Students majoring in economics at Oberlin College are required to complete a research paper in order to earn their economics major. Below is my paper, which I completed in May 2011 as part of a course on public-private partnerships. — JBY, 1/23/16

Why do countries have different broadband penetration rates?

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Introduction

Today's markets are global, and both developed and developing countries are increasingly producing service-sector goods. Widespread access to high-speed Internet can be a competitive advantage in today's "knowledge economy" (Choudrie and Lee 2004; OECD 2008).

At the same time, broadband infrastructure requires significant investment. Due to economies of scale, the market may be uncompetitive—dominated by a few large firms—and rural or low-income areas may be underserved (Gillet et al 2003; Choudrie and Lee 2004). Since broadband is excludable but largely nonrival—once the infrastructure has been installed in an area, one household's use does not significantly diminish the service provided to other households—it might be useful to consider broadband as a public good. Governments may want to encourage broadband penetration in order to address equity concerns or modernize their countries.

The International Monetary Fund's *Balance of Payments Manual* (1993) classifies the following transactions as services: transportation (freight and passenger); travel (business and person); communications services; construction services; insurance services; financial services; computer and information services; royalties and licensing fees; and personal, cultural, and

recreational services. By examining the data related to broadband penetration rates, and by using two datasets comprised primarily of developing or developed nations, this paper hypothesizes that first-world, wealthier, or developed nations are exporting services to less-wealthy developing nations. This trade imbalance spurs the demand for premium communications services and partly accounts for the greater broadband penetration rates observed in developed nations.

Background

In 1999 and 2000, South Korea experimented with several initiatives to encourage broadband penetration and modernize the country's service industry (Choudrie and Lee 2004). Programs such as "Cyber Korea 21" and "Ten Million People Internet Education" promoted Internet literacy, and the government further provided "US$77m of loans [to service providers] at preferential rates." The government also deregulated the telecommunications industry and prepaid for broadband service to public buildings. The result was a highly-competitive telecommunications sector that was able to provide next-generation communications services at cutthroat rates. South Korea's high population density facilitated the spread of the new infrastructure, and the government planned to commit an additional US$926m to extend broadband service to rural areas by 2005. Some researchers have also postulated that broadband adoption in South Korea was aided by the prevalence of Internet cafés which introduced the population to high-speed Internet access and by a cultural predisposition towards improving education.

Broadband Internet access is commonly defined as network connections that carry data at speeds of 64 kilobytes/second to 4.0 megabytes/second (Wikipedia "Broadband Internet

access"). In contrast, maximum data transfer speed for a dial-up Internet connection is 56 kilobytes/second.

In a study of Internet subscription rates in the United States, Gillet et al (2003) suggest that broadband penetration is influenced by several demand- and supply-side factors:

Demand

- *Population*: Aggregate demand for broadband will be greater among larger populations. It is expected but unverified that broadband demand will be greater among more youthful populations.
- *Wealth*: Since broadband is a "premium" service, demand should be greater in wealthier areas.
- *Education*: Gillet et al argue that "white collar workers . . . are more likely to use advanced communications services." One expects that broadband penetration will be greater in areas that have more highly-educated populations and that trade heavily in services.

Supply

- *Telecommunications sector*: Fixed-line broadband Internet is typically delivered through high-speed fiber-optic cables. Since installing the new infrastructure is costly, the supply of broadband should be greater in areas with robust telecommunications industries. Competition should provide the incentive for telecommunications companies to install infrastructure more efficiently and to provide the service at lower rates.
- *Population density*: Broadband infrastructure is easiest to install in densely-populated areas (wiring an apartment building is more cost-effective and ultimately profitable than

wiring an entire suburb). Hence, population density should increase broadband subscription rates.

No study has yet utilized this framework to examine broadband penetration at the international level.

Empirical Framework

Broadband penetration is analyzed from time-varying panel data using a linear fixed-effects regression:

$$Y_{it} = \beta_1 X_{it} + \beta_2 Z_{it} + \mu_i + \epsilon_{it}$$

where

Y = broadband penetration

X = demand-side variables

Z = supply-side variables

μ = individual fixed-effect

ϵ = unexplained error

Broadband penetration is measured as the number of fixed-line broadband Internet subscribers per 100 citizens in a county.

