NET Institute*

www.NETinst.org

Working Paper #11-23

October 2011

ICT Use and Labor: Firm-Level Evidence from Turkey

Hilal Atasoy
University of Illinois at Urbana-Champaign

ICT Use and Labor: Firm-Level Evidence from Turkey

Hilal Atasoy[*†‡]
University of Illinois at Urbana-Champaign

September 26, 2011

Abstract

This study analyzes the adoption and use of information communication technologies (ICTs) by firms and their effects on employment and wages. I use a confidential data set from Turkey that includes detailed surveys focused on how ICTs and the Internet are used by firms. By using the rich survey data, I create an ICT index summarizing ICT adoption and use, along with the skills of the firms, where each category takes into account many applications. The firms with different levels of ICTs differ in many characteristics. I use the generalized propensity score matching method in order to compare firms that are similar in many dimensions such as industry, location, investments, profits, trade balance, and output. I find positive effects of ICTs on employment and wages that are diminishing after a certain level of ICTs. These significant effects are due to an increase in ICT-generated jobs and not due to an increase in non-ICT jobs in the short-run. The effects on non-ICT employment become significant a couple years after investments in ICTs. This implies a change in the skill composition of the firms with higher intensity of ICT use, especially in the short run.

JEL Classifications: J21, O33
Keywords: Information communication technologies, skilled-biased technical change, employment

[*]I am grateful to Darren Lubotsky for continuous encouragement and advice. George Deltas, Ron Laschever, Seung-Hyun Hong and Geoffrey Hewings provided several valuable suggestions. I thank participants to the UIUC Research Seminar, Public Economic Theory Meeting and International Conference on Mathematical Finance and Economics for helpful comments and suggestions. Financial support from the UIUC Graduate College Dissertation Travel Grant and from the NET Institute (www.NETinst.org) is gratefully acknowledged. All remaining errors are mine.

[†]This research uses data by Turkish Statistical Institute and Government Planning Organization of Turkey. The results presented in this paper do not reflect the opinions of the aforementioned organizations.

[‡]E-mail: hatasoy2@illinois.edu, Address: Department of Economics, University of Illinois, 214 David Kinley Hall, 1407 W. Gregory, Urbana, Illinois 61801

1 Introduction

Broadband Internet access enables advanced telecommunication applications and sophisticated data exchange tools that have great impact on users ability to realize the true potential of the Internet. Broadband technology is primarily deployed by the private sector. High fixed costs associated with broadband infrastructure cause information communication technologies (ICTs) to be diffused unequally. This phenomenon of differential access to ICTs from different parts of society is known as the digital divide. The urban-rural digital divide is an important concern, as deployment in urban locations outpaces deployment in rural locations throughout the world. Broadband policies are predicated on the idea that disparities in broadband access across a society could have adverse economic and social consequences on regions with insufficient broadband access. One example of an ICT policy is the United States broadband stimulus package that provides over $17 billion for broadband deployment. The main goal of this policy is to induce economic growth with higher levels of employment and productivity. Evaluating the impact of broadband technology on the economy has important policy implications. Broadband technology is less common in emerging countries, such as Turkey, and there are recent policies that aim to improve broadband access. These policies claim that broadband access stimulates job creation at firm and regional levels. Understanding the economic impacts of ICTs in Turkey is more critical than understanding the same economic impacts in the United States. First, broadband penetration in Turkey is lower than in the United States. The broadband deployment rate is more than 90 percent in the United States, whereas this rate is around 30 percent in Turkey. Since Turkey is at an earlier stage of ICT diffusion, the economic consequences of this technology may be more pronounced and easier to find. Secondly, the opportunity cost of government spending is higher in emerging countries like Turkey.

This paper explores the impacts of ICTs on employment and wages within firms. I employ restricted-use data from Turkey, provided by the Turkish Statistical Institute and the Government Planning Organization. This confidential data set includes nationally representative surveys that were conducted from 2007 to 2010 on how much and for what purposes ICTs and the Internet are used by firms. These firm level responses to questions about ICT use allow me to go beyond aggregate analysis.

I use two variables to measure the ICT level at the firm level: an ICT index and advanced Internet use indicator. First, I create an ICT index summarizing many highly correlated indicators. The ICT index is a weighted average of ICT adoption, use, and skill measures. The ICT adoption indicators include presence of computers and the Internet, as well as the speed level of the Internet connection. Some of the ICT use indicators are: employing these technologies for enterprise resource planning, supply chain management, customer relationship management, e-government, e-banking, and software development. Finally, the ICT skill indicators are measures of employees knowledge about these technologies, the share of employees who use the Internet, the share of employees with ICT training, and the availability of ICT education for employees. I weigh these indicators based on the International Telecommunication Society's ICT Development Index weights.[1] The results are robust to different weights. The ICT index is between 0 and 1, with 0 meaning no ICTs in effect and 1 meaning full use of ICTs within the firms.

Second, the advanced Internet use dummy shows whether the firms use three or more ICT use indicators that are chosen based on the literature: enterprise resource planning, supply chain management, customer relationship management, education, purchasing, customer support and extranet.[2] These applications are known to lead to organizational change.

ICTs can change the employment levels within the firms through two mechanisms. First, ICTs are skill-biased technologies that change the relative demand for skilled and unskilled labor. ICTs require skilled labor for maintenance and use. Skilled labor also have a higher ability to adapt to new technologies Therefore, adoption of these technologies increases the demand and wages for skilled labor.[3] Second, ICTs can lead to expansion by enabling firms

[1] International Telecommunications Union Report (2009)

[2] Forman, Goldfarb and Greenstein (2011) use these Internet applications to create and advanced Internet use measure. These applications are selected based on their effect on the organizational change.

