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Natural Experiments in Mobile Phone Regulation: Estimated Effects of Prohibiting Handset Bundling in Finland and Belgium

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Vertical restrictions have theoretically ambiguous efficiency effects. Marketplace evidence is therefore required to reveal the presence of anti-competitive foreclosure. The bundling of mobile phones with cellular network service offers one such market test. Two European nations—Finland and Belgium—prohibited tying arrangements for mobile service and mobile devices (handsets) in wireless broadband (3G) markets. These rules were abandoned in 2006 and 2010, respectively, creating natural experiments.

This article compares 3G subscribership in European countries from 2003 through 2012. Finland and Belgium, while banning bundles, exhibited 3G penetration levels only about a third of the EU 15 average. Following their respective regime switches, relative 3G penetration levels improved markedly in these countries—Finland, in fact, became an EU leader. Regressions adjusting for market specific factors quantify the effects. The data are consistent with the view that carrier handset subsidies, which are strongly supported by bundling services with hardware, help internalize network effects that, if unsupported by the network carriers, may go unrealized. Vertical integration here appears to assist in productive ecosystem creation, not anti-competitive foreclosure.

Keywords: Mobile Phone Regulation, 3G Networks, Bundling, Foreclosure

JEL Codes: K23, L14, L50, L96

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I. Introduction

The efficiency benefits of vertical restraints are frequently questioned in the mobile phone sector. In particular, the practice of tying mobile phone subscriptions with handsets—often with large carrier subsidies lowering the price of the phone with the signing of a two-year service contract—has attracted critical scrutiny. The primary concern is that such contract bundles foreclose competition between mobile operators, original equipment manufacturers (OEMs), and vendors of content and applications in ways that harm consumers (Frieden 2007; Wu 2007; Crawford 2012). Such views led to the Federal Communications Commission’s decision to add “open access” requirements to the 700 MHz C Block auction, which occurred in March 2008 (FCC 2007).

The foreclosure explanation of bundling contrasts with findings by economists who find vertical integration in mobile markets to support efficiencies (Faulhaber & Farber 2010; Heatley & Howell 2009; Liebowitz & Margolis 2008; Ford et al. 2009; Hahn et al. 2007; Schwartz & Mini 2007). Some note gains from better coordination of upstream and downstream inputs (Mayo & Wallsten 2010), while those conducting laboratory experiments have found that bundling increases consumer welfare (Caliskan et al. 2007). In other industries, empirical studies have measured efficiencies from non-price vertical conduct as well (Cooper et al. 2005).

Importantly, there now exist natural experiments allowing us to observe the effects of mobile handset bundling between 2003 and 2012. In both Finland and Belgium, national governments prohibited mobile carriers from bundling handsets with services and later reversed the policies. The Finns abolished the prohibition in 2006 due to widespread dissatisfaction with 3G (third generation) mobile broadband adoption (Repo 2006). The Belgians prohibited handset bundling through a general, economy-wide prohibition on tie-ins; they were forced to end this rule in 2010 after the European Commission found these tying prohibitions invalid. The use, and then removal, of these regulations yield valuable evidence from European markets. In short, we find that consumers reacted positively to bundled offers relative to unbundled offers, strongly suggesting that the bundles and attendant handset subsidies are powerful tools for ecosystem creation, not vertical foreclosure.

II. Anti-Bundling Regulation in Finland and Belgium

Third generation mobile technologies (3G) offer not only voice and texting services, but high-speed mobile broadband access to the Internet. In 2000 and 2001, 3G licenses were distributed by most European Union countries. The standard manner in which mobile carriers market these services involves the sale of a bundled contract: the customer is offered a 3G handset and a service agreement, usually for one or two years. Typically, the carrier subsidizes the handsets sold in this manner quite heavily, lowering the customer’s upfront payment, sometimes to zero, and recoups the subsidy over the term of the contract.

Telecommunications regulators in Finland and Belgium forbade this business practice, however. Mobile carriers in those countries, therefore, could not subsidize the purchase of a handset with a wireless subscription. As described below, these regulations faced popular opposition and legal challenges, and both countries eventually reversed their policies. Finland was first, in 2006, followed by Belgium in 2010.

A. Finland’s Prohibition of Bundled Handsets, 1997-2006

A Finnish law prohibiting handset-service bundles, dating to 1997, was reiterated in the Communications Market Act of 2003. This ensured that the major Finnish carriers, Elisa, Sonera, and DNA, were unable to sell handsets with mobile service, allowing independent vendors to retail handsets directly to customers. Regulators viewed these anti-bundling mandates as consumer protection measures that provided pricing transparency (Gimeno et al. 2007, p. 7).

Splitting mobile devices from mobile service contracts pre-empted carrier handset subsidies. Demand for mobile service was reportedly diminished (Saarikoski 2006, p. 64). In addition to relatively high upfront prices, coordination issues arose. In many instances, subscribers had difficulty accessing the wireless network with their devices. When consumers did have issues, the OEMs instructed consumers to contact the carriers, and the carriers would often blame the OEMs (*Id.*).

In 2005, regulators reversed course and agreed that carrier-subsidized handsets—a complement to wireless networks—would increase investment in the networks and help create useful ecosystems for data services, benefiting consumers. Allowing carrier bundling of handsets and monthly service, which would allow operators to recoup subsidies via service contracts, was the chosen policy reform. The Finnish communications regulatory agency asked the Finnish parliament to enact the change. Deregulation went into effect in April 2006 (Tallberg et al. 2007, p. 652).

B. Belgium’s Prohibition on Combined Offers, 1991-2010

A more complex story of deregulation and re-regulation has transpired in Belgium. Traditionally, bundled products were prohibited throughout the Belgian economy. Tying prohibitions dating to the 1930s were renewed by the 1991 Trade Practices Act, establishing Belgium’s anti-bundling (*koppelverkoop*) law (De Wit 2010). Hence, tying a mobile handset with a subscription was illegal. The law was ostensibly intended to promote competition and protect consumers from being improperly lured into purchasing below-cost products like subsidized phones (Blenkinsop 2008).

With the release of the iPhone 3G in Belgium in 2008, Belgians saw their European neighbors purchasing the iconic devices at far lower prices. Headlines declared Belgium home to “The World’s Most Expensive iPhone” (Flanders News.be 2008). Table 1 displays the prices of 3G iPhones. iPhone users in Belgium were paying

far more upfront for their devices, but getting service plans that were in many cases no better, and often worse (particularly in data charges) than monthly service plans elsewhere. Public sentiment shifted, strongly supporting the lifting of bundling restrictions.

Table 1. iPhone 3G Prices and Monthly Plans (2008)