Demand-side variables include the *total population* as well as the *percentage of the population between ages 15 and 64* and the *percentage of the population over the age of 64*. Since the total population varies widely among the sample data, it has been transformed logarithmically. The latter two variables are included in order to isolate which age group is driving the demand for broadband; the collinearity between these three measures is insignificant. One expects all variables to be positively correlated with broadband penetration, and that youthful populations will have a greater demand for broadband.

GDP—transformed logarithmically—and *GDP per capita* are used to measure the wealth of a country. This variable should be positively correlated with broadband penetration. Although data on adult and youth literacy rates was available, it would have presented collinearity problems and was not rich enough to be included in the regression. But because education should increase with income levels, and measures of wealth will proxy for the education levels of a country.

The "white-collar" demand of a country is measured by the logarithmic transformations of *commercial service imports* and *exports* (both *in U.S. dollars*). Countries that trade a high volume of commercial services will likely have a greater demand for high-speed Internet access. The demand of highly-educated citizens is also estimated by the number of *researchers and technicians per 1 million citizens*. Broadband penetration should be greater in countries that are more engaged in "knowledge work" (Anderson 2006; Pink 2006).

The sole *supply-side variable* is *mobile cellular subscriptions per 100 citizens*. Since cellular subscription rates often increase as broadband subscription rates increase (Yang et al 2009), and since broadband providers often also provide cellular service (Yang et al 2009), this variable should indicate the robustness of a country's telecommunications sector. However, especially in developing countries, high cellular subscription rates may also indicate a lack of fixed-line infrastructure. Even in developed countries (for example, Japan), cellular subscriptions could substitute for fixed-line broadband access and may dampen demand for broadband.

Data

The World Bank freely provides data on the preceding variables for a variety of countries. The sample period is 2001-2009. Because the data was more complete for some countries than others, two datasets have been constructed. The first dataset excludes all countries

for which broadband penetration rates were not available for half of the sample period. Since even fixed effects regressions require variation in order to run, countries for which broadband penetration did not vary from 0 during the sample period were also excluded. As one might expect, countries that were excluded from this first dataset were primarily small developing nations for which data was not readily available. Dataset 1 still includes a mix both developing and developed countries, for a total of 187 countries.

```
. sum broadbandper poptot pop1564per pop65per gdp  gdppercap mobilecellsubsper
comexusdol comservim whitecollarper popdensity

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
broadbandper |      1559    4.855606    8.639515          0    75.1859
      poptot |      1615    3.43e+07    1.30e+08      19626   1.30e+09
  pop1564per |      1521    63.01351    6.566622    47.7646    82.9247
    pop65per |      1521    7.627221    4.988281    .996999    21.9542
         gdp |      1554    2.64e+11    1.09e+12   7.65e+07   1.44e+13
-------------+--------------------------------------------------------
   gdppercap |      1549    11594.77    17866.28   85.54153     138354
mobilecell~r |      1598    53.13112    42.90017          0    232.068
  comexusdol |      1363    1.65e+10    4.35e+10          0   5.10e+11
   comservim |      1363    1.54e+10    3.79e+10          0   3.70e+11
whitecolla~r |       336     2434.33    2139.813    8.77476   10126.21
-------------+--------------------------------------------------------
  popdensity |      1615    305.9581    1466.821   .1365842   19213.29
```

Figure 1: Summary of Dataset 1.

As Figure 1 shows, there is a great degree of variation in several key parameters (namely, *GDP*, *GDP per capita*, and *total population*). Furthermore, some parameters are more complete—have more observations—than others. As shown in the Appendix, Dataset 1 contains far more developing nations than developed ones. Because the data from developing nations might have influenced the regression results—and because developed nations might be best able to implement any policy recommendations—a second dataset has been constructed using only members of the Organisation for Economic Co-operation and Development (OECD). Dataset 2 contains 33 countries.

```
. sum broadbandper poptot pop1564per pop65per gdp gdppercap mobilecellsubsper
comexusdol comservim whitecollarper popdensity
```

```
    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
broadbandper |       297    13.92709    10.68104          0    41.1188
      poptot |       297    3.61e+07    5.62e+07     285000   3.10e+08
  pop1564per |       297    67.25484    2.140944    61.8866     72.538
    pop65per |       297    14.29111    3.533919    5.33827    21.9542
         gdp |       297    1.06e+12    2.26e+12   6.24e+09   1.44e+13
-------------+--------------------------------------------------------
   gdppercap |       297    29585.03    18872.68   2906.188   117954.7
mobilecell~r |       297    91.78732    27.30578    21.9786    202.973
  comexusdol |       295    5.67e+10    7.67e+10   1.00e+09   5.10e+11
   comservim |       295    5.05e+10    6.51e+10   9.50e+08   3.70e+11
whitecolla~r |       146     3864.34     2110.79   374.5624   10126.21
-------------+--------------------------------------------------------
  popdensity |       297    138.4637    131.5325   2.526978   502.9612
```

Figure 2: Summary of Dataset 2.