[3] Acemoglu (1998), Autor, Katz and Kruger (1998) and Autor, Levy and Murane (2001) find evidence

to lower costs and penetrate larger geographical markets. Higher production levels due to firm expansion will lead to higher employment levels. Presence of these two mechanisms have different policy implications. The first mechanism will change the skill composition of the labor force within the firms and thus increase the skill gap, whereas the second mechanism will not affect the relative demand for skilled and unskilled labor.

The ICT Index and advanced Internet use variables are positively correlated with total employment levels in the firm fixed effects models that remove the unobserved heterogeneity at the firm level. The positive correlation between ICTs and employment is due to relationship between ICTs and ICT-related employment (ICT experts and ICT users). There is no significant relationship between ICTs and non-ICT employment with an exception of high-tech manufacturing firms. These results suggest that ICTs have direct effects on ICT-related employment; firms that adopt and use these technologies hire workers in order to maintain and use the new technologies. The scale effects that increase the demand for other types of employment is not significant for the two year fixed effects models. However, these effects might require longer periods of time to emerge, and this panel might not be long enough for them to be significantly present. The change seen within firms is not high enough in the two-year panel data to identify the effects of ICTs on other types of labor. Additionally, the four-year firm fixed effects regressions that do not include full controls have significant coefficients on non-ICT employment. Overall, the evidence indicates that, in the short term, ICT investment leads to increases only in ICT-related workers. Over a longer period, there are more significant effects on non-ICT employment through scale effects.

There is an endogeneity problem in analyzing the relationship between ICTs and employment due to reverse causality and self-selection. I address this problem in two ways. First, I use the generalized propensity score matching that removes these observable biases. This method calculates the effect of ICTs on employment and wages by only comparing firms that are similar in many dimensions such as industry, location, ownership status, investment,

that information technologies are skill biased. Michaels, Natraj and Van Reenen (2010) provide evidence that information communication technologies are skilled biased as well profits, trade balance, and output. I find positive effects of the ICT index on employment and wages within firms, and these effects diminish after a certain level of ICT investment. When the ICT index increases from 0 to 0.8, employment increases by 5 percent, and wages increase by 8 percent within the firms; these effects stay constant for ICT index levels 0.8 to 1. Second, I use instrumental variables to obtain further evidence on causality. I find different set of instruments to be valid for different industries and technology use classifications within the same sector.

2 Data

The Turkish Statistical Institute and the Government Planning Organization conducted ICT adoption and use surveys from 2007-2010. These survey data include detailed questions about how much and for what purposes ICTs are used within firms. They are nationally representative in each year. This data set is restricted-use since it includes confidential information about the firms and can be only accessed at the Data Research Center of the Turkish Statistical Institute in Ankara, Turkey.

I match ICT use data with business statistics and trade data in order to obtain a full set of control variables of the firms. The business statistics data include detailed information about employment, production, profit, investments, location, sector, capital stock and composition, ownership, branches, and other important firm characteristics. The trade data set includes information on the imports and exports made by each firm and their trade partners. Business statistics are only available for 2007 and 2008 as of now.[4]. The ICT survey has 3,364 observations from 2007 and 4,601 observations from 2008. This survey is an unbalanced panel; some of the firms are surveyed over multiple years. Matching ICT, business, and trade datasets results in a dataset of 5,570 observations over 2007 and 2008. I also use a four-year panel that does not include the full set of control variables for some part of the analysis. Here, I use the balanced panel of 454 firms over four years with a total of 1,816

[4] 2009 and 2010 will be added as they become available

observations.

2.1 Measuring the ICT level

There are many ICT adoption and use indicators in the data set, and they are highly correlated with each other. Including these indicators separately leads to serious multicollinearity problems, and so I summarize this information into two different measures: the ICT index, and the advanced Internet use indicator. The first variable is an overall index that summarizes ICT adoption and use indicators, while the second variable concentrates on the ICT use intensity.

2.1.1 ICT Index

The ICT index is a weighted average of ICT adoption, use, and skill measures. The ICT adoption indicators include presence of computers and the Internet as well as the speed level of the Internet connection (ISDN, ADSL, cable, or mobile). Some of the ICT use indicators are: employing these technologies for enterprise resource planning, supply chain management, customer relationship management, e-commerce, etc. Finally, the ICT skill indicators are measures of employees knowledge about these technologies, the share of employees who use the Internet, the share of employees with ICT training, and the availability of ICT education for employees. I weigh these indicators based on the International Telecommunication Societys ICT Development Index weights. According to this index, ICT adoption is weighted by 40 percent, ICT use is weighted by 40 percent, and ICT skill is weighted by 20 percent. I normalize all the indicators to a range of 0 to 1 and calculate the ICT index as a weighted average. The ICT index is between 0 and 1 with an average of 0.61 and a standard deviation of 0.19. The results are robust to different weighting.

2.1.2 Advanced Internet Use

The second measure of ICTs is the advanced Internet use indicator. This measure concentrates more on ICT use rather than an overall index. The advanced Internet use indicator shows whether firms use at least 3 of the following ICT applications that are known to affect organizational change and inter-establishment communication: [5]

1. Enterprise Resource Planning
2. Supply Chain Management
3. Customer Relationship Management
4. Education
5. Purchasing
6. Customer Support
7. Extranet

2.2 Summary Statistics

Table 1 presents summary statistics of some of the dependent and business variables in the final data set. Means and standard deviations of employment, wages, and some control variables are listed. Control variables include profits, costs, revenue, production, investment, capital stock, the ratio of capital owned by foreign direct investment, imports, exports, the number of establishments within the same firm, and other business statistics.