| Country | Carrier | 8GB | 16GB | Plan | Min. | SMS | Data | Contract |
|-------------|----------|-------|-------|-------|------|-----------|-----------|----------|
| Belgium | Mobistar | \$822 | \$963 | \$47 | 180 | 300 | 200MB | 24 mo.* |
| Canada | Rogers | \$199 | \$299 | \$60 | 150 | 75 | 400MB | 36 mo. |
| Denmark | Telia | \$298 | \$426 | \$128 | 300 | Unlimited | 300MB | 6 mo. |
| Finland | Sonera | \$250 | \$385 | \$50 | 100 | 100 | 100MB | 24 mo. |
| Germany | T-Mobile | \$94 | \$236 | \$77 | 100 | 40 | Unlimited | 24 mo. |
| Hong Kong | Three | \$377 | \$479 | \$24 | 500 | Unlimited | 500MB | 24 mo. |
| Ireland | O2 | \$265 | \$360 | \$71 | 175 | 100 | 1GB | 18 mo. |
| Italy | Vodafone | \$313 | \$423 | \$93 | 400 | 400 | 600MB | 24 mo. |
| Italy | TIM | \$312 | \$422 | \$47 | 0 | 0 | 1GB | 24 mo. |
| Mexico | Telcel | \$331 | \$454 | \$44 | 200 | 100 | 100MB | 24 mo. |
| Netherlands | T-Mobile | \$126 | \$252 | \$47 | 150 | 150 | Unlimited | 24 mo. |
| New Zealand | Vodafone | \$414 | \$527 | \$60 | 120 | 600 | 250MB | 24 mo. |
| Norway | NetCom | \$275 | \$452 | \$79 | 100 | 100 | 100MB | 12 mo.** |
| Sweden | Telia | \$284 | \$451 | \$50 | 100 | 100 | 100MB | 24 mo. |
| Switzerland | Orange | \$199 | \$249 | \$44 | 30 | 50 | 1GB | 24 mo. |
| Switzerland | Swisscom | \$249 | \$349 | \$25 | - | - | 100MB | 24 mo. |
| UK | O2 | \$196 | \$315 | \$59 | 75 | 125 | Unlimited | 18 mo. |
| US | AT&T | \$199 | \$299 | \$70 | 450 | - | Unlimited | 24 mo. |

Source: Van Beijnum 2008. *Belgium did not allow bundling in 2008. **estimated.

Belgian policymakers believed that the absence of bundling depressed consumer demand for advanced mobile handsets (White 2008). In July 2008, government minister Vincent Van Quickenborne sought to eliminate the bundling ban, citing the expensive handsets (Deckmyn 2008).

[Belgian Enterprise Minister Vincent Van Quickenborne] said he will try to scrap this rule . . . because it stops phone operators from selling handsets inexpensively along with fixed service contracts, as is common elsewhere. For instance, Dutch customers over the border can pay just 1 euro (\$1.57) for an iPhone if they pick a contract with operator T-Mobile (White 2008).

Industry analysts attributed slow uptake of mobile handsets in Belgium to the anti-bundling law (S&P, Belgacom S.A. 2012). The ban impeded with carriers

experimenting with profitable bundles of services (amounts of voice, SMS, data) and effectively blocked handset subsidies to increase take-up rates (Van Beijnum 2008).

On April 23, 2009, the Court of Justice of the European Union ruled that the EU's Unfair Commercial Practices Directive 2005/29/EC preempted the Belgian law that prohibited combined offers to consumers (Van de Velde 2009; European Commission 2013). On March 18, 2010, the Belgian Senate repealed the Fair Trade Practices Act and formally approved a New Consumer Protection Act (NautaDutilh 2010), removing legal obstacles to handset bundling.

III. Empirical Approach

A. Inferences from Consumer Adoption

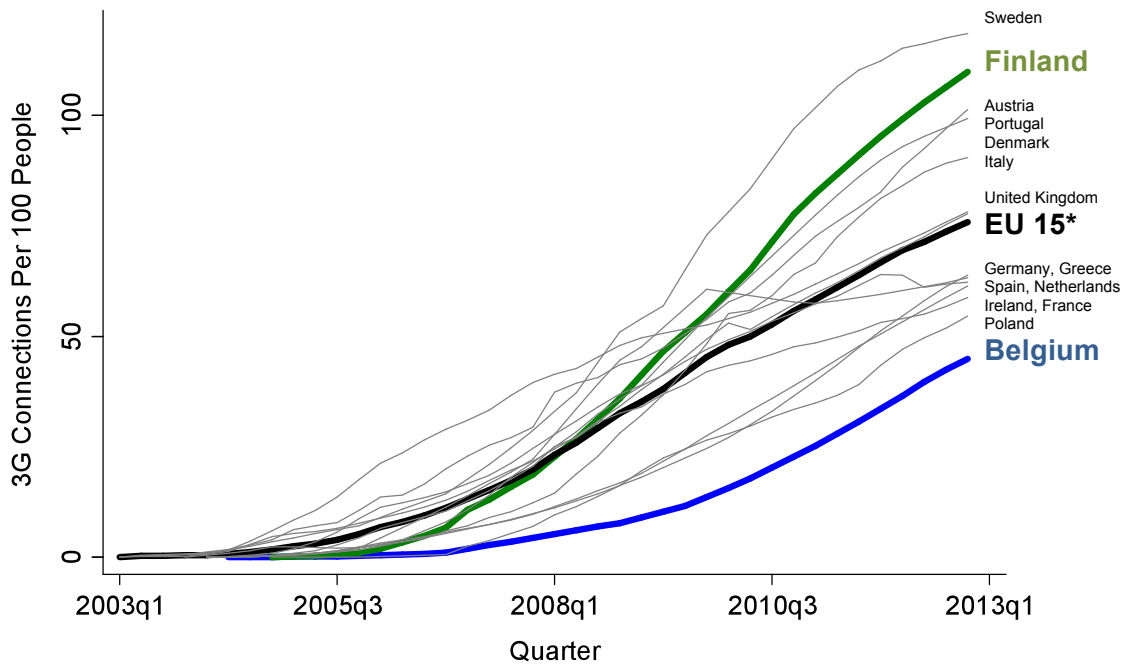
Increased output of 3G subscriptions can provide evidence of efficiencies from non-price vertical conduct when consumers adopt greater quantities of services. Here, we investigate whether increased output is observed at a statistically significant level following deregulation of anti-bundling rules. If so, the implication is that bundling has increased social welfare. Anti-competitive foreclosure would suggest the reverse, a restriction in output, and hence, welfare.

We consider penetration levels as a standard measure of output, where consumers are more likely to adopt services when competition in bundles offered across carriers generate lower prices. As seen in Table 1 above, prices and quantity for voice minutes, texting, data plans, contract length, and handset models vary in composition. Over time, bundles also change with consumer preferences, where demand for each service varies with respect to user applications and behavior (FCC 2013). Our model does not define or track these changes within bundles.

B. Simple Time Series Data

This study examines 3G subscribership over 40 quarters (2003Q1 to 2012Q4) in 27 countries. In a simple time series in Figure 1, we observe subscribership from the earliest deployments onwards. The figure shows 3G connections per 100 people for each EU 15 country, with bold lines for Finland, Belgium, and the EU 15 average *excluding* Finland and Belgium. Growth in 3G connections in Finland and Belgium are the focus of our analysis.

Figure 1. Quarterly 3G Connections in the EU 15 from 2003Q1 – 2012Q4



*excluding Finland & Belgium
 Source: Wireless Intelligence Database, 2013

C. Finland

Almost immediately after reforms allowed handset bundling in April 2006, Finnish mobile operators began offering substantially subsidized handsets tied to subscriptions (Tallberg et al. 2007, pp. 653-54). 3G penetration in Finland rapidly expanded (*Id.*, pp. 655-58). With the ability to subsidize and market 3G phones, mobile carriers saw a 32% increase in phone sales over previous year sales after the change in law (Poropudas 2006). One scholar wrote:

