)	(0.19)	(0.44)	(0.25)	(0.17)	(0.17)	(0.16)	(0.26)	(0.09)
WORK SECTOR DUMMIES									
agriculture	-0.02	0.29**	0.01	0.06	-0.24	-0.17*	-0.14	-0.16**	-0.04
	(0.06)	(0.09)	(0.13)	(0.09)	(0.16)	(0.09)	(0.10)	(0.05)	(0.04)
manufacturing	0.19**	0.41**	0.53*	0.00	0.38**	0.28**	0.23**	0.27**	0.47**
	(0.04)	(0.05)	(0.27)	(0.00)	(0.06)	(0.06)	(0.07)	(0.09)	(0.03)
sales/services	0.12**	0.35**	0.19	0.59**	0.37**	0.26**	0.26**	0.21**	0.33**
	(0.04)	(0.04)	(0.11)	(0.13)	(0.06)	(0.05)	(0.07)	(0.07)	(0.03)
constant	2.85**	2.59**	1.90**	1.59**	2.26**	2.58**	2.23**	2.81**	2.46**
	(0.19)	(0.20)	(0.53)	(0.35)	(0.20)	(0.19)	(0.21)	(0.29)	(0.10)
R^2	0.45	0.44	0.21	0.31	0.44	0.40	0.27	0.21	0.25
No of obs.	1648	1516	777	751	2008	1657	1786	1692	12795

Note : Standard errors (corrected by bootstrapping) given in parenthesis
* signicantly different from zero at the five percent level
** significantly different from zero at the one percent level

Table 4.3.5 Elasticities from household wage equations with computer use treated as endogeous

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
Pred. Computer use	0.12	0.07	0.12	0.19	0.14	0.18	0.15	0.11	0.24
DEMOGRAPHIC VARIABLES									
male	0.05	0.07	-0.06	0.11	-0.01	0.11	0.08	0.00	0.08
age	0.18	0.00	-0.41	-0.04	0.23	0.48	0.49	0.37	0.45
education	0.34	0.63	0.65	0.31	1.05	0.22	0.34	0.44	0.22
Household no.	0.48	0.42	0.48	0.20	0.29	0.50	0.32	0.56	0.47
urban	0.17	0.01	0.19	0.14	0.19	0.21	0.18	0.09	0.20
Main race	0.07	0.42	0.22	-0.02	-0.08	0.11	-0.04	0.13	0.10
Marital Status dummies									
married	0.37	0.25	0.52	0.09	0.21	-0.04	-0.13	0.04	0.12
divorced	0.08	-0.13	0.45	-	-0.25	-0.47	-0.47	-0.12	-0.16
separated	-0.12	-	-	-0.64	-0.51	-0.33	-0.43	0.08	-0.29
widowed	-0.04	0.03	-	-0.29	-0.25	-0.44	-0.45	-0.04	-0.24
Never married	0.26	0.23	0.51	-0.26	0.04	-0.19	-0.29	0.15	-0.10
WORK SECTOR DUMMIES									
agriculture	-0.02	0.29	0.01	0.06	-0.24	-0.17	-0.14	-0.16	-0.04
manufacturing	0.19	0.41	0.53	0.00	0.38	0.28	0.23	0.27	0.47
Sales/services	0.12	0.35	0.19	0.59	0.37	0.26	0.26	0.21	0.33

Table 4.3.6 Elasticities from household wage equation with computer use treated as exogenous

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
Computer use	0.25	0.22	0.84	0.85	0.46	0.38	0.35	0.23	0.48
DEMOGRAPHIC VARIABLES									
male	0.07	0.07	-0.03	0.11	-0.01	0.1	0.08	-0.02	0.08
age	0.00	0.00	-0.41	0.00	0.18	0.48	0.00	0.37	0.05
education	0.45	0.74	0.78	0.41	1.05	0.33	0.46	0.66	0.44
Household no.	0.51	0.42	0.53	0.17	0.26	0.53	0.29	0.50	0.39
urban	0.28	0.04	0.39	0.4	0.41	0.28	0.31	0.24	0.38
Main race	0.04	0.44	0.17	-0.05	-0.06	0.11	-0.07	0.1	0.08
Marital status dummies									
married	0.37	0.22	0.45	0.15	0.15	0.02	-0.16	-0.06	0.07
divorced	0.06	-0.17	0.39	-0.03	-0.33	-0.41	-0.53	-0.18	-0.24
separated	0.14	0.15	-0.75	-0.51	-0.56	-0.26	-0.46	0.15	-0.25
widowed	-0.02	0.01	0.03	-0.19	-0.3	-0.35	-0.46	-0.13	-0.27
Never married	0.34	0.28	0.52	-0.07	0.09	-0.05	-0.2	0.21	0.06
WORK SECTOR DUMMIES									
agriculture	-0.06	0.3	-0.03	0.02	-0.28	-0.26	-0.2	-0.2	-0.12
manufacturing	0.19	0.41	0.49	0.52	0.35	0.27	0.23	0.27	0.48
Sales/services	0.1	0.36	0.21	0.61	0.36	0.25	0.28	0.22	0.37