Table 2 presents the summary statistics for ICT variables. The ICT Index and advanced Internet use are variables that are calculated in order to measure the ICT levels within the firms. The variables represent the share of firms using each application. The share of the firms have computers is 96 percent and 83percent have broadband connections. The other

[5] Forman, Goldfarb and Greenstein (2011)

summary statistics are the average ratio of firms using listed ICT applications. The share of firms engage in e-commerce is 23 percent and 62 percent of firms use ICTs for marketing purposes. Forty two percent of firms use ICTs for training and educational purposes. Other commonly used applications are online banking, online transactions and e-government.

3 Empirical Specification and Results

3.1 A firm fixed effects model of ICTs and Employment

I use the following basic model for empirical specification:

$$\text{Log(employment)}_{it} = \beta_0 + \beta_1 \text{ICT Index}_{it} + \delta X_{it} + \alpha_i + \lambda_t + \epsilon_{it} \tag{1}$$

where $\text{Log(employment)}_{it}$ is the log of employment in firm i at time t, ICT Index_{it} is the ICT Index of firm i at time t, X_{it} includes firm controls such as value-added, capital, exports, imports, R&D expenditure, patents. The firm fixed effects term that absorbs any permanent heterogeneity at the firm level is α_i. The time control that absorbs time specific shocks shared by all the firms is λ_t.

Table 3 presents the OLS and firm fixed effects regressions where the dependent variable is log of employment. In column 2, the OLS regression controls for city, sector, year, capital stock, value-added, export value, import value, R&D expenditure, share of revenue from services, and trade. In column 4, the firm fixed effect model also controls for business and trade statistics, except city and sector that are fixed for firms. The rest of the tables control for the same firm characteristics. In the OLS model with a full set of controls, the coefficient of the ICT Index is 1.5, suggesting that employment increases by 1.5% within the firms when their ICT index moves from 0 to 1. In the firm fixed effects regressions, the coefficient drops to 0.33%.

Table 4 presents OLS and fixed effects results where the dependent variable is log of wages per employee in each firm. A higher ICT Index is also associated with higher average wages. Again, the magnitudes of the coefficients are smaller when firm heterogeneity is controlled for.

3.2 ICT employment vs. Non-ICT employment

The positive effects of ICTs on employment can be due to two mechanisms: an increase in ICT employees with the adoption of new technologies, and overall expansion in the firm. Next, I analyze the effects of ICTs on different types of labor to obtain evidence of the presence of these mechanisms. There are two categories listed in the data set for ICT-related employment: ICT experts and ICT users. ICT experts are the employees who maintain the networks and databases. ICT users are the employees who use the ICT systems and applications.

Table 5 presents the ICT index coefficients on ICT employment (ICT experts and users) and non-ICT employment in the firm (employment other than ICT experts and ICT users) from fixed effects regressions. The coefficient of the ICT index on log of ICT employment is 0.9 and significant. The coefficient on log of non-ICT employment is insignificant. This implies that the positive relationship between ICTs and overall employment is due to ICT-related employment and not the remaining employment in the firm fixed effects regressions.

When I repeat the OLS and fixed effects regressions using advanced Internet use dummy instead of the ICT Index, I obtain slightly higher coefficients on log of employment and ICT employment. Table 6 reports the firm fixed effects regression results where the independent variable for ICTs is advanced Internet use. These results control for basic Internet (non-broadband Internet connections) and the presence of computers, as well as other firm characteristics, in order to ensure the relationship between advanced Internet use and employment is not due to the presence of computers or Internet.

Using both the ICT Index and advanced Internet use measures, there is significant positive relationship between ICTs and ICT employment and non-significant relationship between ICTs and non-ICT employment. The positive effects of ICTs on ICT employment is not surprising; the firms that adopt and use these technologies more heavily need labor in order to deploy, use, and maintain them. The two year panel data might be too short for the scale effects to take place. Increases in productivity and production would lead to increases in employment, but these changes are hard to observe over a year.

3.3 Lags of ICT measures in four year panel

Next, I use the four year panel data (2007-2010) in order to estimate ICT effects on labor over a longer time period. I lack the control variables for 2009 and 2010, and I only include the firm's initial values of control variables. Table 7 presents the results where log ICT employment and log non-ICT employment are regressed on the first and second lags of ICT index and advanced Internet use. The first and second lags of ICT variables are significant for the fixed regressions where the dependent variable is log ICT employment. The effects of ICTs on ICT employment diminish over time. On the other hand, the effects on non-ICT employment are significant using the lagged ICT variables, and the magnitude increases over time. These results support that ICT investments lead to an increase in ICT workers for a while, and that this effect decreases over time. The initial setup and use of these technologies might require more labor. ICT investments can only increase other types of employment after a couple years, since this mechanism is indirect. The increases in production and geographical market do not happen immediately, so we observe the effects of ICT investments on non-ICT workers only using the lagged ICT measures.

3.4 Generalized Propensity Score Matching of Firms

I use the generalized propensity score (GPS) matching method to predict the ICT Index based on observable characteristics such as profits, production, capital, ownership, sector, location, revenue, investment, loss, number of branches, and other business statistics. The idea behind this method is to match the firms that are the most similar along several characteristics that determine ICT index level and employment level. This method eliminates the bias associated with differences in observable covariates.

