P E R S P E C T I V E S

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES

Fabricating a Broadband Crisis? More Evidence on the Misleading Inferences from OECD Rankings

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Introduction

The late Senator Daniel Patrick Moynihan was famous for observing that "Everyone is entitled to his own opinion, but not his own facts." If only current policymakers heeded such wisdom when it comes to citing international rankings of broadband penetration as a justification for aggressive public policy interventions.

Indeed, there are many policymakers (and policy peddlers) in this country—including current Federal Communications Commission Chairman Julius Genachowski—that (apparently) believe that the U.S. is "falling behind" in broadband adoption and, therefore, aggressive regulatory intervention is required to remove this blight from our national reputation.[1] This belief is derived largely from data on broadband connections collected and reported by the *Organization for Economic and Cooperative Development* ("OECD").[2] Every six months, the OECD releases its data on *per-capita* broadband connections for its thirty member countries, and these countries are listed in descending order based on per-capita connections. This practice presents the data in terms of a rank, and that rank has (regrettably) become the standard by which to judge the successes and failures of broadband policy in this and other countries.

In numerous papers, I have debunked the idea that the OECD rankings can be used as a measure of relative performance.[3] One reason per-capita connections are an invalid measure of broadband penetration is that each country has its own unique maximum value for the measure (all share zero as the minimum). In other words, if in every OECD country every household and business had broadband (the "Broadband Nirvana"), you would still observe large differences in their per-capita subscription rates. As such, each country's per-capita subscription rate has its own scale, and consequently, comparing per-capita connections presents the quintessential apples-to-oranges problem. Moreover, in this Nirvana, the U.S. ranks 20th, five spots below its present position. Consequently, if near ubiquitous adoption across the OECD is the expected outcome (even for just the more developed economies), then the U.S. will always have a middling rank.

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Also, as I have argued before, when interpreting rank it is essential to first establish an *expectation of rank*. Without a meaningful expectation, it is impossible to say whether our observed rank is too high, too low, or just right. In PERSPECTIVE NO. 08-03, *Broadband Expectations and the Convergence of Ranks,* I provide compelling evidence that the U.S. is meeting expectations on broadband connections per capita (a rank close

to 15th is expected even with good performance). That is, there is no "broadband crisis."[4]

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Importantly, this "meeting expectations" outcome does not imply there is no role for public policy to engage in targeted efforts to expand coverage and adoption. The Phoenix Center has supported such actions. But keep in mind that such policies are unlikely to change our per-capita rank. For certain, the $4.3 Billion spent by the National Telecommunications and Information Administration (NTIA) as directed by the American Recovery and Reinvestment Act will barely dent per-capita subscription rates as reported by the OECD, as the agency's efforts are targeted mostly to low population markets and, more recently, to public-access facilities often uncounted by the OECD. If OECD ranking is the standard of success, then the NTIA's multi-billion dollar effort to expand availability and adoption is a waste of time and money. Of course, many feel the NTIA's efforts are worthwhile and that its billions in support have been and will be wisely spent. Nevertheless, if OECD ranks are the performance metric, then the NTIA's efforts will prove a failure.

Despite the obvious and demonstrated defects in the OECD rankings, and the lack of any rebuttal to our complaints, the use of the rankings continue, mainly because the data have proven a particularly powerful tool for fabricating a "broadband crisis" to justify an increasingly aggressive regulatory agenda. Given that the use of the OECD ranking continues largely unabated despite the facts, some additional evidence on its defects seems called for. In this PERSPECTIVE, I aim to simplify the analysis by sharing a few examples which undermine the legitimacy of per-capita measures of adoption. To do so, I rely on the OECD's own data for household adoption and per-capita rankings, thereby preventing any claim of data manipulation or selectivity. Hopefully, this additional analysis will encourage policymakers to employ more meaningful data in the future, though I have little hope that those promoting a broadband crisis will waver from prior practice. By analytical standards, the Broadband Nirvana was a death blow to rankings. Even so, some refuse to let the facts get in the way of a good story.[5]

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The Defect in the OECD Rankings

Every six months, the OECD releases its broadband rankings.[6] This rank is based on per-capita connection counts, which is the sum of household connections and business connections divided by population. The manner in which countries count such connections may vary widely by country, but this fact is largely ignored. The OECD tries to place some restrictions on the data collection such as minimum speeds, but exact equivalence of what is counted is impossible to obtain.