This analysis was done based on total household income, which could be earned by multiple individuals in the household. Thus, in order to ensure a one-to-one correspondence between the working individual and the wages earned, to ensure that the computer premium for the individual worker is captured, the same analysis was done on households with only one working individual (Table 4.3.7). However, it is difficult to derive any robust conclusions from the individual country regressions. There is a drastic reduction in sample sizes, which are small enough to make the coefficients suspect. If instead emphasis is placed on the 1312 single working individuals in all nine countries, the sample size is large enough for statistical inference, without drawing any erroneous conclusions. The results in the total column which captures all nine countries, shows that there is a return to personal Computer adoption as it has a positive and significant impact on wages (and this is at the 1percent level of significance). The results also reveal that in the countries sampled, altogether, an individual is likely to earn more if male, highly educated, living in an urban area, and working in the agricultural, manufacturing and sales or services sector. Each of these variables is significant at least at the 5 percent level of significance. While belonging to the dominant nationality within the country and age both have a positive effect on wages, the effects are not statistically significant.

Table 4.3.8 presents the estimated elasticities for the individual worker. Although there are some negative elasticities in this case (due perhaps to the very small sample sizes), the absolute values of the returns to computer use are comparable to the returns from the household wage equations. The overall premium for all countries combined is 21 percent, which is quite close to the 24 percent obtained from the previous estimation, and still higher than Kruger's estimate. In absolute value, the computer premium for each individual country ranges from 6 percent (Bulgaria), to 20 percent (Moldova), though Russia has an unusually high premium of 40 percent.

Table 4.3.7 OLS Regression on natural log of Income for single Working individuals

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
Pred. Computer use	0.98**	0.46	-1.37	1.91	0.57	1.93**	-0.12	-1.22	1.52**
	(0.36)	(0.42)	(2.95)	(1.20)	(0.32)	(0.47)	(0.36)	(1.54)	(0.29)
DEMOGRAPHIC VARIABLES									
male	0.21**	0.22*	-1.82	0.16	0.37**	0.24*	0.31**	0.06	0.30**
	(0.09)	(0.10)	(0.75)	(0.12)	(0.12)	(0.10)	(0.10)	(0.18)	(0.06)
age	0.01	0.01*	-0.04	0.00	0.004	0.02**	0.004	0.01	0.01
	(0.00)	(0.00)	(0.02)	(0.01)	(0.005)	(0.02)	(0.004)	(0.01)	(0.01)
education	0.03*	0.03*	0.19	0.03	0.08**	0.01	0.05**	0.05	0.02**
	(0.01)	(0.02)	(0.11)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)
urban	0.21**	0.11	0.51	-0.18	0.39**	0.28**	0.09	0.20	0.32**
	(0.08)	(0.10)	(0.53)	(0.13)	(0.12)	(0.07)	(0.08)	(0.23)	(0.05)
Main race	-0.05	0.22	-0.31	-0.15	-0.08	0.05	-0.12	-0.11	0.02
	(0.10)	(0.17)	(1.05)	(0.14)	(0.16)	(0.11)	(0.09)	(0.20)	(0.06)
WORK SECTOR DUMMIES									
Agriculture	0.39	0.74	-	-0.13	-0.10	0.50*	1.16**		0.46*
	(0.22)	(0.53)	-	(0.46)	(0.70)	(0.25)	(0.38)		(0.20)
manufacturing	0.52**	0.86**	2.32	-	0.62	0.82*	-0.03	0.33	0.79**
	(0.16)	(0.25)	(0.83)	-	(0.33)	(0.37)	(0.32)	(0.43)	(0.13)
Sales/services	0.19	0.58	-0.63	1.72**	0.66**	0.50**	0.68**	0.56	0.45**
	(0.21)	(0.32)	(0.92)	(0.48)	(0.24)	(0.18)	(0.20)	(0.52)	(0.12)
constant	2.82**	2.34**	1.99	1.10*	2.07**	1.71**	1.73**	2.84**	1.88**
	(0.32)	(0.35)	(1.96)	(0.49)	(0.37)	(0.67)	(0.32)	(0.69)	(0.38)
R^2	0.38	0.29	0.67	0.39	0.50	0.38	0.29	0.20	0.23
No of obs.	179	133	19	64	211	342	206	55	1312