A point of note: Dataset 2 excludes several outlier nations. For instance, the maximum *broadband subscriptions per 100 citizens* drops from 75 to 41 due to the exclusion of Liechtenstein, a German-speaking country in Alps. Liechtenstein is considered the richest country in the world as measured by GDP per capita, but it has a population of only 35,000 (Wikipedia "Liechtenstein"). Hopefully, excluding such outlier nations will yield a better-fit regression.

Results

Dataset 1: All Countries

```
. xtreg broadbandper lnpoptot pop1564per pop65per lngdp mobilecellsubsper
lncommexdol lncommimdol whitecollarper popdensity, fe

Fixed-effects (within) regression               Number of obs      =       318
Group variable: countrynum~r                    Number of groups   =        68

R-sq:  within  = 0.7474                         Obs per group: min =         1
       between = 0.0313                                        avg =       4.7
       overall = 0.0485                                        max =         8

                                                F(9,241)           =     79.23
corr(u_i, Xb)  = -0.9853                        Prob > F           =    0.0000

------------------------------------------------------------------------------
broadbandper |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lnpoptot |   26.15795   7.356293     3.56   0.000     11.66711    40.64879
  pop1564per |  -2.591909   .4924988    -5.26   0.000    -3.562061   -1.621757
```

```
    pop65per |    1.19033   .7221183     1.65   0.101    -.2321389      2.6128
       lngdp |  -3.162183     1.9863    -1.59   0.113    -7.074908    .7505423
mobilecell~r |   .0561702   .0175798     3.20   0.002     .0215405    .0907998
 lncommexdol |   .1799305   1.631881     0.11   0.912     -3.03464    3.394501
 lncommimdol |   9.912184   2.018968     4.91   0.000     5.935107    13.88926
whitecolla~r |   .0036565    .000623     5.87   0.000     .0024292    .0048837
  popdensity |   .0073854   .0031645     2.33   0.020     .0011518     .013619
       _cons |  -420.9733   113.8155    -3.70   0.000    -645.1736   -196.7731
-------------+----------------------------------------------------------------
     sigma_u |  48.715508
     sigma_e |  2.6415582
         rho |  .99706836   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(67, 241) =    13.35                 Prob > F = 0.0000
```

Figure 3: Fixed-effects regression results for Dataset 1.

An F-value of 79.23 and an R^2 of 0.74 indicate that this regression is highly significant and explains a large degree of the variation in international broadband penetration rates. Nearly all of the variables, with the exception of *GDP* and *commercial service exports*, are as significant.

Because the parameter *total population* carries a coefficient of 26.16 and is highly significant, this researcher concludes that total population is by far the largest determinant of broadband penetration. Surprisingly, the *percentage of the population between ages 15 and 64* significantly decreases broadband penetration; the *percentage of population over the age of 64* increases broadband penetration by half that amount but is significant only at the 10% level. These results suggest that while total population drives the demand for broadband, the *working age* and *retiree* population of a country do not.

These results could arise from including a disproportionate number of developing countries in the dataset, since in developing countries the working age population may be more likely to be engaged in manufacturing or manual labor—occupations which do not demand high-speed broadband access—rather than knowledge work (Anderson 2006; Pink 2006). Since the number of *researchers and technicians* in a country do significantly drive demand (albeit only slightly), this conclusion seems valid.