The formula for broadband adoption used by the OECD for country i at time t is:

$$A_{i,t}^{OECD} = \frac{h_{i,t} + b_{i,t}}{N_{i,t}} \qquad (1)$$

where $h_{i,t}$ is fixed-line household connections in country i at time t, $b_{i,t}$ is fixed-line business connections (of the sort counted in the country) in country i at time t, and $N_{i,t}$ is the population in country i at time t. If there are 100 households connections, 20 business connections, and 300 persons, then the per-capita connection rate is 0.40 [=(100+20)/300].

A major defect in this measure of relative broadband subscription is apparent at first glance. The denominator of Equation (1) is population rather than a measure of market potential. Households and businesses buy connections, and these connections are shared among many users. Thus, if the country has 100% adoption of both households and businesses, then the ratio A^{OECD} is not 1.0 (typically well below it). In fact, it could be just about anything, given that population bears no particular relationship to the market potential of connections by households and businesses.[7] For households, household size can be used to convert population to a meaningful measure of potential, but there is no established or consistent conversion between potential business connections and population.

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Plainly, Equation (1) is not the statistic of interest. For policy purposes, the metric of greater interest is the percent of households with broadband connections, or

$$A_{i,t}^{H} = \frac{h_{i,t}}{H_{i,t}} \qquad (2)$$

where $H_{i,t}$ is the total number of households (or other geographically relevant area) in country i at time t. Business connectivity is rarely an issue (save in rural markets, but the total connection count in such markets is very small on a national scale), but we can define business penetration (of the sort counted by the OECD) as

$$A_{i,t}^{B} = \frac{b_{i,t}}{B_{i,t}} \qquad (3)$$

where $B_{i,t}$ is the total number of households (or other geographically relevant area) in country i at time t.[8] The two could be combined to render

$$A_{i,t}^{HB} = \frac{h_{i,t} + b_{i,t}}{H_{i,t} + B_{i,t}}, \qquad (4)$$

but doing so is not very informative, since the calculation presumes a business and household connection have equal weight. In policy debates, the focus is mostly on household adoption.

Household Adoption and Rankings

The benefit of Equations (2)-(4) is that the value of the adoption index A^H and A^B lies on the unit interval for all countries. That is, for every country the minimum value is 0.0 and the maximum value is 1.0. As a result, these values can be sensibly compared across countries. As discussed above, per-capita rates are not identically scaled in that the maximum value for each country is not identical across the OECD, so by definition *per-capita* subscriptions cannot be meaningfully compared.

In most cases, the debate over rankings starts with the per-capita data in Equation (1) and then jumps to household adoption as shown in Equation (2).[9] The linkage between per-capita connections and household penetration presents

an opportunity to assess the validity of the per-capita rankings in terms of actual adoption.

The OECD also provides some limited data on household penetration (or A^H).[10] The quality of this data is unknown.[11] OECD officials have encouraged the use of their household adoption data as an alternative to its per-capita rankings, though there are some admitted shortcomings to the data.[12] Using this data, we can evaluate the claim that a higher *per-capita connection rate* reliably and consistently implies a higher *adoption* rate. If the relationship does not hold uniformly, then the per-capita data is, without question, an invalid measure of performance of broadband adoption of a country.

The latest data for which the OECD reports household adoption rates of broadband for nearly all members is 2007. As such, I will use this data. My findings are unchanged by using the latest available data, though there are fewer countries with this data.