Note : Standard errors given in parenthesis

Standard errors for Russia and Total were corrected by bootstrapping

* signicantly different from zero at the 5 percent level

** significantly different from zero at the 1 percent level

Table 4.3.8 Elasticities : Income Equation for Single Working Individuals

	Belarus	Bulgaria	Georgia	Moldova	Romania	Russia	Ukraine	Uzbekistan	Total
Pred. Computer use	0.17	0.06	-0.10	0.20	0.10	0.40	0.16	-0.11	0.21
DEMOGRAPHIC VARIABLES									
male	0.21	0.22	-1.82	0.16	0.37	0.24	0.31	0.06	0.14
age	0.44	0.49	-1.66	0.00	0.18	0.97	49.09	0.37	0.45
education	0.34	0.32	2.48	0.31	0.84	0.11	11.38	0.55	0.22
urban	0.21	0.11	0.51	-0.18	0.39	0.28	0.09	0.20	0.32
Main race	-0.05	0.22	-0.31	-0.15	-0.08	0.05	-0.12	-0.11	0.02
WORK SECTOR DUMMIES									
agriculture	0.39	0.74	-	-0.13	-0.10	0.50	1.16	-	0.46
manufacturing	0.52	0.86	2.32	-	0.62	0.82	-0.03	0.33	0.79
Sales/services	0.19	0.58	-0.63	1.72	0.66	0.50	0.68	0.56	0.45

Correcting the Standard errors

As earlier noted in a previous section, the standard errors from the two stage least squares process of estimation need to be corrected. The standard errors in both wage equations are thus adjusted by the process of bootstrapping. However, because of the small sample sizes in the regression for the individual workers, it was impossible to do bootstrapping, and thus only the regressions for Russia and all countries combined (total) have bootstrapped errors.

Alternative estimation Methods and Tests

The two stage estimation technique was also carried out using the linear probability model in the first stage. The results were very similar, thus confirming the findings from the previous analysis. In addition, the hausman test was carried out to test for the consistency of the OLS estimates after the two-stage estimation, and also to test for the appropriateness of the instruments used in the estimation process. While it is difficult to speak on the appropriateness of instruments based on this test, which is a rather weak test for this purpose, it was found that the estimated coefficients were consistent and stable after the test was carried out.

4.4 THE DIGITAL DIVIDE

In examining the means of the variables of interest in section 4.1, Russia clearly has the largest proportion of people who had ever used a computer (21 percent). In this section, an attempt is made to further investigate the differences in computer use between Russia and the other countries in this study. Two questions are answered in this section:

-Is there a statistically significant difference in computer use in Russia relative to other countries in the sample?

-If there is, what are the sources of these differences and how can we account for them?

4.4.1 Log likelihood ratio test

To answer the first question, I test for differences in adoption rates using the likelihood ratio test. The method utilized was to pool the observations for both Russia and different groups of the other countries. One group included former soviet republics (Armenia, Belarus, Georgia, Moldova, Ukrain and Uzbekistan) and the other group was composed of Bulgaria and Romania, the two countries in the sample situated in central Europe. I then run a probit model for Russia, a probit model for the other groups of countries and a pooled probit model for Russia and the other groups of countries.

The null hypothesis to be tested is:

The coefficients of the full model (the separate models for Russia and the other country groups) are the same as the coefficients for the reduced model (the combined Russia-other country group model).

The alternate hypothesis is that coefficients of the full model do not equal coefficients for the reduced model.

The likelihood ratio test is $2(L_R + L_X - L_{XR})$;

where

L_R = log likelihood for the Russia probit model

L_X = log likelihood for the other country group probit model

L_{XR} = log likelihood for combined Russia-other country group model.