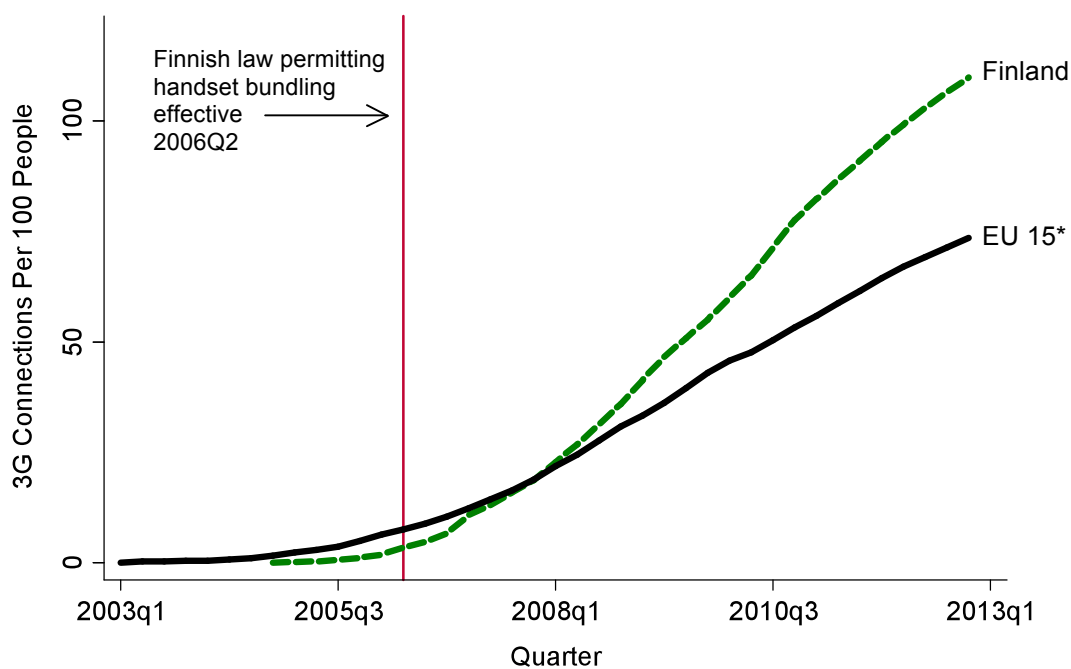
The Finnish Parliament allowed bundling . . . starting April 2006. In practice this has led to consumers buying subsidised 3G handsets. In Finland 3G has taken off because of bundling. There is a clear cause and effect relationship between allowing bundling and 3G becoming popular in Finland (Saarikoski 2006, p. 7 n. 22).

After the policy change, consumers began acquiring more advanced handsets and consuming more data (Repo 2006). In turn, operators built out their 3G networks. Greater speeds and more network coverage led to even more demand for 3G handsets (Tallberg et al. 2007; Kivi 2007; Okholm 2008; Howell & Sangekar 2008). A virtual circle formed. By 2006Q3, bundled 3G subscriptions represented 35% of all subscriptions and 3G penetration in Finland went from 3.4% in 2006Q2 to 46.6% in 2009Q2 and to

86.78% in 2011Q2 (Wireless Intelligence 2013). Studies report quantity demanded (for mobile traffic) increased by 300% to 400% from August 2005 to September 2006 (Okholm 2008, p. 19).

By 2012Q4, Finland had regained its reputation as a European mobile tech leader with 109.9% 3G penetration, trailing only Sweden in per capita connections (Wireless Intelligence 2013). As displayed in Table 2, the quarter that its rules were reversed, Finland exhibited 3G penetration at 44% of the EU 15 average (3.42 / 7.77). By 2008Q2, two years after the policy reversal in 2006Q2, Finland exhibited 3G penetration at 117% of the EU 15 average (26.78 / 22.97). In 2012Q4, 3G penetration increased to 161% of the EU 15 average (109.9 / 68.25).

Figure 2. Finland's 3G Connections & EU 15 Average



*excluding Finland
Source: Wireless Intelligence Database, 2013

Table 2. Finland's 3G Subscribership & EU 15 Average

| | 2004Q2 | 2005Q2 | 2006Q2 | 2007Q2 | 2008Q2 | 2012Q4 |
|----------|--------|--------|--------|--------|--------|--------|
| Finland | 0.00 | 0.35 | 3.42 | 13.06 | 26.78 | 109.89 |
| EU 15* | 0.53 | 3.10 | 7.77 | 14.21 | 22.97 | 68.25 |
| % EU 15* | 0% | 11% | 44% | 92% | 117% | 161% |

*excluding Finland. Source: Wireless Intelligence Database, 2013.

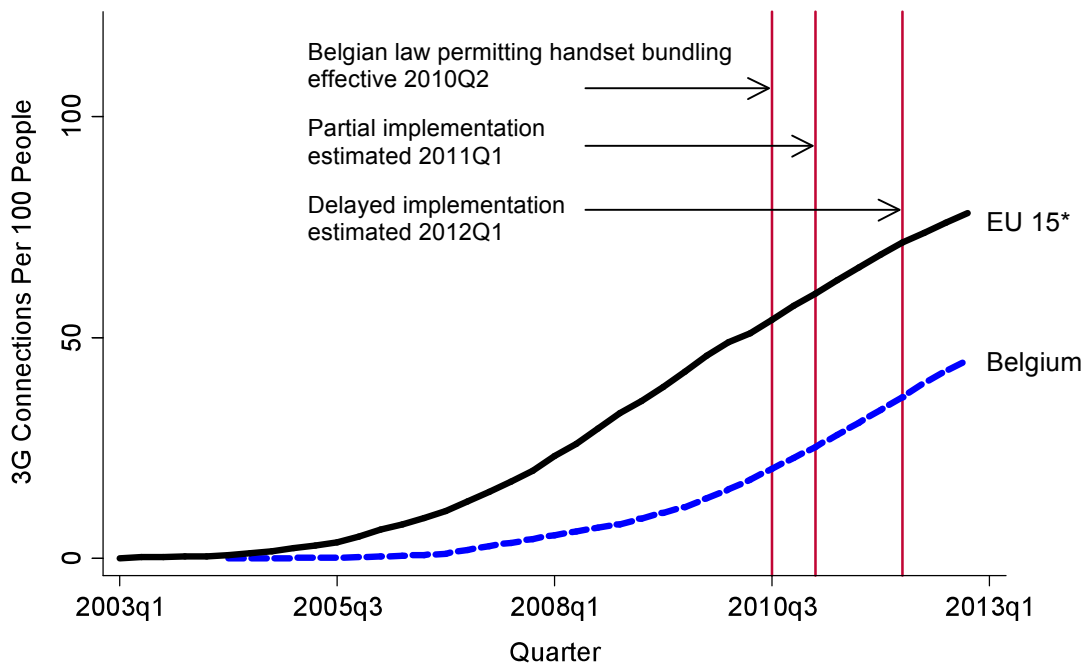
D. Belgium

Following reversal of the prohibition on combined offers, a positive but weak uptick was observed in 3G penetration between 2010 and 2012 as seen in Figure 3. In 2008Q2, prior to its 2010Q2 policy change, 3G penetration in Belgium trailed at 26% of the EU 15 average (6.09 / 23.45), see Table 3. Several quarters later in 2012Q2, Belgium exhibited 3G penetration at 61% of the EU 15 average (39.65 / 64.62). In 2012Q4, 3G penetration remained at 65% of the EU 15 average (44.87 / 69.37).

The relatively slow uptake compared to the EU 15 and to Finland, in particular, may be associated with unique constraints on Belgian mobile carriers, despite changes in regulatory policy in 2010. From 2010 to 2013, Belgacom noted that the three mobile carriers were slow to offer handset bundles (Belgacom S.A. 2012). Mobistar, for instance, the second-largest Belgian carrier, did not offer subsidized handsets until 2012 (Mobistar 2012; Mobistar 2013).

In 2011, the Belgian legislature prescribed constraints on standard bundles as practiced in most other countries—a re-regulation. “The revised Telecommunications Act . . . restricts initial contract periods to six months, leaving operators with a short [time] to recoup their subsidy” (Telecompaper 2013). This six-month maximum is an outlier among developed nations. The OECD, in a comprehensive report, listed contract plan durations ranging from 12 to 36 months in international analysis, with 24 months the mode (OECD 2013, pp. 35-37).