Korea has a household adoption rate 20 percentage points higher than the Netherlands, yet Korea ranks lower in per-capita terms. Plainly, the per-capita measure fails to provide an accurate assessment of relative adoption.

According to the OECD data, Korea has (by far) the highest household adoption rate of OECD countries at 94.1% in 2007. That is, 94.1% of Korean households have broadband in the home. By implication of its adoption rate, Korea should rank first in the per-capita rankings if the per-capita approach sheds meaningful light on relative adoption. However, in 2007, Korea ranked 5th. Four countries outranked Korea even though Korea is the clear leader in fixed-broadband adoption. In first place for the per-capita rankings is the Netherlands, even though the household adoption rate in that country is only 73.8%. Korea has a household adoption rate 20 percentage points higher than the Netherlands, yet Korea ranks lower in per-capita terms. Plainly, the per-capita measure fails to provide an accurate assessment of relative adoption. This defect in the per-capita metric must be explained and resolved for the per-capita connection counts to have any policy significance as a measure of relative performance.

The household adoption rate in Greece in 2007 was a meager 7.5%. Household adoption in Poland, the Czech Republic, and the Slovak Republic was four times that rate (29.6%, 28.1%, and 26.5%, respectively). The OECD's per capita rankings, however, place Greece above all three countries!

Another useful example is to compare Canada and Switzerland. According to OECD data, the household adoption rate in Canada was 64.2% in 2007, which is slightly above that of Switzerland at 63% in that same year. On per-capita terms, however, Switzerland ranks 3rd to Canada's 11th position—an 8 spot difference. Those that rely on the rankings data would conclude that Canada has much to learn from Switzerland, but we know this is not true. Canada has slightly higher broadband adoption than the higher ranking Switzerland. Again, the per-capita approach provides misleading inferences.

A comparison of Austria and France further exposes the defect of per-capita rankings. Household adoption in Austria in 2007 was 46.1%, a few points higher than the 42.9% adoption rate in France. Yet, in per-capita

terms, France's 9th place rank was well above Austria's 19th place rank—a huge 10 spot difference. Again, the OECD ranking data flunks the consistency test.

A particularly potent comparison considers Greece, Poland, and the Czech and Slovak Republics. The household adoption rate in Greece in 2007 was a meager 7.5%. Household adoption in Poland, the Czech Republic, and the Slovak Republic was four times that rate (29.6%, 28.1%, and 26.5%, respectively). The OECD's per capita rankings, however, place Greece above all three countries. The per-capita rankings are plainly unreliable measures of relative performance.

Telephone Data — Same Problem

The fixed line telephone business is far more mature than broadband, and adoption has peaked and is now falling in many countries as mobile and Internet service replace the functionality of plain old telephone services. Like broadband, telephone services are also reported on a per-capita basis, and doing so is subject to the same defects. A few examples illustrate the point.

... consider Belgium and France, with identical household adoption rates of 98%. On a per-capita basis, Belgium ranks 19th (45.35) and France ranks 10th (55.72). This is a large difference in ranks for two countries with identical and very high adoption rates.

To begin, I took data on households with telephone service and main telephone lines per capita from the International Telecommunications Union's ("ITU") *ICT Indicators* database for year 2005.[13] Consider three countries: Australia, New Zealand and Spain. These three are chosen because their household adoption rates for fixed telephone service are all 97%. Certainly, none of these countries is lagging in adoption by any sensible measure, and all have identical adoption rates. The per-capita data tells a radically different story. For these three countries, the per-capita subscription rates are 50.21 for Australia, 42.91 for New Zealand, and 45.58 for Spain. Among OECD countries, the three rank 12th, 22nd, and 18th on per capita adoption. Yet, these three countries have identical and nearly complete adoption. Once more, the per-capita calculations mislead.