The *percentage of the population under the age of 15* was constructed by subtracting the *percentage of the population over the age of 64* and the *percentage of the population between ages 15 and 64* from 100. Although one might suspect that the *youth* population of a country would drive the demand for broadband, a fixed-effects regression run using this constructed variable contradicts that hypothesis. The coefficient on the parameter is -1.19 and significant at the 10% level (Figure 4). Again, the results may be biased by the disproportionate number developing nations in the dataset; in developing nations, youths may be less likely to surf the web, communicate online, or play massively-multiplayer online video games—leisure activities that all demand high-speed internet access (Choundire and Lee 2004).

```
. xtreg broadbandper lnpoptot pop14per pop1564per lngdp mobilecellsubsper
lncommexdol lncommimdol whitecollarper popdensity, fe

Fixed-effects (within) regression               Number of obs      =       318
Group variable: countrynum~r                    Number of groups   =        68

R-sq:  within  = 0.7474                         Obs per group: min =         1
       between = 0.0313                                        avg =       4.7
       overall = 0.0485                                        max =         8

                                                F(9,241)           =     79.23
corr(u_i, Xb)  = -0.9853                        Prob > F           =    0.0000

------------------------------------------------------------------------------
broadbandper |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lnpoptot |   26.15795   7.356293     3.56   0.000     11.66711    40.64879
    pop14per |  -1.190329   .7221183    -1.65   0.101    -2.612798    .2321404
  pop1564per |  -3.782238   .7376827    -5.13   0.000    -5.235367   -2.329109
       lngdp |  -3.162184     1.9863    -1.59   0.113     -7.07491    .7505409
mobilecell~r |   .0561702   .0175798     3.20   0.002     .0215405    .0907998
 lncommexdol |   .1799311   1.631881     0.11   0.912    -3.034639    3.394501
 lncommimdol |   9.912185   2.018968     4.91   0.000     5.935109    13.88926
whitecolla~r |   .0036565    .000623     5.87   0.000     .0024292    .0048837
  popdensity |   .0073854   .0031645     2.33   0.020     .0011518     .013619
       _cons |  -301.9404   113.6721    -2.66   0.008     -525.858   -78.02279
-------------+----------------------------------------------------------------
     sigma_u |  48.715505
     sigma_e |  2.6415583
         rho |  .99706836   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(67, 241) =    13.35             Prob > F = 0.0000
```

Figure 4: A fixed-effects regression run using the percentage of the population under the age of 15 *instead of the* percentage of the population over the age of 64.

After total population, the second-largest determinant of broadband penetration appears to be *commercial services imports*. While *commercial service exports* also positively influences broadband penetration, in Figure 3 it is the sole insignificant parameter. This suggests that countries heavily trading in services will have greater broadband penetration rates. The impact of *commercial services imports* and *exports* reverses when the fixed-effects regression is run on only OECD countries, but that will be explained in the next section.

Mobile cellular subscriptions also influence broadband penetration, albeit only slightly. One suspects that a robust telecommunications sector is integral to widespread broadband penetration. Because mobile cellular subscriptions appear to increase broadband penetration, there is no significant trade-off between cellular subscriptions and broadband subscriptions. Instead, the two may be complements.

Finally, the wealth and education of a country, as measured by the logarithmic transformation of *GDP*, would decrease the demand for broadband were it significant. Income *distribution* rather than *total* wealth may be a more important driver of broadband demand, as supported by the results of the regression in Figure 5. With an F-value of 133.62 and an R^2 of 0.83, this regression is actually more significant than the one in Figure 3. In the regression in Figure 5, *GDP per capita* increases broadband penetration only slightly but is highly significant. This supports the conclusion that since broadband is a premium service, it is more likely to be demanded by wealthier households.

```
. xtreg broadbandper lnpoptot pop1564per pop65per gdppercap mobilecellsubsper
lncommexdol lncommimdol whitecollarper

popdensity, fe

Fixed-effects (within) regression               Number of obs      =       318
Group variable: countrynum~r                    Number of groups   =        68

R-sq:  within  = 0.8331                         Obs per group: min =         1
```

```
       between = 0.5786                                        avg =       4.7
       overall = 0.4611                                        max =         8

                                               F(9,241)          =    133.62
corr(u_i, Xb)  = -0.9413                       Prob > F          =    0.0000

------------------------------------------------------------------------------
broadbandper |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lnpoptot |   5.745479    6.23757     0.92   0.358    -6.541637    18.03259
  pop1564per |  -1.697694   .4082165    -4.16   0.000    -2.501822   -.8935666
    pop65per |   2.442949   .5914617     4.13   0.000     1.277855    3.608043
   gdppercap |    .000477   .0000422    11.29   0.000     .0003938    .0005602
mobilecell~r |   .0536753   .0135962     3.95   0.000     .0268927    .0804579
 lncommexdol |  -4.322522   1.324131    -3.26   0.001     -6.93087   -1.714174
 lncommimdol |   5.483412   1.390707     3.94   0.000     2.743919    8.222905
whitecolla~r |   .0028431   .0005116     5.56   0.000     .0018353    .0038509
  popdensity |   .0044956   .0025857     1.74   0.083    -.0005978     .009589
       _cons |  -47.59476   98.35216    -0.48   0.629    -241.3344    146.1449
-------------+----------------------------------------------------------------
     sigma_u |  18.352538
     sigma_e |  2.1474978
         rho |  .98649275   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(67, 241) =    21.07             Prob > F = 0.0000
```