Figure 3. Belgium’s 3G Connections & EU 15 Average



*excluding Belgium
Source: Wireless Intelligence Database, 2013

Table 3. Belgium’s 3G Subscribership & EU 15 Average

| | 2008Q2 | 2009Q2 | 2010Q2 | 2011Q2 | 2012Q2 | 2012Q2 |
|----------|--------|--------|--------|--------|--------|--------|
| Belgium | 6.09 | 10.35 | 17.85 | 27.90 | 39.65 | 44.87 |
| EU 15* | 23.45 | 34.32 | 43.76 | 54.11 | 64.62 | 69.37 |
| % EU 15* | 26% | 30% | 41% | 52% | 61% | 65% |

*excluding Belgium. Source: Wireless Intelligence Database, 2013.

E. Difference-in-Differences Approach

Difference-in-differences (DD) models are herein employed to measure economic effects with respect to country and bundling policy. The DD method allows for analysis of before and after effects in treatment and control groups to estimate average treatment effects (Angrist 2008; Wooldridge 2006; Kutner et al. 2004). DD is well-suited to this analytical exercise, involving natural experiments, with some limitations (Tyler, Murnane & Willett 2000; Card & Krueger 1994; Conley & Taber 2011). For our purposes, the D/D method provides statistics to compare before and after effects. The difference-in-differences estimator measures the change in subscribership output after bundling rule changes in treatment countries, with controls for average subscribership growth across EU 15 and EU 27 countries. Due to the partial and delayed nature of Belgium’s implementation of handset bundles, three time periods are tested for output effects, as seen in Figure 3.

F. Data

The primary source of our data is the Wireless Intelligence Database of the GSM Association. Quarterly data on 3G connections and covariates for each of 27 European Union countries provide 1,080 observations, 913 of which are available for 3G connections. The gross domestic product is indexed by purchasing power standard, according to Eurostat.

Table 4. Descriptive Statistics for EU 27 Dataset from 2003Q1 – 2012Q4

| Description | Obs. | Mean | Std. Dev. | Min | Max |
|-------------------------|-------|------------|------------|---------|------------|
| 3G Connections per 100 | 913 | 26.63 | 25.82 | 0.00 | 118.62 |
| 2G Connections per 100 | 1,080 | 88.82 | 20.35 | 23.98 | 146.17 |
| Mobile Sector HHI | 1,080 | 3707 | 781 | 2226 | 6544 |
| GDP in PPS | 1,080 | 98 | 43 | 31 | 275 |
| Population | 1,080 | 18,400,000 | 22,700,000 | 404,151 | 82,500,000 |
| Density (Pop / Sq. Km.) | 1,080 | 170 | 238 | 15 | 1312 |

Source: Wireless Intelligence Database, 2013 and Eurostat, 2013.

In the econometric model we designate control groups as EU 15/27 countries excluding Finland or Belgium. The EU 15 countries are the most affluent of the EU 27. Finland and Belgium are both considered EU 15 countries, and our analysis includes EU 27 as a robustness check. Covariates include other features of national economies that may affect 3G penetration rates. These include the Herfindahl-Hirschman Index, charting market concentration among mobile carriers, gross national product in purchasing price standard, population density, and 2G connections.

G. Econometric Model

We seek to measure 3G subscribership before and after implementation of laws that permitted handset bundles, while adjusting for general trends seemingly unrelated to the policy switches. Our study focuses on estimates of differences in 3G connections in equation (1) and \ln 3G connections in equation (2). Equation (1) provides statistical comparison of 3G connections before and after the policy switch. Equation (2) uses the natural log of 3G connections to consider relative changes in 3G connections over time.

We measure 3G connections per 100 people and \ln 3G connections per 100 people in two regression models:

- (1) $3G_{it} = \beta_0 + \beta_1 Policy_{it} + \beta_2 Country_{it} + \beta_3 Country_{it} * Policy_{it} + \Omega_{it} + e_{it}$, and,
- (2) $\ln 3G_{it} = \beta_0 + \beta_1 Policy_{it} + \beta_2 Country_{it} + \beta_3 Country_{it} * Policy_{it} + \Omega_{it} + e_{it}$,

for all $i = 1$ to 27 countries and $t = 1$ to 40 quarters, where $\text{Country}_{it} = 1$ for Finland / Belgium, 0 for EU 15/27 excluding Finland / Belgium, $\text{Policy}_{it} = 1$ for after bundling, 0 for before bundling, with an interaction term, $\text{Country}_{it} * \text{Policy}_{it} = 1$ for Finland / Belgium after bundling. Vector Ω_{it} of covariates includes $\ln(\text{HHI}) = \text{HHI}$ concentration per quarter, $\ln(\text{GDP}) = \text{GDP}$ in PPS per year, $\ln(\text{Density}) = \text{population density}$ per quarter, $2\text{G} = 2\text{G Connections}$ and $\ln(2\text{G}) = \ln(2\text{G Connections})$ per quarter. Mean 3G connections or $\ln 3\text{G connections}$, \bar{Y} , are estimated for the before and after periods for the treatment and control groups in a standard difference-in-differences format, $\alpha = E[Y_{it} | \text{Country}_{it}=1, \text{Policy}_{it}=1] - E[Y_{it} | \text{Country}_{it}=1, \text{Policy}_{it}=0] - (E[Y_{it} | \text{Country}_{it}=0, \text{Policy}_{it}=1] - E[Y_{it} | \text{Country}_{it}=0, \text{Policy}_{it}=0]) = (\bar{Y}_{11} - \bar{Y}_{10}) - (\bar{Y}_{01} - \bar{Y}_{00})$.

Mean level effects are generated from the coefficients as follows, $\bar{Y}_{11} = \beta_0 + \beta_1 \text{Policy}_{it} + \beta_2 \text{Country}_{it} + \beta_3 \text{Country}_{it} * \text{Policy}_{it}$ which represents the treatment country effect after the policy change, $\bar{Y}_{10} = \beta_0 + \beta_2 \text{Country}_{it}$, which represents the treatment country effect before the policy change, $\bar{Y}_{01} = \beta_0 + \beta_1 \text{Policy}_{it}$ which represents the EU control effect after the policy change, and $\bar{Y}_{00} = \beta_0$ which represents the EU control effect before the policy change. We estimate $\hat{\alpha}$, and consider the effects of policy on 3G connections and $\ln 3\text{G connections}$ with respect to the EU15/27 control. The difference-in-differences estimator reduces to the coefficient on the interaction variable, $\beta_3 \text{Country}_{it} * \text{Policy}_{it}$. Estimated means are described by the coefficients, $\beta_3 \text{Country}_{it} * \text{Policy}_{it}$, which is the difference-in-differences of the country minus EU average, $\beta_1 \text{Policy}_{it} + \beta_3 \text{Country}_{it} * \text{Policy}_{it}$ which is the difference for the treatment country from after effects minus before effects, and $\beta_1 \text{Policy}_{it}$ which describes the EU average difference from after minus before effects.

We present the null hypothesis as follows. If handset bundling is part of a vertical scheme to foreclose competition, the implication is that bundling will be correlated with lower output. Conversely, the intent of prohibition, as stated by regulators and scholarly advocates of the policy, is to increase output. We therefore set the null hypothesis, H_0 , as predicting that the prohibition of bundles is positively related to higher output and the legality of bundles as negatively related to higher output, $H_0: \beta_3 < 0$. Alternatively, H_1 implies a negative correlation with bundling prohibitions and a positive correlation with legal bundling, $H_1: \beta_3 > 0$. A positive difference-in-differences estimator, β_3 , will indicate a rejection of the null hypothesis, H_0 . Three time periods are tested for the Belgian case to account for Belgium's staged legalization of handset bundling. The first period is 2010Q3-2012Q4, the second period (partial deregulation) is 2011Q1-2012Q4, and the third period (delayed implementation) is 2012Q1-2012Q4.