Next, consider Belgium and France, with identical household adoption rates of 98%. On a per-capita basis, Belgium ranks 19th (45.35) and France ranks 10th (55.72). This is a large difference in ranks for two countries with identical and very high adoption rates. In the broadband context, Belgium would be a laggard relative to France, despite being identical with regard to adoption. The evidence is overwhelming—the per-capita connection data presents an inaccurate picture of adoption.

Rank is a Low Information Statistic

The data just presented clearly show that per-capita rank is an unreliable and misleading measure of relative performance. On that issue, there is no question. But what about the use of ranks generally as a measure of relative performance? It is easy to demonstrate that rankings, whether used to order good or bad metrics, may make relevant information and present an inaccurate picture of reality. Rankings are a *low information statistic*. To produce a rank, important information is tossed away, and throwing out relevant details is rarely a good idea for good policy making.

Table 1. Ranks are Low Information Statistics

Country	Value	Rank
A	0.901	1
B	0.902	2
C	0.903	3
D	0.500	4

Table 1 summarizes the issue simply. In the table, we have two numbers for four entities (perhaps countries), where the first number is an indicator of performance (with higher values being better). The first three numbers are essentially identical (and statistically likely would be), but the last is well below the others. Country C is not meaningfully behind Country A even though its rank is lower. In the broadband debate, the argument would be that that Country C is a broadband laggard, when in fact that is really not the case.

Armed with nothing other than the rankings, it is expected that Country C will be lumped in with Country D even though there is a large difference between their performances. Rankings hide the reality that A, B, and C are equal, and D is a laggard.

This scenario is not merely a hypothetical. Consider telephone adoption in 2005 for the countries Australia, New Zealand, and Finland. Household adoption for the three countries is 97%, 97%, and 53.8%.[14] Clearly, Finland is well behind the others. On per-capita terms, the countries rank 12th, 22nd, and 23rd. This situation matches the example provided above. The tendency is to lump New Zealand and Finland together based on rank, when in fact New Zealand is identical to Australia and well above Finland.

Table 2. Data for Fixed Telephone

Country	Household Adoption	Per-Capita Rank
Australia	97.0%	12
New Zealand	97.0%	22
Finland	53.8%	23

As shown here, left with only rankings, we cannot say much about performance because we have lost the information of interest, which is the actual level of adoption. As such, rank is not a very useful statistic, save to provide a very high level summary of data to persons with almost no time to really study the facts.

Moreover, rankings evaluated in a vacuum do not permit an assessment of performance. To assess performance, the observed subscription rate or rank must be compared to some reasonable expectation of subscription or rank. Doing well or poorly cannot be determined without a target performance level. Whether or not 15th is too low or too high depends on what you expect the rank of the U.S. to be.

As detailed in PERSPECTIVE No. 09-01, *Normalizing Broadband Statistics*[15] and in our recently-published published paper, *The Broadband Adoption Index: Improving Measurements and Comparisons of Broadband Deployment and Adoption,*[16] for the position in any ranking to matter there must be some expectation of rank so that a meaningful comparison can be made. Ranking 15th may be very good for some countries, yet not so good for others.

To date, the only meaningful attempt to develop an expectation of per-capita subscription rank is found in PERSPECTIVE 09-01.[17] In that analysis, the expected position of the U.S. is about 16th place in a per-capita ranking, which is almost exactly where the U.S. is presently ranked in terms of per-capita broadband subscriptions. In that regard, the U.S. is meeting expectations. Supporting that finding is the analysis in POLICY PAPER NO. 33, *The Broadband Efficiency Index: What Really Drives Broadband Adoption Across the OECD?*[18] In that PAPER, an econometric technique called Stochastic Frontier Analysis was used to evaluate the performance of OECD countries in terms of per-capita subscription rates. The U.S. is found to meet expectations, which is consistent with the findings of PERSPECTIVE 09-01.[19] PERSPECTIVE 09-01 and POLICY PAPER NO. 33 indicate that the only real

outlier in broadband subscription is Greece—a country that is well behind expectations with regard to broadband adoption (by nearly any measure).