The likelihood ratio test is distributed χ^2 (k), with k degrees of freedom, where k is the number of parameters in the pooled probit model.

The likelihood ratio test computes χ^2 and rejects the assumption if χ^2 is larger than a Chi-Square percentile with *k* degrees of freedom.

Table 4.4.1 presents the results of the log likelihood ratio test:

Table 4.4.1 The log likelihood ratio test

Country	L_X	L_R	L_{XR}	$2(L_R + L_X - L_{XR})$
Central European countries	-842.22	-541.08	-1441.2	115.79
Former Soviet republics	-1929.3	-541.08	-2584.37	227.98

$\chi^2(22, 0.99) = 40.29$

Pr ($\chi^2 \geq 2\ (L_R + L_X - L_{XR})$) $\approx$ 0, in both cases, so the conclusion is that there is strong evidence against the reduced model. The coefficients are not the same, and thus, there is significant difference between the model for Russia and the model for the other groups of countries.

As stated earlier, Russia was chosen as the reference country because it had the highest proportion of computer adopters.

4.4.2 Even and Macpherson Decomposition

To answer the second question on sources of differences in adoption rates, a decomposition technique is required. Usually, the technique applied in most decomposition analysis is the Oaxaca decomposition technique, where earnings differentials between men and women or between different races are divided into explained and unexplained components. (Altonji and Blank, 1999).

Using the Oaxaca decomposition, the gap in computer use between other countries and Russia can be written as:

$$(\overline{Z}^R - \overline{Z}^o) = (\overline{Z}^R - \hat{Z}^o) + (\hat{Z}^o - \overline{Z}^o)$$

Total difference: $(\overline{Z}^{R} - \overline{Z}^{o})$ i.e., differences in mean predicted values of computer adoption between Russia and the other country.

Total explained difference: $\sum (B^{R} (\overline{Z}^{R} - \overline{Z}^{o}))$

Unexplained difference: $\sum (\overline{Z}^{R} - \overline{Z}^{o}) - \sum (B^{R} (\overline{Z}^{R} - \overline{Z}^{o}))$

$\overline{Z}^{R}$ = actual computer use mean for Russia
$\overline{Z}^{o}$ = actual computer use mean for other country
B^{R} = Regression coefficient for Russia

The explained difference is attributed to differences in the endowments and characteristics of computer users in the different countries, while the unexplained part is attributed to differences in the estimated coefficients, which is interpreted as the differences in returns to similar characteristics of adopters between Russians and citizens of the other country. However, this technique is only useful if the estimation method is limited to Ordinary Least Squares, which assumes a linear relationship among the variables of interest (Lui, 2000). In this case, the probit model (a non-linear technique) is utilized, so the technique outlined by Even and Macpherson (1993) is used instead.

Lui (2000), outlines the decomposition procedure as follows:
x_{ij} is a vector defined as the vector of characteristics of the individual in each country, and D_{ij} is a binary variable that indicates whether the individual adopts computer technology or not. Then the probit model can be represented as:
$\Pr (D_{ij} = 1 | x_{ij}) = F(x_{ij}b)$
From the estimated probit coefficients, the average predicted probability of computer use for each country is calculated $(\hat{P})$. The difference between the average predicted probability of computer adoption can then be decomposed into explained and unexplained components.

The observed difference in computer use:

$\hat{P}_R - \hat{P}_O =$ explained difference + unexplained difference

where :

Explained component is defined as $\hat{P}(x_{iR}, \hat{B}_{iR}) - \hat{P}(x_{iO}, \hat{B}_{iR})$, and the unexplained component as $\hat{P}(x_{iR}, \hat{B}_{iR}) - \hat{P}(x_{iO}, \hat{B}_{iO})$

Fraction of explained difference due to changes in the kth independent variable is defined as

$$[\hat{P}(x_{iR}, \hat{B}_{iR}) - \hat{P}(x_{iO}, \hat{B}_{iR})] \left[\frac{(\bar{x}_{Rk} - \bar{x}_{Ok})\hat{B}_{Rk}}{(\bar{x}_R - \bar{x}_O)\hat{B}_R} \right]$$

Where

$\hat{P}(x_{iR}, \hat{B}_{iR})$ is the predicted probability of computer adoption for Russia, using Russian coefficients

$\hat{P}(x_{iO}, \hat{B}_{iR})$ is the predicted probability of computer adoption for the other country, using Russian coefficients

$\bar{x}_{Rk}$ = Mean of kth explanatory variable in Russia.