IV. Results

DD regressions compared 3G subscribership in each treatment country with EU averages in time periods following policy switches. In Finland, the DD estimator in 3G connections was highly positive, whereas the DD estimator in $\ln 3\text{G connections}$ had a smaller effect. In Belgium, the DD in 3G connections showed that Belgium adopted fewer 3G connections than the EU average, indicated by a negative coefficient. The three

time periods show positive differences above the EU average, and less negative deficits in 3G connections in each of the time periods for partial and delayed implementation of handset bundling. The null hypothesis, H_0 , is rejected for equation (1) in most cases, and is rejected for equation (2) in all test cases, as summarized in Table 5.

Table 5. 3G Connections and ln 3G Connections: Summary of Results

| Equation | Treatment/Control | Bundling Period | $H_0 : \beta_3$ Predicts | β_3 Result | Stat. Signif? | Reject H_0 |
|-----------------------|-------------------|-----------------|-----------------------------|---------------------|------------------|-----------------|
| (1) 3G Connections | Finland/EU15/27 | 2006Q3-2012Q4 | - | + | Yes | Yes |
| (1) 3G Connections | Belgium/EU15/27 | 2010Q3-2012Q4 | - | - | Yes | No |
| (1) 3G Connections | Belgium/EU15/27 | 2011Q1-2012Q4 | - | - | Yes | No |
| (1) 3G Connections | Belgium/EU15/27 | 2012Q1-2012Q4 | - | - | Yes | No |
| (2) ln 3G Connections | Finland/EU15/27 | 2006Q3-2012Q4 | - | + | No | No |
| (2) ln 3G Connections | Belgium/EU15/27 | 2010Q3-2012Q4 | - | + | Yes | Yes |
| (2) ln 3G Connections | Belgium/EU15/27 | 2011Q1-2012Q4 | - | + | Yes | Yes |
| (2) ln 3G Connections | Belgium/EU15/27 | 2012Q1-2012Q4 | - | + | Yes | Yes |

A. Finland

In Finland, the end of the bundling ban is highly correlated to a dramatic rise in 3G connections over the EU average. Table 6 shows the difference-in-differences results with before and after levels of 3G connections for the treatment and control groups.

Columns (1) and (2) include the before and after levels in 3G connections and ln 3G connections for Finland. Columns (3) and (4) include the before and after data for EU 15/27 control groups excluding Finland. Columns (5) and (6) include mean \bar{Y} estimates for the differences by subtracting the before level from the after level of 3G subscribers. Column (7) indicates the difference-in-differences estimator as the difference in means by subtracting the EU difference from the Finnish treatment group.

Table 6. 3G Connections in Finland with Bundling from 2006Q3 – 2012Q4

| | Finland (Treatment) | | EU15/27 (Control) | | Difference | | D/D Coeff. |
|-----------|------------------------|-----------------|----------------------|-----------------|-----------------|-----------------|-------------------|
| | Before | After | Before | After | Finland | EU15/27 | |
| | (1) | (2) | (3) | (4) | (2)-(1) (5) | (4)-(3) (6) | (5)-(6) (7) |
| 3G, EU 15 | 1.08 (0.90) | 54.93 (9.14) | 3.02 (0.35) | 40.66 (1.75) | 53.85 (8.24) | 37.64 (1.40) | 16.21** (6.84) |
| 3G, EU 27 | 1.08 | 54.93 | 2.60 | 33.10 | 53.85 | 30.49 | 23.36*** |

| | | | | | | | |
|--------------|--------|--------|--------|--------|--------|--------|--------|
| | (0.78) | (8.52) | (0.28) | (1.26) | (7.74) | (0.98) | (6.76) |
| ln 3G, EU 15 | -0.78 | 3.71 | -0.16 | 3.42 | 4.49 | 3.58 | 0.92 |
| | (0.81) | (1.65) | (0.17) | (0.34) | (0.84) | (0.17) | (0.67) |
| ln 3G, EU 27 | -0.78 | 3.71 | -0.30 | 3.10 | 4.49 | 3.41 | 1.09 |
| | (0.77) | (1.57) | (0.13) | (0.27) | (0.80) | (0.14) | (0.66) |
| EU 15 Obs. | 7 | 26 | 146 | 364 | 33 | 510 | 543 |
| EU 27 Obs. | 7 | 26 | 205 | 675 | 33 | 880 | 913 |

EU 15/27 controls exclude Finland. Robust standard errors in parentheses. *** p<0.01 ** p<0.05, * p<0.1

The estimated increase in Finland of 3G connections over the EU 15/27 average in the after period of 2006Q3 to 2012Q4 is shown in Column (7) as 16.21 connections per 100 people over the EU 15 average, and 23.36 connections per 100 people over the EU 27 average. These are statistically significant and positive differences, with R^2 values 0.382 and 0.283 respectively. The null hypothesis, $H_0: \beta_3 < 0$, is rejected here. Similar results are seen in ln 3G connections. The difference-in-differences estimator in Column (7) says that ln 3G connections rose in Finland, 0.92 and 1.09, more than in the EU 15 and EU 27. These are not statistically significant increases, albeit positive, however. R^2 values are 0.611 and 0.559. The null hypothesis, $H_0: \beta_3 < 0$, cannot be rejected.

An important explanation for this result in the difference in ln 3G connections is the short time period before the policy change from 2003Q1 to 2006Q2 where 3G connections were as low as 1 to 3 connections per 100 people. In a natural log transformation, the growth rates are much steeper in the early period, than the later, where each incremental connection accounts for a high percentage of growth from the prior period. The result from the ln 3G connections regression is depicted in Figure 4.

B. Belgium

In Belgium, the severe lag in 3G adoption below its EU 15 peers warrants closer analysis due to local events in bundling constraints. Several reasons can explain the unusual deficit in Belgian uptake of 3G connections. The six-month maximum on the length of subscription contracts may give rise to a partial deregulation of bundling restrictions given the 12 to 24-month international practice (Martens 2010). The continued delay by Belgian operators to implement handset subsidies after 2012 also may explain Belgian outcomes.

In Table 7, the estimated growth in Belgium of 3G connections over the EU 15/27 average during the after period of 2010Q3 to 2012Q4 is shown in Column (7) as -20.59 connections per 100 people and -12.63 connections per 100 people. These are statistically significant and negative differences, with R^2 values 0.570 and 0.508 respectively. The null hypothesis, $H_0: \beta_3 < 0$, is not rejected here due to the negative difference in gains in 3G connections in Belgium.

Table 7. 3G Connections in Belgium with Bundling from 2010Q3 – 2012Q4

| | Belgium (Treatment) | | EU15/27 (Control) | | Difference | | D/D Coeff. |
|--------------|---------------------|-----------------|-------------------|-----------------|-----------------|-----------------|---------------------|
| | Before | After | Before | After | Belgium | EU15/27 | |
| | (1) | (2) | (3) | (4) | (2)-(1) (5) | (4)-(3) (6) | (5)-(6) (7) |
| 3G, EU 15 | 4.82 (2.42) | 32.41 (7.88) | 18.68 (0.97) | 66.86 (3.01) | 27.59 (5.46) | 48.18 (2.03) | -20.59*** (3.43) |
| 3G, EU 27 | 4.82 (1.92) | 32.41 (6.62) | 15.27 (0.66) | 55.49 (2.21) | 27.59 (4.70) | 40.22 (1.54) | -12.63*** (3.16) |
| ln 3G, EU 15 | 0.31 (0.54) | 3.45 (1.10) | 1.87 (0.11) | 4.15 (0.22) | 3.13 (0.55) | 2.28 (0.11) | 0.85* (0.44) |
| ln 3G, EU 27 | 0.31 (0.50) | 3.45 (1.02) | 1.71 (0.08) | 3.94 (0.16) | 3.13 (0.52) | 2.22 (0.08) | 0.91** (0.43) |
| EU 15 Obs. | 25 | 10 | 368 | 140 | 35 | 508 | 543 |
| EU 27 Obs. | 25 | 10 | 618 | 260 | 35 | 878 | 913 |

EU 15/27 controls exclude Belgium. Robust standard errors in parentheses. ***p<0.01 **p<0.05, *p<0.1

However, examination of results from equation (2) indicates a different result. The difference-in-differences estimator in Column (7) says that ln 3G connections rose in Belgium by 0.85 and 0.91, above the EU 15 and EU 27. These are statistically significant increases and the null hypothesis, $H_0: \beta_3 < 0$, is rejected, with R^2 values 0.276 and 0.293.