Adoption is Not the Right Statistic

Another defect in the use of rankings, and even household adoption, is that comparing adoption rates is not the ideal measure of relative performance. As discussed in detail in earlier research, broadband in an input to the production of economic benefits.[20] Colloquially, I refer to this defect as the "*George and Bobby Got-A-Chicken Theory*." That is, just because celebrity (and Iron Chef) Bobby Flay and myself both have a chicken does not imply that the two resulting dinners will be equally tasty. In the same way, a broadband circuit may have very different payoffs in different countries.

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As numerous studies and the general debate demonstrate, broadband is important because it generates economic benefits, such as increased Gross Domestic Product, employment, reduced depression, and so forth.[21] The description of broadband as a General Purpose Technology ("GPT") forces one to contemplate the effect of broadband connections on economic outcomes rather than simply counting broadband connections. Broadband connectivity converts to economic benefits and this conversion rate will not be identical in every country (or state, region, or city).

We can think about the benefits of broadband using the following formula:[22]

$$Q_{i,j} = \lambda_{i,j} x_{i,j}, \quad (4)$$

where Q_i is some measure of desirable output j in country i, x_i are inputs of production used to make Q_i in country j, and λ_i describes how the various x_i are translated into the Q_i in country j. Theoretically, we can view broadband as just another x_i, or as a GPT that effects the sized of λ_i, thereby altering the marginal productivity of the complementary inputs x_i. If we treat broadband connectivity as an x_{BB}, then an one-unit increase in broadband increases output by $\lambda_{BB,j}$. But note that $\lambda_{BB,j}$ is likely to be specific to each country j.

Direct comparison of broadband adoption across countries presumes that the marginal benefit of a connection in one country is identical to that of another. Such equivalence is unlikely to hold. Labor productivity across countries clearly illustrates this point. According to the OECD, an additional hour of work in the United States creates $45.2 of GDP, whereas an additional hour of labor in the OECD (on average) produces only $34.2 of GDP.[23] A single unit of (the labor) input is worth 30% more in the U.S. than in the OECD broadly, a notable difference.

In many studies of broadband's impact, the relationship of interest in the change in the growth rate of GDP due to some increase in broadband connectivity. Say, just for purposes of illustration, a study finds that an increase in broadband connectivity of a single connection increases per-capita GDP by 0.1% (where this number is arbitrarily chosen and used to keep the math simple).[24] In the U.S., with a per-capita GDP of $46,008, that single line would have a much larger effect than in Turkey with a per-capita GDP of $9,125. The social value (in terms of GDP growth) of an additional broadband connection in the U.S. is worth $46, but only $9 in Turkey (numbers are illustrative only). When contemplating costly social policy to increase

adoption, this difference is significant. In the U.S., we should be willing to spend up to $46 to get that additional line, whereas the less developed country would optimally spend no more than $9. A lower adoption rate in Turkey, therefore, is entirely justified on economic grounds (unless the cost side of the equation is materially different).

A recent study by economists Leonard Waverman and Kaylan DasGupta properly considers broadband as an input of production in an innovation economy, rather than a measure of success itself.[25] As such, the relevance of broadband depends on the presence of complementary inputs to communications technology required to convert connectivity into economic value. In that study, the U.S. ranks 1st among a number of countries, though the value of the Connectivity Index in the U.S. is very similar to a number of other countries in the sample. Another recent study, by the ECONOMIST INTELLIGENCE UNIT (the EIU"), uses a similar "input" mentality for assessing performance and places the U.S. in 3rd place among many advanced economies.[26] The EIU study evaluates each country across 100 separate criteria, including Internet connectivity. Again, the index being ranked is very similar to many other countries at the top of the ranking, so a few rank differences are immaterial.