The first step is to estimate the conditional density of the treatment given the covariates.

$$r(t, x) = f_{T|X}(t|x) \tag{2}$$

The generalized propensity score is $R = r(T|X)$. The next step is to estimate the conditional expectation of the outcome(employment) as a function of the treatment level T (ICT Index) and GPS level R (Estimated ICT Index),

$$\beta(t, r) = E[Y|T = t, R = r] \tag{3}$$

To estimate the dose-response function at a particular level of treatment, I average this conditional expectation over the GPS at a particular level of treatment,

$$\mu(t) = E[\beta(t, r(t, x))] \tag{4}$$

To see whether this specification of the propensity score is adequate, I investigate how it affects the balancing of covariates. To test for the balancing of covariates, I divide the ICT Index into 3 ranges and test whether the adjusted means in each group is different from the other 2 groups. Covariates are not balanced when unadjusted, meaning the firms that have different levels of ICT index differ in the covariates. These observable covariates are balanced when adjusted for GPS. The means of covariates are not statistically different from each other among the 3 ranges of ICT Index levels. This indicates that the GPS method is able to correct for any observable heterogeneity between the firms.

Figure 1 presents the dose-response function estimated by the generalized propensity score method. Here, the ICT Index levels range from 0 to 100, indicating the percentage of ICT adoption and use intensity. The effect of the ICT Index increases up to a level of 80 percent, where the effect is maximized with a 5% increase in employment level. Then the coefficient remains around 5% between ICT Index levels of 80 to 100 percent.

Figure 2 presents the dose-response function estimates of the effects of the ICT Index on wages. The ICT Index causes an increase of between 9-10% in wages, and this relationship increases linearly. I also estimate a similar function for ICT adoption, use, and skill indices separately. Figure 3 is the dose-response function of ICT use index (a subsection of overall ICT Index), which looks similar to the ICT Index dose-response function. The effect is maximized around 80 percent, followed by a slight decrease.

Next, I divide total employment into ICT-related and non-ICT employment. Figure 3 presents the dose-response function estimates of the effects of the ICT index on ICT employment. The effect of the ICT Index on ICT employment ranges is around 4 percent at the lower level of the ICT Index, and this effect goes up to 5.5 percent at the top levels of the ICT Index. The second part of Figure 3 presents the treatment effect function which shows the effects on differences between current ICT employment and ICT employment in the previous period. Figure 4 presents the dose response function and the treatment effect function of the ICT index on log of non-ICT employment. The effect on non-ICT employment goes up to 1 percent for firms that have a 100 percent ICT index.

4 Instrumental Variables

I use instrumental variables in order to predict firm level advanced Internet use. After using them for all the firms, I separate the firms by industries, since it is unlikely that these instruments are valid for all type of firms.

First, I use 5 different instruments for firm level advanced Internet use for all firms:

1. The city level ICT adoption index of all firms minus the firm in each observation (an index between 0 and 1)

2. Whether the firm has an outsourcing opportunity of ICT tasks at a branch of the firm located in a different country

3. The city level broadband penetration rate (between 0 and 100 percent)

4. Whether the firm is located in one of the cities where the first Internet connection was available in Turkey in 1994

5. Whether the firm is located in a city that has fiber optic Internet technology.

Table 7 presents the instrumental variable estimation results. Here, I use the two year panel that includes full control variables. The first stage regressions all have high explanatory power and significant coefficients of instruments on advanced Internet use dummy. The second stage regressions are presented for three dependent variables. The results are significant for ICT employment and average wages per employee. The coefficients on non-ICT employment are not significant in the IV estimation. The standard errors are corrected for the panel observations and for heteroskedasticity.

4.1 Specification Testing of Instruments by Industries

Next, I test for the validity of the instruments by using different combinations of instruments for different sectors. City level Internet deployment variables are not good instruments for industries where firm location is endogenous. On the other hand, they can be good instruments for sectors that are present in all cities. Firm level outsourcing at a foreign branch variable is not a good instrument for industries in which it is uncommon to have a branch in a different country. I use 4 different groups to test this:

1. Manufacturing: These firms choose the city location, and it is likely that they have a foreign branch.

2. Services: These are usually firms of local services that are present in every city, and it is not likely that they have a foreign branch.

3. Wholesale: This is a big very industry in Turkey, as there are not many large supermarkets/stores. These firms distribute to all the neighborhood stores. These firms are

located in all cities with no foreign branch.

4. Exporting Firms : These are the firms that do exporting regardless of their sector. These firms usually have foreign branches, and their location is endogenous.

I used different combination of instruments and sectors for specification tests. I used an over-identifying restrictions test, an IV redundancy test, and an orthogonality test in order to decide whether a set of instruments is valid. The results coincide with the intuition that not all the instruments are valid for all industries. The city level instruments work for the sectors that have to be present in every city. The outsourcing instrument does not work for these sectors since they usually do not have foreign branches. On the other hand, the outsourcing instrument works well for the manufacturing sector and exporting firms. When the city level instruments are added, the set of instruments become invalid since these firms choose their location. Table 8 summarizes the sets of IVs that are valid based on the above tests.

Table 9 presents the IV estimation results with the valid IV specification for each sector. All combinations of the instruments presented have strong first stage results, with high F-statistics and no weak and under identification based on tests, with an exception of the services sector.

4.2 More detailed classifications in manufacturing and services sectors

There is significant within-sector heterogeneity. I further divide the manufacturing and services industries into smaller groups in order to remove some of the relevant heterogeneity within the sectors. I classify the manufacturing firms as high-tech and low-tech, and the services firms as knowledge-intensive and less knowledge-intensive based on OECD Nace Rev 1.1 industry codes.