An important explanation of this result is the rate of change in Belgium over time. Although it lagged the EU 15/27 average in the after period in absolute 3G connections, the change in ln 3G connections exceeded that of the EU average. In a natural log transformation, regressions provide a view of growth that incorporate relative changes over time.

In a closer look at subscribership in Belgium, we see that 3G connections lagged the levels seen in the rest of Europe. We then conducted additional tests on two other bundling periods, to investigate whether partial and delayed implementation of bundling in 2011 and 2012 show the estimator becoming less negative over time in 3G connections, or more positive over time in ln 3G connections.

For each of the three bundling periods, the regressions on equation (1) and equation (2) are repeated and summarized. The change in the difference-in-differences coefficient is presented to compare output effects on each of the three periods. We find that there is improvement with later periods of bundling implementation, consistent with the Belgian story of partial and delayed bundling implementation.

Table 8. Difference-in-Differences Results for 3G Connections in Belgium

| <i>3G Connections</i> | Bundling Period | D/D Coeff. | Robust SE | t | Obs. | R ² |
|-----------------------|-----------------|------------|-----------|-------|------|----------------|
| EU 15 | 2010Q3-2012Q4 | -20.59*** | 3.43 | -6.01 | 543 | 0.570 |
| | 2011Q1-2012Q4 | -19.29*** | 3.49 | -5.53 | 543 | 0.499 |
| | 2012Q1-2012Q4 | -16.45*** | 3.88 | -4.24 | 543 | 0.297 |
| EU15 with covariates | 2010Q3-2012Q4 | -14.56*** | 3.17 | -4.6 | 543 | 0.637 |
| | 2011Q1-2012Q4 | -11.16*** | 3.19 | -3.5 | 543 | 0.587 |
| | 2012Q1-2012Q4 | -4.71 | 3.59 | -1.31 | 543 | 0.490 |
| EU 27 | 2010Q3-2012Q4 | -12.63*** | 3.16 | -4 | 913 | 0.508 |
| | 2011Q1-2012Q4 | -11.66*** | 3.16 | -3.69 | 913 | 0.453 |
| | 2012Q1-2012Q4 | -9.47*** | 3.33 | -2.84 | 913 | 0.274 |
| EU 27 with covariates | 2010Q3-2012Q4 | -8.16*** | 2.68 | -3.05 | 913 | 0.643 |
| | 2011Q1-2012Q4 | -6.69** | 2.62 | -2.55 | 913 | 0.601 |
| | 2012Q1-2012Q4 | -3.68 | 2.70 | -1.37 | 913 | 0.493 |

Table 9. Difference-in-Differences Results for ln 3G Connections in Belgium

| <i>ln 3G Connections</i> | Bundling Period | D/D Coeff. | Robust SE | t | Obs. | R ² |
|--------------------------|-----------------|------------|-----------|------|------|----------------|
| EU 15 | 2010Q3-2012Q4 | 0.85* | 0.44 | 1.92 | 543 | 0.276 |
| | 2011Q1-2012Q4 | 0.84* | 0.43 | 1.95 | 543 | 0.222 |
| | 2012Q1-2012Q4 | 0.82** | 0.41 | 1.98 | 543 | 0.119 |
| EU15 with covariates | 2010Q3-2012Q4 | 0.54 | 0.46 | 1.18 | 543 | 0.306 |
| | 2011Q1-2012Q4 | 0.73 | 0.45 | 1.63 | 543 | 0.247 |
| | 2012Q1-2012Q4 | 1.12*** | 0.43 | 2.62 | 543 | 0.159 |
| EU 27 | 2010Q3-2012Q4 | 0.91** | 0.43 | 2.1 | 913 | 0.293 |
| | 2011Q1-2012Q4 | 0.9** | 0.43 | 2.11 | 913 | 0.236 |
| | 2012Q1-2012Q4 | 0.87** | 0.41 | 2.12 | 913 | 0.122 |
| EU 27 with covariates | 2010Q3-2012Q4 | 0.79* | 0.43 | 1.85 | 913 | 0.352 |
| | 2011Q1-2012Q4 | 0.86** | 0.42 | 2.04 | 913 | 0.293 |
| | 2012Q1-2012Q4 | 1.01** | 0.40 | 2.49 | 913 | 0.191 |

Tables 8 and 9 compare results from three bundling periods, 2010Q3 to 2012Q4 (the baseline case tested above), 2011Q1 to 2012Q4, and 2012Q1 to 2012Q4. The difference-in-differences estimator from equation (1) shows that the 3G subscribership differential becomes less negative, and the estimator for equation (2) shows that ln 3G connections becomes more positive when accounting for covariates in later quarters. The

difference-in-differences level of 3G connections with covariates, for instance, is estimated as -14.56 in the earliest period, where the deficit shrinks in later periods, to -11.16 to -4.71. The estimator for ln 3G connections with covariates follows similar behavior, where ln 3G connections increase from 0.54, 0.73, to 1.12. Without covariates, the difference-in-differences for ln 3G connections appears to decline with small increments with a low R^2 . This ambiguous result can be tested with more data to increase the sample size for comparison of additional quarters of 3G connections.

Consistent with the baseline case in Belgium, the null hypothesis, $H_0: \beta_3 < 0$, is rejected for later periods of partial and delayed implementation of handset bundling. Handset bundling, albeit in limited forms in 2011 and 2012, is correlated with positive differences in ln 3G connections for all three time periods. The three time periods also provide estimates of changes in 3G subscribership through various bundling policy changes. The negative coefficient remains for 3G connections, but the estimates become less negative. The positive coefficient grows for ln 3G connections over time when including covariates, with ambiguous effects without covariates. Overall, the exercise to investigate later time segments allows for robustness checks on the result.

Other robustness checks confirm this analysis. Regressions with covariates include and exclude 2G connections, as seen in the Appendix. The negative coefficient on ln(HHI) in regression results is expected, where higher levels of concentration indicate less competition, higher prices, and lower output in 3G connections. The positive coefficient on ln(GDP in PPS) is expected, where higher gross domestic product in purchasing price standard indicates more income to purchase consumer goods and services such as 3G connections. The negative coefficient on ln(Density) is explained by an investigation of mean values of country level data, where some countries have large land area with small concentrated populations, lowering the level of population density without accounting for the distribution of urban centers. While density may explain economies of scale from mobile network deployment, this metric measures populated land areas and total land area with uniform treatment. The coefficients on 2G connections in equation (1) and ln 2G connections in equation (2) are negative. This negative correlation to 3G connections may be explained by the replacement of 2G connections with 3G connections. To account for the transition to 3G services, we include regressions excluding the 2G connections covariate as well. Results, as listed in the Appendix, are robust with respect to 2G connections. Heteroskedastic-consistent standard errors are checked through application of robust standard errors in ordinary least squares analysis.