Conclusion

In this PERSPECTIVE, I have provided, once more, compelling evidence demonstrating the illegitimacy of the OECD's per-capita broadband rankings as a reliable measure of relative performance for broadband adoption. Using the OECD's own data on per-capita adoption and household adoption across the OECD, numerous examples are provided demonstrating the misleading conclusions drawn from the per-capita data. In light of this additional evidence, the use of per-capita rankings for policy formation is again discouraged.

Additionally, I provided a brief discussion in the general weakness of rankings data of any sort, and demonstrate why the whole exercise of comparing adoption rates is not productive. Comparing adoption is not useful absent some measure of the relative productivity of adoption across countries. If policymakers are interested in an analytically legitimate way of assessing broadband performance, then I would point them to our recently published paper, *The Broadband Adoption Index: Improving Measurements and Comparisons of Broadband Deployment and Adoption,* which derives country-specific benchmarks based upon the social value of various Internet access technologies.[27]

NOTES:

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[1] *See, e.g.,* Prepared Remarks of Chairman Julius Genachowski, Federal Communications Commission, *Broadband: Our Enduring Engine for Prosperity and Opportunity,* NARUC Conference, Washington, D.C. (February 16, 2010)(available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296262A1.pdf).

[2] http://www.oecd.org/sti/ict/broadband.

[3] *See, e.g.,* G. S. Ford, T. M. Koutsky, and L. S. Spiwak, *The Frontier of Broadband Adoption Across the OECD: A Comparison of Performance*, INTERNATIONAL ECONOMIC JOURNAL (Forthcoming 2010); G. S. Ford, T. M. Koutsky, and L. S. Spiwak, *The Broadband Performance Index: A Policy-Relevant Method of Comparing Broadband Adoption Among Countries*, PHOENIX CENTER POLICY PAPER NO. 29 (July 2007) (http://www.phoenix-center.org/pcpp/PCPP29Final.pdf); G. S. Ford, T. M. Koutsky, and L. S. Spiwak, *The Broadband Efficiency Index: What Really Drives Broadband Adoption Across the OECD?* PHOENIX CENTER POLICY PAPER NO. 33 (May 2008) (http://www.phoenix-center.org/pcpp/PCPP33Final.pdf); G. S. Ford, *Broadband Expectations and the Convergence of Ranks*, PHOENIX CENTER PERSPECTIVES NO. 08-03 (Second Edition) (October 1, 2008) (http://www.phoenix-center.org/perspectives/Perspective08-03Final.pdf); G. S. Ford, *Normalizing Broadband Connections*, PHOENIX CENTER PERSPECTIVES NO. 09-01 (May 12, 2009) (http://www.phoenix-center.org/perspectives/Perspective09-02Final.pdf); T. R. Beard, G. S. Ford, L. S. Spiwak, and M. L. Stern, *The Broadband Adoption Index: Improving Measurements and Comparisons of Broadband Deployment and Adoption*, 62 FEDERAL COMMUNICATIONS LAW JOURNAL 343 (2010) (available at: http://tinyurl.com/FCLJ-BAI); Video and Presentations from Phoenix Center Workshop: *Understanding Broadband Metrics: The Broadband Adoption Index,* Wednesday, July 15, 2009, National Press Club (http://www.phoenix-center.org/bai.html).

[4] *Convergence of Ranks, Id*.

[5] S. Meinrath and J. Losey, *Denial of Service*, SLATE (April 28, 2010).

[6] The OECD provides a valuable service by making the connection count data available. It is not the data that is the problem, but the translation of the ranks into a policy-relevant performance measurement that is defective.

[7] *See Broadband Performance Index*, *supra* n. 3, at Table 2. The maximum subscription rate in the U.S. is estimated to be 38 connections per 100 persons, whereas in Sweden it is 54.1 connections per 100 persons.

[8] Data on business penetration (not per-capita) is provided by the OECD at http://www.oecd.org/dataoecd/20/62/39574066.xls. For most OECD countries, business adoption is about 80% or better.