Table 10 shows the valid instruments for different sector classifications based on the specification tests. Table 11 presents the instrument variable estimation results using the valid set of instruments for each industry classification. There are further differences in between high-tech manufacturing and low-tech manufacturing firms, and especially between knowledge-intensive and less knowledge-intensive services firms. Location instruments work better for low-tech manufacturing firms and less-knowledge intensive services firms.

5 Robustness Checks

5.1 Relationship of ICTs with past employment levels

I use past variables of business and trade statistics of the firms taken between 2003 and 2006 (the current data set is for 2007 and 2008) for falsification tests. In order to see whether the relationship between advanced Internet use and employment is due to some other unobservable factors, I regress current advanced Internet use levels on past employment levels. In column 1 of table 8, the dependent variable is advanced Internet use, and in column 2 the dependent variable is ICT index. Past employment levels do not predict current ICT levels. This evidence supports the causal interpretation from ICTs to employment.

5.2 Effects on other labor variables

If the relationship between advanced Internet use and ICT employment is due to some unobservable factors, we might expect to see an accidental significant relationship with other employment variables as well. Table 8 presents the regressions where dependent variables are R&D employment, part-time employment, and hours worked. There are no significant effects of advanced Internet use on R&D employment, part-time employment, and hours worked.

5.3 Whether the firm hired an ICT employee

The data set includes information on whether the firm hired one or more ICT employee(s) (ICT experts and ICT users) within the last year. There is no information on how many people they have hired for these jobs. Table 9 presents probit regressions of dummy variables for whether the firm hired ICT experts and ICT users on advanced Internet use. These probit regressions control for all the firm characteristics. There are also questions about types of problems the firm has encountered in the process of hiring ICT experts. These problems are: absence of enough candidates, absence of educated candidates, absence of experienced candidates, and high wage demands of candidates. Not all the firms answered this question, so the sample size drops in the last column. With additional controls for these factors, the firms that use advanced Internet applications are 60 percent more likely to hire a new ICT expert. This also supports the mechanism of firms hiring new ICT workers to maintain the technology.

6 Conclusion

This paper analyzes how ICT adoption and use affect employment and wages within firms. I use a confidential data set provided by the provided by the Turkish Statistical Institute and the Government Planning Organization. Detailed surveys were conducted from 2007-2010 on how much and for what purposes ICTs and the Internet are used by individuals and firms. I summarize several ICT adoption and use indicators into an ICT Index to measure how intensely these technologies are utilized within each firm. I also analyze these ICT indicators separately.

In addition to OLS and fixed effects models, I use the generalized propensity score matching method in order to control for the observed heterogeneity between firms. I find a significant positive association between ICT use intensity, employment and wages within the firms.

The positive effects of ICTs on employment can be due to two mechanisms: the increase in ICT employees with the adoption of new technologies, and overall expansion in the firm. I test for the presence of these mechanisms by dividing the total employment into ICT and non-ICT employment. ICT use increases ICT employment especially in the short term, and this effect seems to diminish over time. On the other hand, ICT use does not significantly change non-ICT employment in the 2 year fixed effects models, but there are significant and increasing effects in the 4 year fixed effects models. These results suggest that ICT investments lead to firm expansion not immediately but over a longer period. Instrumental variable estimations and falsification tests supports the causal direction from ICT investments to employment.

References

[1] Measuring the information society: The ict development index. *International Telecommunications Union Report* (2009).

[2] Acemoglu, D. Why do new technologies complement skills? directed technical change and wage inequality. *The Quarterly Journal of Economics, 113*, 4 (Nov 1998), 1055–1089.

[3] Acemoglu, D. Technical change, inequality, and the labor market. *Journal of Economic Literature* (March 2002), 7–72.

[4] Autor, D. Wiring the labor market. *Journal of Economic Perspectives 15*, 1 (2001), 25–40.

[5] Autor, D., Katz, F., and Kruger, B. Computing inequality: Have computers changed the labor market? *The Quarterly Journal of Economics* (November 1998), 1169–1213.

[6] Autor, D., Levy, F., and Murane, R. The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics 118*, 4 (November 2003).

[7] Forman, C., Goldfarb, A., and Greenstein, S. The internet and wages: A puzzle. *forthcoming in American Economic Review* (2011).

[8] Imai, K., and Van Dyke, D. Causal inference with general treatment regimes: Generalizing the propensity score. *Journal of the American Statistical Association 99*, 467 (2004), 854–866.

[9] Imbens, G., and Hirano, K. *Applied Bayesian Modeling and Causal Inference from Incomplete-Data Perspectives.* New York: Wiley, 2004, ch. The Propensity Score with Continuous Treatments.

[10] Michaels, G., Natraj, A., and Van Reenen, J. Has ict polarized skill demand? evidence from eleven countries over 25 years. *NBER Working Paper*, 16138 (June 2010).

[11] Rosenbaum, P., and Rubin, D. The central role of the propensity score in observational studies for causal effects. *Biometrika 70*, 1 (1983), 41–55.