Figure 5: Using GDP per capita *instead of* GDP *as a measure of wealth.*

Furthermore, the regression in Figure 5 tells a slightly different story than one in Figure 3. *Total population* exerts a smaller but insignificant effect. While the coefficients and significance levels of most of the other parameters do not change, the results for *commercial service exports* and *imports* continue to be puzzling. Both parameters are highly significant, but *commercial service exports* now decreases broadband penetration by nearly the same amount as *commercial service imports* increases it.

Dataset 2: OECD Countries

```
. xtreg broadbandper lnpoptot pop1564per pop65per lngdp mobilecellsubsper lncommexdol
lncommimdol whitecollarper popdensity, fe

Fixed-effects (within) regression               Number of obs      =       145
Group variable: countrynum~r                    Number of groups   =        27

R-sq:  within  = 0.8498                         Obs per group: min =         1
       between = 0.0181                                        avg =       5.4
       overall = 0.0434                                        max =         8

                                                F(9,109)          =     68.51
```

```
corr(u_i, Xb)  = -0.9952                         Prob > F          =    0.0000

------------------------------------------------------------------------------
broadbandper |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lnpoptot |   23.17325   11.91633     1.94   0.054    -.4445335    46.79103
  pop1564per |  -2.149608   .8420006    -2.55   0.012    -3.818426   -.4807901
    pop65per |   .3972617   .9745043     0.41   0.684    -1.534174    2.328697
       lngdp |  -1.874749   3.494113    -0.54   0.593    -8.799967     5.05047
mobilecell~r |   .0684825   .0296765     2.31   0.023     .0096647    .1273003
 lncommexdol |   9.840947   3.559912     2.76   0.007     2.785318    16.89658
 lncommimdol |    3.11779   4.213264     0.74   0.461    -5.232763    11.46834
whitecolla~r |   .0011872    .000785     1.51   0.133    -.0003687    .0027431
  popdensity |   .5083158   .1753971     2.90   0.005     .1606844    .8559473
       _cons |  -573.2891   182.4094    -3.14   0.002    -934.8187   -211.7596
-------------+----------------------------------------------------------------
     sigma_u |  95.121711
     sigma_e |   2.521804
         rho |  .99929764   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(26, 109) =    17.79             Prob > F = 0.0000
```

Figure 6: Fixed-effects regression results for only OECD member nations.

The model when applied to only OECD countries yields similar results. An F-value of 68.51 and an R^2 of 0.85 indicate that this model is highly significant and explains a large degree of the variation in the data. While fewer of the parameters are significant, few of the coefficient estimates vary notably. Thus, even with a smaller dataset, the model proposed in this paper appears to be the best available predictor of international broadband subscription rates.

Among the OECD countries, *total population* continues to drive broadband penetration more than any of the other parameters. This parameter is significant at the 10% level, while the *working age population* and the *retiree population* are no longer significant.

With an estimated coefficient of 9.84, *commercial service imports* increase broadband penetration nearly as much *commercial service exports* did in the first estimation. *Commercial service imports* is positive and significant at the 1% level; *commercial service imports* is positive but insignificant. While the reversal is surprising, it nonetheless still suggests that countries heavily trading in commercial services will have greater broadband penetration rates.