[9] *See, e.g.,* Free Press, *America Needs a National Broadband Policy, Not More Excuses*, Press Release (April 23, 2007).

[10] http://www.oecd.org/dataoecd/20/59/39574039.xls.

[11] *Id*. Different definitions of broadband may be used.

[12] G. Lynch, *New Broadband Adoption Index Proposed as Replacement for "Bad" OECD Statistics,* COMMSDAY.COM (Australia)(available at: http://www.commsday.com/commsday/?p=406)(" I (Taylor Reynolds) am the economist who works on broadband statistics here at the OECD and I wanted to quickly write and correct a piece of misinformation which has been promoted in the article. The article gives the impression that the OECD does not collect data on broadband penetration by households when in fact the OECD has been gathering and disseminating this data since 2000.").

[13] http://www.itu.int/ITU-D/ict/statistics.

[14] *Id*.

[15] *Supra* n. 3.

[16] *Supra* n. 3.

[17] *Supra* n. 3.

[18] *Supra* n. 3.

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[19] *Supra* n. 3.

[20] *Broadband Adoption Index*, *supra* n. 3.

[21] For a review of some of the literature on the economic effects of the Internet, *see* L. Holt and M. Jamison, *Broadband and Contributions to Economic Growth: Lessons from the US Experience*, 33 TELECOMMUNICATIONS POLICY 575-581 (2009). Micro-level studies are increasingly prevalent and not restricted to issues narrowly construed as economics. *See, e.g.*, Sherry G. Ford and George S. Ford, *Internet Use and Depression Among the Elderly*, PHOENIX CENTER POLICY PAPER NO. 38 (October 2009) (available at: http://www.phoenix-center.org/pcpp/PCPP38Final.pdf) and the citations therein; S. Greenstein and R. McDevitt, *The Broadband Bonus: Accounting for Broadband Internet's Impact on U.S. GDP*, National Bureau of Economic Research Working Paper No. 14758 (available at: http://www.nber.org/papers/w14758.pdf); R. Gholami, S. Lee, and A. Heshmati, *The Causal Relationship between Information and Communication Technology and Foreign Direct Investment*, Discussion Paper No. 2003/30 (2003); R. Crandall, W. Lehr, and R. Litan, *The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data*, ISSUES IN ECONOMIC POLICY (July 2007)(available at: http://www.brookings.edu/views/papers/crandall/200706litan.pdf); M. Fornefeld, G. Delaunay, and D. Elixmann, *The Impact of Broadband on Growth and Productivity*, European Commission (2008)(available at: http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/final_report-micus-broadband_impact-short.pdf).

[22] E. Helpman, GENERAL PURPOSE TECHNOLOGIES AND ECONOMIC GROWTH (1998), at 57.

[23] http://www.oecd.org/statistics/productivity.

[24] For a study of this type, *see, e.g.*, C. Qiang, C. Rossotto, and K. Kimura, *Economic Impacts of Broadband*, in INFORMATION AND COMMUNICATIONS FOR DEVELOPMENT 2009: EXTENDING REACH AND INCREASING IMPACT, Ch. 3., World Bank (2009) (available at: http://go.worldbank.org/NATLOH7HV0. This study is interesting in that it is often cited to support broadband adoption in individual countries, whereas the econometric model measures the GDP impact of increases in adoption across multiple countries.

[25] L. Waverman and K. DasGupta, *Connectivity Scorecard 2009*, LECG Report (2009) (available at: http://www.connectivityscorecard.org/images/uploads/media/TheConnectivityReport2009.pdf).

[26] *Digital Economy Rankings 2010: Beyond e-Readiness*, ECONOMIST INTELLIGENCE UNIT (2010) (available at: http://graphics.eiu.com/upload/EIU_Digital_economy_rankings_2010_FINAL_WEB.pdf).

[27] *Supra* n. 3.