Table 1: Summary Statistics

Employment, Business and Trade Statistics

	Mean	Standard Deviation
Employment	459.24	1424.62
R&D Employment	4.58	40.97
Female Employees	110.75	346.25
Male Employees	348.14	1193.12
Weekly hours worked	44.95	2.71
Total Wages (in million TL)	1.02	0.51
Total Payment (in million TL)	12.42	56.45
Total Cost (in million TL)	135	768
Total Revenue (in million TL)	158	850
Profits (in million TL)	8.63	80.8
Loss (in million TL)	2.71	25.9
Investment (in million TL)	5.04	11.7
Value Added (in million TL)	28.1	159
Capital (in million TL)	4.73	3.64
R&D Expenditures (in million TL)	0.15	2.87
Patent Value (in million TL)	0.34	4.05
Export Value (in million TL)	29.2	414
Import Value(in million TL)	12.9	146

Table 2: ICT Summary Statistics

ICT Adoption and Use Statistics

	Mean	Standard Deviation
ICT Index	0.6142	0.1924
Advanced Internet Use	0.3682	0.4823
Presence of computers	0.9657	0.1819
Presence of broadband	0.8364	0.2439
Employees using computers	124.12	470.25
Employees using internet	94.682	378.43
Enterprise Resource Planning	0.2850	0.4514
Customer Relationship Management	0.1994	0.3996
Supply Chain Management	0.1428	0.3499
Purchasing	0.4361	0.4959
Education	0.4266	0.4946
Webpage Customer Support	0.2749	0.3472
Extranet	0.1745	0.2763
E-commerce	0.1232	03754
E-government	0.6931	0.4613
E-banking	0.8645	0.3422
E-commerce	0.2323	0.1735
E-government	0.7993	0.4005
Has a webpage	0.7476	0.4344
Marketing	0.6224	0.4849
Inventory	0.5828	0.4932
Training	0.1662	0.3723
Payments	0.4709	0.4999
Security software use (among e-commerce firms)	0.9942	0.0758

Table 3: OLS and Fixed Effects

Dependent Variable: Log employment

	OLS	OLS full controls	Fixed effects	Fixed effects full controls
ICT Index	1.5029***	1.4626***	0.3128**	0.3591**
	(0.0840)	(0.0820)	(0.1539)	(0.1539)
Industry Fixed Effects	Yes	Yes	No	No
City Fixed Effect	Yes	Yes	No	No
Firm Fixed Effects	No	No	Yes	Yes
Observations	5570	5570	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: OLS and Fixed Effects

Dependent Variable: Log wages

	OLS	OLS full controls	FE	FE full contols
ICT Index	0.5797***	0.5788***	0.3353**	0.2628*
	(0.0667)	(0.0667)	(0.1504)	(0.1492)
Industry Fixed Effects	Yes	Yes	No	No
City Fixed Effect	Yes	Yes	No	No
Firm Fixed Effects	No	No	Yes	Yes
Observations	5570	5570	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: ICT employment and Non-ICT employment

	ICT employment	Non-ICT employment
ICT Index	0.9238***	0.2178
	(0.2846)	(0.1427)
Firm Fixed Effects	Yes	Yes
Full Controls	Yes	Yes
Observations	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Advanced Internet Use

	Log Employment	Log ICT Employment	Log Non-ICT Employment	Wages
Advanced Internet Use	0.5136***	1.0572***	0.0971	0.4981***
	(0.0640)	(0.0946)	(0.0719)	(0.0221)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Full Controls	Yes	Yes	Yes	Yes
Observations	5570	5570	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Four Year Panel: 2007-2010

Dependent Var: Log ICT Employment

	(1)	(2)	(3)	(4)
Lag 1 ICT Index	1.2542***			
	(0.1440)			
Lag 1 Advanced Internet Use		0.5163***		
		(0.0789)		
Lag 2 ICT Index			0.8326***	
			(0.2428)	
Lag 2 Advanced Internet Use				0.1344**
				(0.0517)

Dependent Var: Log Non-ICT Employment

	(1)	(2)	(3)	(4)
Lag 1 ICT Index	0.1153			
	(0.3034)			
Lag 1 Advanced Internet Use		0.1692**		
		(0.0860)		
Lag 2 ICT Index			0.2524*	
			(0.1362)	
Lag 2 Advanced Internet Use				0.3167*
				(0.1793)
Fixed Effects	Yes	Yes	Yes	Yes
Full Controls	No	No	No	No
Observations	1362	1362	908	908

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Instrumental Variable Estimation

First Stage Regressions					
Dependent Variable: Advanced Internet Use					
Instruments	city ict adoption	ict at foreign branch	city broadband penetration	first internet	fiber optic access
city ict adoption	3.4121***				
	(0.1376)				
ict at foreign branch		0.3350***			
		(0.0115)			
city broadband penetration			0.0024***		
			(0.0001)		
first internet access				0.0361***	
				(0.0039)	
fiber optic access					0.0365***
					(0.0041)
F-statistics	72.07	86.14	142.30	131.27	131.12

Second Stage Regressions					
Instruments	city ict adoption	foreign branch	city broadband penetration	first internet	fiber
Dependent Variable: Log ICT Employment					
Advanced Internet Use	0.1204***	0.78341***	1.5670***	2.3252***	2.2663***
	(0.0351)	(0.0500)	(0.0921)	(0.2559)	(0.2549)
Dependent Variable: Log Wages					
Advanced Internet Use	1.2792**	1.5277***	1.6685***	3.5229***	3.0256***
	(0.5276)	(0.3719)	(0.3555)	(0.9898)	(0.7634)
Dependent Variable: Log Non-ICT Employment					
Advanced Internet Use	-0.0611	-0.0313	0.1701	0.2961	0.2302
	(0.0701)	(0.0715)	(0.1077)	(0.2080)	(0.1921)
Observations	5570	5570	5570	5570	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Validity of IVs for different sectors

	Manufacturing	Services	Wholesale	Exporting
City level firm ICT adoption index	×	✓	✓	×
Outsourcing of ICTs at a foreign	✓	×	×	✓
City broadband penetration rate	✓	✓	✓	✓
City with a first internet 1994	×	✓	×	×
City with fiber	×	✓	✓	×