Since Dataset 1 includes more developing nations than developed ones, and since that relationship is reversed in Dataset 2, the observed switch between *commercial service imports* and *commercial service exports* could suggest that developing nations are importing commercial services from developed ones. Business writers who study Internet-era economics have recently begun to argue that first-world nations need to maintain their competitive edge in service sector industries. Daniel Pink has noted the surge in Indian accountants and Chinese programmers, and Chris Anderson—editor-in-chief of *Wired* and former business editor for *The Economist*—has reported on the effects of Chinese intellectual property theft. Even though generalizations should not be made without sufficient data, the results of the regressions in Figures 3 and 6 might suggest that developing nations have primarily been importing services from developed nations for the past decade.

Furthermore, among the OECD member nations, higher *population density* leads to higher broadband penetration. The effect is small but very significant. This confirms the expectation that broadband penetration benefits from economies of scale, that it is easier to install broadband infrastructure among a densely-concentrated, urban population.

The effect of *GDP* is, surprisingly, negative and insignificant. As with Dataset 1, replacing *GDP* with *GDP per capita* yields a more significant regression and a small but highly significant effect for household wealth.

```
. xtreg broadbandper lnpoptot pop1564per pop65per gdppercap mobilecellsubsper
lncommexdol lncommimdol whitecollarper popdensity, fe

Fixed-effects (within) regression               Number of obs      =       145
Group variable: countrynum~r                    Number of groups   =        27

R-sq:  within  = 0.8983                         Obs per group: min =         1
       between = 0.0526                                        avg =       5.4
       overall = 0.0477                                        max =         8

                                                F(9,109)           =    106.93
corr(u_i, Xb)  = -0.9583                        Prob > F           =    0.0000
```

```
------------------------------------------------------------------------------
broadbandper |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lnpoptot |   18.89587   9.774066     1.93   0.056    -.4760142    38.26775
  pop1564per |  -1.548924   .6666119    -2.32   0.022    -2.870127   -.2277209
     pop65per |   1.892988   .8278374     2.29   0.024     .2522416    3.533735
   gdppercap |   .0004502   .0000622     7.24   0.000     .0003269    .0005735
mobilecell~r |   .0742936   .0225115     3.30   0.001     .0296764    .1189107
 lncommexdol |   4.165353   3.033346     1.37   0.173     -1.84664    10.17735
 lncommimdol |  -.3208878   3.079249    -0.10   0.917    -6.423859    5.782083
whitecolla~r |   .0015207   .0006309     2.41   0.018     .0002703    .0027711
  popdensity |  -.0186352   .1586906    -0.12   0.907    -.3331547    .2958844
       _cons |   -331.368   153.8179    -2.15   0.033      -636.23   -26.50593
-------------+----------------------------------------------------------------
     sigma_u |  31.664265
     sigma_e |  2.0753834
         rho |  .99572244   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(26, 109) =    28.53                 Prob > F = 0.0000
```

Figure 7: Using GDP per capita *instead of* GDP *as a measure of wealth in OECD member nations.*

In Figure 7, the effects of the population parameters and *mobile cellular subscriptions* are stronger and more significant. These results can be explained as before.

	Figure 3	**Figure 4**	**Figure 5**	**Figure 6**	**Figure 7**
Dataset	*1*	*1*	*1*	*2*	*2*
Total population	26.157 (7.356)***	26.157 (7.356)***	5.745 (6.238)	23.173 (11.916)**	18.896 (9.774)*
Percentage of the population between the ages of 15 and 64	-2.591 (0.492)***	-3.782 (0.738)***	-1.698 (0.408)***	-2.150 (0.842)***	-1.549 (0.667)**
Percentage of the population over the age of 64	1.190 (0.722)*		2.443 (0.591)***	0.397 (0.975)	1.892 (0.828)**
Percentage of the population under the age of 15		-1.190 (0.722)*			
GDP	-3.162 (1.986)	-3.162 (1.986)		-1.874 (3.494)	
GDP per capita			0.000 (0.000)***		0.000 (0.000)***
Commercial service exports (USD)	0.179 (1.631)	0.179 (1.631)	-4.323 (1.324)***	9.841 (3.560)***	4.165 (3.033)
Commercial service imports (USD)	9.912 (2.018)***	9.912 (2.018)***	5.483 (1.390)***	3.118 (4.213)	-0.321 (3.079)
Researchers and technicians per 1	0.003 (0.001)***	0.003 (0.001)***	0.003 (0.001)***	0.001 (0.001)	0.002 (0.001)**

million citizens					
Mobile cellular subscriptions per 100 citizens	0.056 (0.018)***	0.056 (0.018)***	0.054 (0.016)***	0.068 (0.030)**	0.074 (0.022)***
Population density	0.007 (0.003)**	0.007 (0.003)**	0.004 (0.003)*	0.508 (0.175)***	-0.019 (0.157)

*** 1% level of significance
** 5% level of significance
* 10% level of significance

Figure 8: Summary of results.