V. Mobile Handsets and Service Adoption

Empirical examples of anti-competitive foreclosure are limited in the literature; studies generally find that vertical integration, and its contractual cousin—bundling—are efficient and pro-consumer (Cooper et al. 2005; Lafontaine & Slade 2007; Riordan 2008; Owen 2011). Since 2007, vertical restraints, which were often struck down in antitrust law under a *per se* rule against price-fixing in the past, are now evaluated under the rule of reason standard (Leegin 2007). While the antitrust bar accepts this view of non-price vertical conduct, Liebowitz and Margolis (2008, p. 42) note, telecom policy scholars

have often remained skeptical: “Arguably it is now telecommunications law that is the arena that is most hostile to bundles and tie-in sales.” Tim Wu, Rob Frieden, and others allege consumers are harmed by carrier control over handsets. The output expansions in Finland, particularly, and in Belgium after deregulation undermine that view.

Consistent with the data, it is likely that mobile handset subsidies enable efficiencies. Vertical integration assists coordinating investments in developing ecosystems. Network effects in handset adoption impact the development of content and applications that complement 3G devices. By subsidizing new, costly, and more functional phones for customers, the mobile carrier helps to “seed” network growth. So long as the network can reasonably recoup subsidies via long-term service contracts, the result is a positive-sum game: a valuable ecosystem is created, delivering net benefits to consumers and suppliers. In effect, the wireless operator internalizes externalities by contracting with handset manufacturers (Liebowitz & Margolis 1994; Barnett 2011).

Technology platforms have substantial network effects. 3G technology ushered in new opportunities for mobile data usage, but the creation of applications – exploiting these opportunities – required an “installed base” in order to attract investments in such complements. Carriers and handset makers confront a chicken-egg problem: (a) at first, potential 3G customers will find almost no apps and no social networks, and hence evince little demand for expensive new 3G phones; and (b) at first, software developers will not write apps for a nonexistent market. Technology companies have devised ways to get around these coordination problems, including giving away (or subsidizing) software or hardware to gain a critical mass of users (Barnett 2011, pp. 1875-89). Subsidizing handsets also encourages adoption by revealing carriers’ commitments to supporting the technology. In this way, the carriers encourage platform development, increasing demand for the wireless services they supply.

Retail product bundles can provide other efficiencies. Consumers may benefit from a reduction in search costs and transaction costs (Tallberg et al. 2007, p. 649). Because consumers, as a practical matter, use their phones with a particular carrier, one-stop shopping benefits the consumer as two transactions become one. As demonstrated in Finland, bundling restrictions increased search costs for consumers who frequently could not figure out how to access the network with their devices. Information was fragmented when retail interfaces were separated between handset manufacturer and mobile operator (Saarikoski 2006, p. 65). This depressed demand for devices and advanced networks.

VI. Conclusion

Two natural experiments in bundling policy have demonstrated significant output effects. The evidence does not support the view that bundling 3G handsets with 3G network service contracts restricts consumer welfare; indeed, the positive effect of deregulation in both Finland and Belgium, albeit in differing doses and under distinct conditions, supports the view that the integrated offerings common in the marketing of

mobile services allow firms and consumers to realize, and share, efficiency gains. It bears noting that this is the conclusion not only of the observed empirical results, but of regulators in both Finland and Belgium, who moved to relax the prohibition on bundling in order to stimulate growth in the sector.

Appendix A: Data Sources

Wireless Intelligence Database: Our main source of data was the Wireless Intelligence database of the GSM Association, London, United Kingdom. This data includes 1,080 observations of quarterly data for 3G mobile connections in 27 European Union countries, between 2003Q1 and 2012Q4. The sample includes the following 27 countries: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. EU 15 countries with greater mean quarterly GDP between 2003 and 2012 include: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, United Kingdom, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom, with quarterly GDP in millions of euro (from 1.1.1999), code `namq_gdp_c`, not seasonally adjusted data, at current prices, from Eurostat, 2013, http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/database. A note is warranted on other data sources for mobile 3G penetration rates. International Telecommunications Union mobile broadband indicator definitions have changed several times during the same period, and were not included in this study, notably, `271mb` (2007); `271mb_use` (2010); `911mb_active` (2011); `271mw` (2011); `i271mw` (2011); or `911mw` (2012). The European Commission Digital Scorecard/COCOM dataset also has discontinuities and were not included here, notably, `mbb_penet` (2012); or `i_iu3g` (2012).

3G Connections: The Wireless Intelligence Database considers third-generation (3G) network technologies, CDMA2000 1xEV-DO, CDMA2000 1xEV-DO Rev. A, CDMA2000 1xEV-DO Rev. B, WCDMA, WCDMA HSPA, and TD-SCDMA. Wireless Intelligence classifies a connection as registered on a mobile network at the end of the period for 3G unique SIM cards (or phone numbers, where SIM cards are not used).

2G Connections: The Wireless Intelligence Database considers second-generation (2G) network technologies, cdmaOne, CDMA2000 1X, GSM, PDC, PHS, iDEN, and TDMA.

Herfindahl-Hirschman Index: The Wireless Intelligence Database includes a quarterly measure of market concentration from 0 (even competition) to 10,000 (no competition).

Population: The Wireless Intelligence Database includes quarterly population data, sourced from United Nations, Population Division World Population Prospects, which counts all residents at the end of each period.

GDP in PPS: Eurostat provides GDP per capita in Purchasing Power Standards (PPS), code `tec00114`, from 2003 to 2012, indexed by EU28=100 and EU27=100, http://epp.eurostat.ec.europa.eu/portal/page/portal/purchasing_power_parities/data/main_tables.

Population Density: Calculated from quarterly population data and country area in square kilometers from the World Bank World Development Indicators (WDI) database, 2013.

Appendix B: Data Summary and Regression Results

Table B1. Mean Values for Countries in the EU 27 Dataset from 2003Q1 – 2012Q4

| Country | EU 15 | 3G | 2G | HHI | GDP | Population | Density |
|----------------|-------|------|-------|------|-----|------------|---------|
| Austria | Yes | 37.7 | 82.3 | 3104 | 127 | 8,311,836 | 99 |
| Belgium | Yes | 12.7 | 88.1 | 3580 | 119 | 10,566,781 | 346 |
| Bulgaria | No | 16.0 | 85.5 | 4497 | 41 | 7,610,947 | 69 |
| Cyprus | No | 25.0 | 83.7 | 4849 | 94 | 1,069,219 | 116 |
| Czech Republic | No | 11.8 | 101.1 | 3576 | 80 | 10,365,493 | 131 |
| Denmark | Yes | 32.3 | 90.7 | 2874 | 125 | 5,488,226 | 127 |
| Estonia | No | 17.9 | 91.2 | 3666 | 64 | 1,343,698 | 30 |
| Finland | Yes | 43.5 | 88.6 | 3519 | 116 | 5,307,339 | 16 |
| France | Yes | 21.2 | 64.8 | 3737 | 109 | 61,925,864 | 113 |
| Germany | Yes | 20.6 | 89.5 | 2973 | 117 | 82,383,817 | 231 |
| Greece | Yes | 33.9 | 96.8 | 3401 | 89 | 11,274,426 | 85 |
| Hungary | No | 18.7 | 79.6 | 3667 | 64 | 10,033,764 | 108 |
| Ireland | Yes | 29.0 | 80.7 | 3665 | 137 | 4,318,834 | 61 |
| Italy | Yes | 36.9 | 94.2 | 3135 | 104 | 59,620,823 | 198 |
| Latvia | No | 14.9 | 70.0 | 4355 | 54 | 2,278,310 | 35 |
| Lithuania | No | 16.1 | 100.7 | 3540 | 60 | 3,367,532 | 52 |
| Luxembourg | No | 40.5 | 104.7 | 4373 | 263 | 483,755 | 187 |
| Malta | No | 28.6 | 74.0 | 4789 | 83 | 412,960 | 1291 |
| Netherlands | Yes | 21.0 | 85.8 | 3366 | 131 | 16,461,939 | 396 |
| Poland | Yes | 19.5 | 71.9 | 3069 | 57 | 38,227,845 | 122 |
| Portugal | Yes | 41.6 | 95.1 | 3526 | 79 | 10,608,525 | 115 |
| Romania | No | 18.5 | 68.4 | 3725 | 42 | 21,625,851 | 91 |
| Slovakia | No | 17.3 | 76.4 | 4473 | 67 | 5,440,675 | 111 |
| Slovenia | No | 21.4 | 74.2 | 5334 | 86 | 2,016,707 | 99 |
| Spain | Yes | 30.1 | 79.1 | 3505 | 102 | 44,747,755 | 89 |
| Sweden | Yes | 47.0 | 75.2 | 3328 | 125 | 9,213,595 | 20 |
| United Kingdom | Yes | 30.3 | 83.0 | 2461 | 116 | 61,176,065 | 251 |