Table 10: IVs for different sectors

First Stage Regressions: Dependent Variable is Advanced Internet Use

	Manufacturing	Services	Wholesale	Exporting
city ict adoption		0.3855**	0.3965**	
		(0.2098)	(0.1971)	
outsource at foreign branch	0.2611***			0.1760***
	(0.0394)			(0.0383)
city broadband penetration	0.0011**	0.0014**	0.0010**	0.0015**
	(0.0006)	(0.0007)	(0 .0006)	(0.0008)
first internet access		0.0587*		
		(0.0368)		
fiber optic access		0.0189***	0.0315***	
		(0.0077)	(0.0124)	
Observations	2703	1040	2060	1702
F-statistics	25.94	10.74	22.84	26.90

Second Stage Regressions

Dependent Variable: Log ICT Employment

	Manufacturing	Services	Wholesale	Exporting
Advanced Internet Use	1.4496***	3.1850**	1.7962***	0.9886**
	(0.2738)	(1.5066)	(0.3610)	(0.4510)
Dependent Variable: Log Wages				
Advanced Internet Use	1.2598***	2.9476**	1.6226***	1.3308***
	(0.5138)	(1.4567)	(0.3377)	(0.4021)
Dependent Variable: Log Non-ICT Employment				
Advanced Internet Use	0.3178	0.4625	-0.0438	-0.0359
	(0.2829)	(0.5085)	(0.3536)	(0.3250)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Validity of IVs for manufacturing and services sectors

	High-tech manufacturing	Low-tech manufacturing	Knowledge-int services	Less knowledge-int services
City level firm ICT adoption index	×	×	×	✓
Outsourcing of ICTs at a foreign	✓	✓	✓	×
City broadband penetration rate	✓	✓	✓	✓
City with a first internet 1994	×	×	×	✓
City with fiber	×	✓	×	✓

Table 12: IVs for manufacturing and services

First Stage Regressions: Dependent Variable is Advanced Internet Use

	High-tech manufacture	Low-tech manufacture	Knowledge-intensive services	Less knowledge-intensive services
city ict adoption				1.5330***
				(0.5783)
outsource at foreign branch	0.1757***	0.3428***	0.3588***	
	(0.0681)	(0.0860)	(.0718)	
city broadband penetration	0.0099**	0.0021**	0.0019*	0.0038**
	(0.0039)	(0.0010)	(0.0008)	(0.0017)
first internet access				0.0974*
				(0.0578)
fiber optic access		0.1476**		0 .1763**
		(0.0737)		(0.0737)
Observations	538	1116	336	704
F-statistics	12.34	15.89	8.52	19.17

Second Stage Regressions

Dependent Variable: Log ICT Employment

	High-tech manufacture	Low-tech manufacture	Knowledge-intensive services	Less knowledge-intensive services
Advanced Internet Use	2.5190***	1.1891***	0.9741**	1.6027***
	(0.9175)	(0.3706)	(0.4625)	(0.3730)
Dependent Variable: Log Wages				
Advanced Internet Use	1.3272***	1.0593***	1.4660***	1.6990***
	(0.5044)	(0.3656)	(0.4810)	(0.3950)
Dependent Variable: Log Non-ICT Employment				
Advanced Internet Use	1.8776**	0.5435	0.3810	0.5807
	(0.7849)	(0.5039)	(0.5549)	(0.4127)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Past Employment

	Advanced Internet Use	ICT Index
Log 2003 Employment	0.0114	-0.0041
	(0.0122)	(0.0034)
Log 2004 Employment	0.0041	0.0036
	(0.0109)	(0.0032)
Log 2005 Employment	0.0083	0.0043
	(0.0098)	(0.0035)
Log 2006 Employment	-0.0027	0.0025
	(0.0098)	(0.0030)
Firm Fixed Effects	Yes	Yes
Observations	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14: Other Labor Variables

	Log R&D Employment	Log Part-Time Employment	Log Hours Worked
Advanced Internet Use	-0.0283	-0.0003	-0.0007
	(0.0448)	(0.0606)	(0.0035)
ICT_Index	0.1838	0.0367	0.0103
	(0.2178)	(0.2412)	(0.0140)
Firm Fixed Effects	Yes	Yes	Yes
Observations	5570	5570	5570

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15: Probit for ICT hire

	Hired ICT User	Hired ICT Expert	Hired ICT Expert	Hired ICT Expert
Advanced Internet Use	0.7143***	0.7428***	0.7175***	0.5907***
	(0.0461)	(0.0410)	(0.0423)	(0.1675)
Had a problem hiring ICT worker			-0.0429	
			(0.0921)	
Not enough number of candidates				-0.1839*
				(0.1054)
Not enough educated candidates				-0.1330
				(0.1905)
Not enough experienced candidates				0.1199
				(0.2246)
High wage demand of candidates				-0.0727
				(0.1635)
Industry Fixed Effects	Yes	Yes	YesYes	
City Fixed Effects	Yes	Yes	Yes	Yes
Full Controls	Yes	Yes	Yes	Yes
Observations	5570	5570	5532	1133

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1: Generalized Propensity Score: Dependent Var is Log of Employment