Conclusions

At the international level, the largest determinants of broadband penetration are total population and commercial services trade. The coefficients on measures of wealth, education, population density, and telecommunications sector robustness are often small but highly significant; this researcher concludes that they contribute to broadband penetration as well although to a lesser degree.

Since total population and commercial services trade act primarily by increasing the demand for broadband, it would appear that demand-side variables are more important than supply-side variables in determining nationwide broadband penetration. It may that a strong service-sector economy stimulates broadband penetration not only directly but also indirectly by typifying the kind of wealthy, highly-educated populace likely to demand premium communications services.

From a policy perspective, then, it would seem that governments can best increase broadband penetration by stimulating the service sectors of their economies (total population is largely outside a government's control). A strong service sector provides a healthy environment for broadband penetration.

Future Research

To verify the conclusions above, a new dataset should be constructed that models the effects of different government programs. Gillet et al (2003) suggest that to promote broadband penetration, a government can assume the role of 1) user, 2) rule-maker, 3) financier, and 4) infrastructure developer (Gillet et al 2003). In the first role, the government stimulates demand; in the latter three, it encourages supply. In the first three roles, the government is a provider; only in the last role is it a producer. A simple way to augment the model proposed in this paper would be to include dummy variables indicating whether or not a government has acted in one or more of the four roles. Such a study could provide more precise policy recommendations.

Appendix

The full list of countries in Dataset 1 is as follows:

Afghanistan	Ghana	Oman
Albania	Greece	Pakistan
Algeria	Greenland	Palau
Andorra	Grenada	Panama
Angola	Guatemala	Papua New Guinea
Antigua and Barbuda	Guinea	Paraguay
Argentina	Guinea-Bissau	Peru
Armenia	Guyana	Philippines
Aruba	Haiti	Poland
Australia	Honduras	Portugal
Austria	Hong Kong SAR	Puerto Rico
the Bahamas	Hungary	Qatar
Bahrain	Iceland	Romania
Barbados	India	Russia
Belarus	Indonesia	Rwanda
Belgium	Iran	Samoa
Belize	Iraq	San Marino
Benin	Ireland	Sao Tome and Principe
Bermuda	Israel	Saudi Arabia
Bhutan	Italy	Senegal
Bolivia	Jamaica	Serbia
Bosnia and Herzegovina	Japan	Seychelles
Botswana	Jordan	Sierra Leone
Brazil	Kazakhstan	Singapore
Brunei Darussalam	Kenya	Slovak Republic
Bulgaria	Korea (Rep. of)	Slovenia

Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Cape Verde
Chad
Chile
China
Colombia
Congo (Dem. Rep.)
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Estonia
Ethiopia
Faeroe Islands
Fiji
Finland
France
French Polynesia
Gabon
Gambia
Georgia
Germany
Kuwait
Kyrgyz Republic
Lao PDR
Latvia
Lebanon
Lesotho
Libya
Liechtenstein
Lithuania
Luxembourg
Macedonia
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Micronesia
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Caledonia
New Zealand
Nicaragua
Niger
N. Mariana Islands
Norway
Solomon Islands
Somalia
South Africa
Spain
Sri Lanka
St. Kitts and Nevis
St. Lucia
St. Vincent and the Grenadines
Sudan
Suriname
Swaziland
Sweden
Switzerland
Syrian Arab Republic
Tajikistan
Tanzania
Thailand
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Vanuatu
Venezuela
Vietnam
Virgin Islands (U.S.)
West Bank and Gaza
Yemen
Zambia
Zimbabwe

The full list of countries in Dataset 2 is as follows:

Australia
Austria
Belgium
Canada
Chile
Czech Republic
Greece
Hungary
Iceland
Israel
Italy
Japan
Norway
Poland
Portugal
Slovak Republic
Slovenia
Spain

Denmark	Korea (Rep. of)	Sweden
Estonia	Luxembourg	Switzerland
Finland	Mexico	Turkey
France	Netherlands	United Kingdom
Germany	New Zealand	United States

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