$\bar{x}_{Ok}$ = Mean of kth explanatory variable in other country

$\hat{B}_{Rk}$ = Probit coefficient of kth explanatory variable in Russia.

$\bar{x}_R$ = Overall mean of all explanatory variables in Russia

$\bar{x}_O$ =Overall mean of all explanatory variables in other country.

$\hat{B}_R$ = Overall mean of probit coefficients for all explanatory variables in Russia.

The explained component represents changes in adoption rates between Russia and the other country due to differences in characteristics.

The unexplained component represents changes in the adoption decision of individuals in Russia and in the other country that results if the probability of an individual adopting computer technology in Russia is determined by the other country's probit coefficients.

Table 4.4.2 below reveals the results of the decomposition.

The variables that are displayed in the results were chosen as the most important characteristics because they are the most theoretically important variables and as it turned out in the previous section, also the most empirically important determinants of computer adoption. The results show that the total predicted gap is positive, implying that Russia has greater adoption probabilities than the other groups of countries in the sample. However, it is also clear that the differences in adoption rates between Russia and the other countries are due mostly to the unexplained components, and thus to differences in coefficients and not characteristics.

The total explained difference is negative in both cases, implying that if the other groups of countries had Russian coefficients, they would adopt computers at a higher rate than in Russia, but this result is only applicable to the countries as they are grouped, not to individual countries.

Further decomposing the total explained difference, the importance of skills is emphasized, at least in central European countries. Education and language skills are very important components of the explained difference between Central European countries and Russia. Infrastructure is of extreme importance, accounting for almost half of the explained difference between this group of countries and Russia. However, infrastructure is far less important for the former soviet republics, only accounting for less than one percent of the explained difference. For this group of countries, individual skills (language and education) were more important in components of the explained difference.

Table 4.4.2 Decomposing the differences in adoption rates between Russia and other groups of countries

	Central European countries	Former soviet Republics
Total difference	0.057	0.036
percent	100	100
Total Explained difference	-0.120	-0.072
Education	0.033	-0.008
percent	-27.500	11.050
Infrastructure	-0.054	0.000
percent	45.000	-0.071
English	-0.031	-0.008
percent	25.833	11.050
Commerce lang	-0.018	-0.004
percent	15.000	5.525
Unexplained difference	0.177	0.109
percent	311.524	300.159

The fact that most of the differences in adoption is due to coefficients means that coefficients in Russia are different from coefficients in these other countries, implying that the responses to the explanatory variables vary differently in these different groups of countries. The reasons for the differences may not be fully known. Perhaps there are other country specific issues, which perhaps may not be so easy to capture and measure, that determine differences in adoption rates.

CHAPTER FIVE

SUMMARY, POLICY IMPLICATIONS AND CONCLUSIONS

The nine countries that have been analyzed in this study represent a diversity of cultures, languages and sizes even though they all once shared a common communist past. Since making the transition from communism, they have faced several challenges in adapting their societies and economies to democracy and capitalism. The levels of success they have achieved differ from country to country, but they have all had to deal with the often-negative heritage of communism, including generally inadequate telecommunications infrastructure.

This study was intended to investigate what determines computer adoption in these economies, and what impact adoption of computers has on wages. It was earlier established that in more advanced Western European countries and the United States, the computer and related technologies played a major role in the economic advances of the late nineties and beyond, and it was important to investigate whether computers would have the same impact in these developing transitional economies, regardless of their inadequate existing infrastructure. Results from analysis done in the fourth chapter showed that adopters of computer technology were younger and better educated as in more advanced countries. Human capital turned out to be of major importance confirming the skill- technology complementarity hypothesis examined in chapter three, and substantiating the human capital model also developed in chapter three, which affirmed the importance of human capital in determining levels of computer adoption.

Other factors also turned out to be of utmost importance in the adoption process, including levels of infrastructure, (both on a local and country wide basis), per capita GDP, and language skills, particularly ability to speak English, the language of 80 percent of the internet.

A Mincerian earnings function, augmented by the predicted computer use from the adoption equation, was also scrutinized to determine the existence and size, if any, of the returns to computer use. The return to all of these countries combined was 24 percent, which was even higher than the returns that Krueger calculated for the United States.