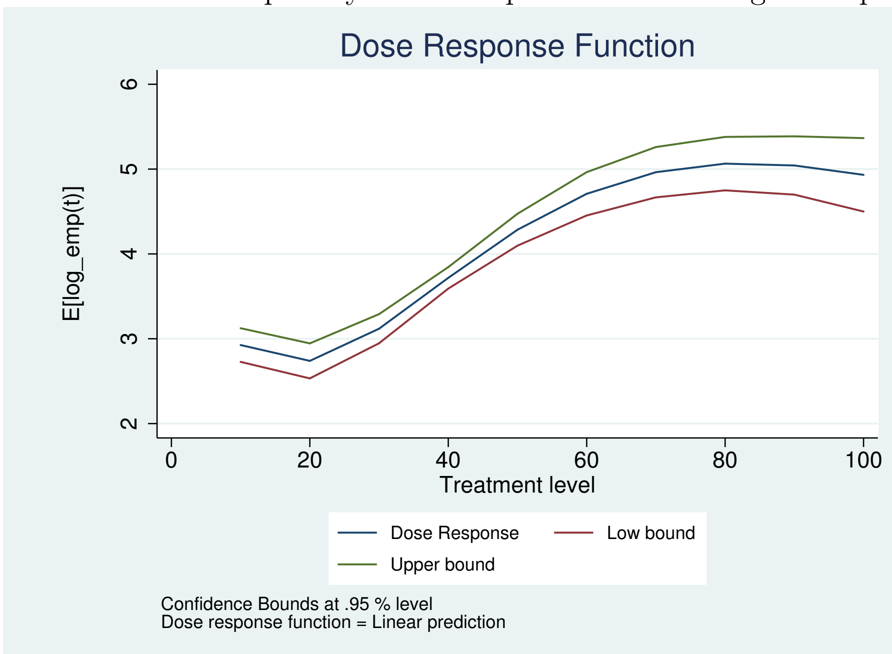

Figure 2: Generalized Propensity Score: Dependent Var is Log of Wages

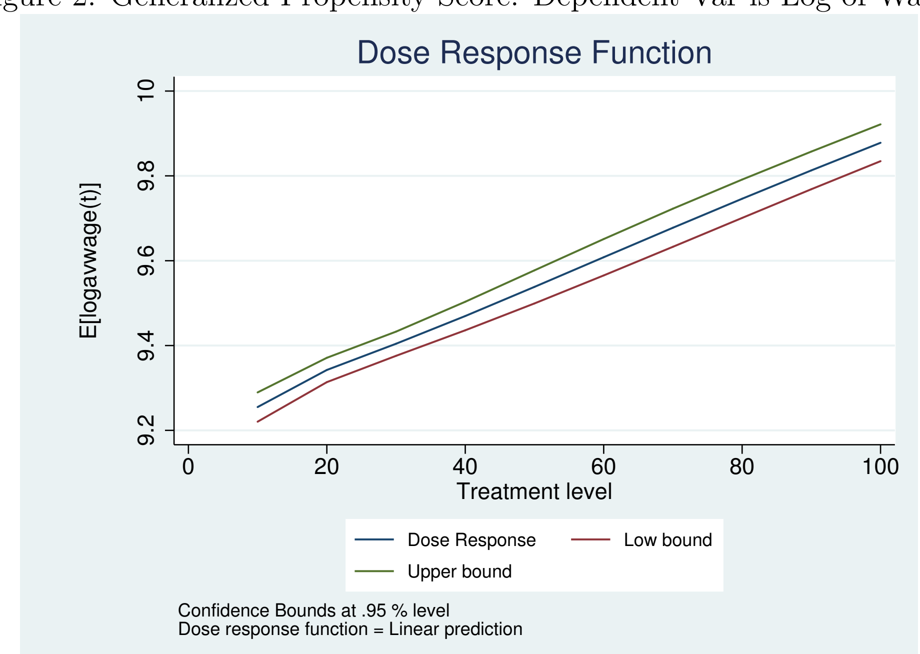

Figure 3: Generalized Propensity Score: Dependent Var is Log of ICT Employment

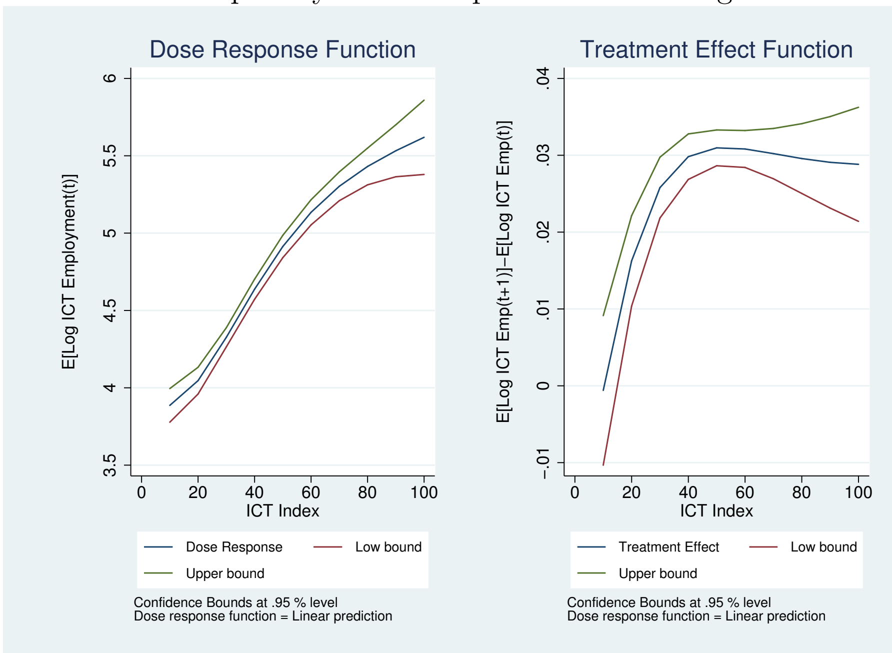

Figure 4: Generalized Propensity Score: Dependent Var is Log of Non-ICT Employment