When the analysis was done for single income households, the results were similar. There was a return of 21 percent, which was also quite substantial.

These results have generated a number of policy issues that need to be looked into if the information and telecommunications sectors will end up being an engine of growth in these economies. In implementing these recommendations, the government of these countries will have to take a leading role in the process because of the dominant role that they have played in these economies for so long.

First is the importance of human capital. However, as was discovered when examining the countries individually in chapter two, it is clear that literacy rates are very high, almost 100 percent in all countries without exception. Despite this, computer use is low. Perhaps the question is not education, but the type of education. It may be important for the government to step in to ensure that computers and related technologies are introduced in schools as early as possible, and also to ensure that information technology is incorporated into school curricula. Since younger people are more likely to adopt computer technology, it is important to ensure that this is done as early as is feasible for maximum exposure to these technologies.

Language is another major policy issue. The ability to speak a major language of the G7, English in particular, was found to be of major importance in determining computer adoption. In most of these nine countries, the lingua franca is generally not a major international language. Russian is spoken in a few of them, but English is more widely spoken and used, and is the language in which most advanced learning in technology issues takes place. Therefore, in order not to be totally cut off from advances in the field, and to be able to utilize the resources available, these countries may want to introduce the learning of English, or any other major language into the school curriculum as well. Ensuring that the citizenry is at least bilingual guarantees that resources and developments in the field of information and communications technology are accessible.

Infrastructure incorporates a number of policy issues. First, it is important that the telecommunications sector be deregulated. This involves a few important stages:

-Adoption of telecom law that stipulates privatization of the incumbent monopoly.

-Actual steps taken to privatize the incumbent operators

-Creation of an independent regulatory body to manage the telecommunications sector in each of these countries. In many countries, the national government is still in control, which has stunted the development of these sectors. (Chaillou,2002)

Some of the countries in the survey, Bulgaria, Romania and Ukraine, for instance, are interested in joining the European Union (EU). In order for them to do so, however, they have to structure their economic policies to conform to EU policies, which is actually an added incentive for them to deregulate their economic institutions.

Another added benefit of deregulation and privatization is the fact that it attracts foreign investment. In addition to this leading to a more competitive telecommunications sector, with better management and high quality output, there are multiplier benefits to the entire economy as well. Increased foreign investment is expected to result in creation of employment opportunities for citizens and diffusion of more modern technologies among other benefits.

The high cost of delivery of telecommunications services, due to a variety of reasons is another infrastructure related policy issue. As noted in the second chapter, monopolies tend to increase the cost of provision of telecommunications services, raising them beyond the reach of the average consumer. While many potential adopters may not be able to afford to buy their own personal computers, they may be interested in communicating with someone else by email. Pending the time when the institutional restructuring takes place and competition is put in place, it is important to put computers and related technologies in locations where they can be easily accessed either at a subsidized rate, or without cost. Libraries and schools are good starting places.

In the long run, there is no substitute for sound economic policies that encourage the development of an independent, competitive and efficient telecommunications sector, which will encourage foreign investment and all the attendant potential benefits. It is also important that governments of these countries adopt policies that will stimulate economic growth, which may require more openness and fewer controls. As per capita GDP rises, as was seen in chapter four, it is likely the funds will exist to further develop the telecommunications sector, and more individuals will be able to afford to adopt computer technology.

In conclusion, the information revolution has been a defining factor of the late 20th and early 21st century.

> The world is in the midst of an all-purpose technological revolution based on information technology (IT), defined here as computers, computer software, and telecommunications equipment. The macroeconomic benefits of the IT revolution are already apparent in some economies, especially the United States. Historical experience has shown that such revolutions have often been accompanied by financial booms and busts, and the IT revolution has been no exception. But, while spending on IT goods is likely to remain weak in the immediate future, as past over-investment unwinds, the longer-term benefits for the global economy are likely to continue, or even accelerate, in the years to come (IMF, 2001).

However, these longer-term benefits can only be enjoyed by economies that take the initiative and fully adopt and utilize these technologies. For the transitional economies in this survey and the others not included but which they could also represent, computers and related technology are a possible engine of growth. In order to take this opportunity however, some massive internal restructuring is required. Failure to take the initiative and embrace this revolution may result in the region forever struggling, living in the shadow of the more affluent countries in Western Europe and the United States, without any hopes of ever catching up.

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