Source: Wireless Intelligence Database, 2013, Eurostat, 2013, World Bank World Development Indicators (WDI), 2013. The dataset includes quarterly data for 27 countries between 2003Q1 and 2012Q4. 3G is 3G connections per 100 people. 2G is 2G connections per 100 people. EU 15 countries are selected from mean quarterly GDP in current prices from 2003 to 2012. GDP in purchasing price standard is provided on an annual basis from Eurostat. Area is in square kilometers. Density is in population per square kilometer.

Table B2. Regression Results for 3G Connections in Finland

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|-------------------------------|-----------------------|-----------------------|---------------------------|-----------------------|-----------------------|
| Indicators | 3G Connections Per 100 People | | | | | |
| | EU 15 (excluding Finland) | | | EU 27 (excluding Finland) | | |
| <i>Country*Policy</i> | 16.21** (6.841) | 12.54* (6.819) | 15.17*** (5.662) | 23.36*** (6.758) | 19.27*** (6.757) | 18.23*** (5.828) |
| <i>Policy</i> | 37.64*** (1.400) | 37.43*** (1.408) | 30.55*** (1.412) | 30.49*** (0.982) | 31.52*** (1.134) | 29.27*** (0.975) |
| <i>Country</i> | -1.94*** (0.552) | -16.79*** (3.188) | -5.48* (2.847) | -1.52*** (0.508) | -10.16*** (2.334) | -8.48*** (2.448) |
| ln(HHI) | | -38.84*** (6.178) | -38.44*** (4.763) | | -28.90*** (3.204) | -29.57*** (2.638) |
| ln(GDP) | | 3.55 (4.531) | -4.86 (4.154) | | 17.23*** (1.927) | 13.71*** (1.520) |
| ln(Density) | | -9.68*** (1.547) | -5.23*** (0.788) | | -3.67*** (1.054) | -3.61*** (0.691) |
| 2G Connections | | | -0.81*** (0.052) | | | -0.62*** (0.031) |
| Constant | 3.02*** (0.350) | 346.96*** (53.181) | 437.27*** (41.685) | 2.60*** (0.276) | 177.22*** (28.271) | 256.30*** (24.770) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.382 | 0.454 | 0.664 | 0.283 | 0.403 | 0.615 |

Robust standard errors in parentheses

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

**Table B3. Regression Results for 3G Connections in Belgium
(Bundling Period 2010Q3 – 2012Q4)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|-------------------------------|-----------------------|-----------------------|---------------------------|----------------------|-----------------------|
| Indicators | 3G Connections Per 100 People | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | -20.59*** (3.426) | -20.96*** (3.270) | -14.56*** (3.167) | -12.63*** (3.156) | -12.83*** (3.039) | -8.16*** (2.675) |
| <i>Policy</i> | 48.18*** (2.035) | 47.45*** (1.787) | 39.36*** (2.408) | 40.22*** (1.544) | 39.54*** (1.340) | 33.24*** (1.320) |
| <i>Country</i> | -13.86*** (1.446) | -2.50 (1.939) | -2.49 (2.098) | -10.45*** (1.257) | -10.74*** (1.478) | -10.95*** (1.695) |
| ln(HHI) | | -26.72*** (5.861) | -29.96*** (5.663) | | -17.72*** (2.702) | -20.53*** (2.520) |
| ln(GDP) | | 3.30 (3.446) | -0.26 (3.669) | | 17.17*** (1.372) | 15.08*** (1.182) |
| ln(Density) | | -7.57*** (1.116) | -6.92*** (0.988) | | -3.27*** (0.828) | -3.31*** (0.718) |
| 2G Connections | | | -0.32*** (0.070) | | | -0.31*** (0.031) |
| Constant | 18.68*** (0.973) | 254.27*** (52.237) | 324.09*** (52.748) | 15.27*** (0.663) | 97.60*** (24.009) | 160.40*** (22.765) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.570 | 0.616 | 0.637 | 0.507 | 0.601 | 0.643 |

Robust standard errors in parentheses

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

Table B4. Regression Results for 3G Connections in Belgium (2)
(Bundling Period 2011Q1 – 2012Q4)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|-------------------------------|-----------------------|-----------------------|---------------------------|-----------------------|-----------------------|
| Indicators | 3G Connections Per 100 People | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | -19.29*** (3.488) | -19.48*** (3.296) | -11.16*** (3.185) | -11.66*** (3.158) | -11.62*** (3.003) | -6.69** (2.620) |
| <i>Policy</i> | 48.36*** (2.255) | 47.50*** (1.974) | 36.01*** (2.723) | 40.73*** (1.706) | 39.82*** (1.477) | 32.40*** (1.487) |
| <i>Country</i> | -15.24*** (1.673) | -3.80* (2.169) | -3.20 (2.335) | -11.48*** (1.484) | -11.80*** (1.672) | -11.65*** (1.864) |
| ln(HHI) | | -27.27*** (6.305) | -31.77*** (5.934) | | -19.45*** (2.890) | -22.42*** (2.681) |
| ln(GDP) | | 2.91 (3.659) | -1.93 (4.070) | | 16.65*** (1.466) | 14.39*** (1.288) |
| ln(Density) | | -7.62*** (1.239) | -6.72*** (1.055) | | -3.21*** (0.883) | -3.26*** (0.757) |
| 2G Connections | | | -0.44*** (0.074) | | | -0.35*** (0.032) |
| Constant | 21.29*** (1.048) | 263.32*** (55.301) | 358.76*** (54.598) | 17.53*** (0.713) | 116.00*** (25.706) | 184.39*** (24.170) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.499 | 0.546 | 0.587 | 0.453 | 0.546 | 0.601 |

Robust standard errors in parentheses

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

**Table B5. Regression Results for 3G Connections in Belgium (3)
(Bundling Period 2012Q1 – 2012Q4)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|-------------------------------|-----------------------|-----------------------|---------------------------|-----------------------|-----------------------|
| Indicators | 3G Connections Per 100 People | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | -16.45*** (3.879) | -16.02*** (3.566) | -4.71 (3.595) | -9.47*** (3.330) | -8.90*** (3.064) | -3.68 (2.695) |
| <i>Policy</i> | 48.25*** (3.049) | 46.80*** (2.686) | 26.83*** (3.294) | 41.27*** (2.315) | 39.78*** (1.989) | 28.81*** (1.990) |
| <i>Country</i> | -17.57*** (2.172) | -5.23* (2.718) | -2.75 (2.756) | -13.23*** (1.989) | -13.53*** (2.157) | -12.31*** (2.254) |
| ln(HHI) | | -32.44*** (7.460) | -38.32*** (6.380) | | -25.43*** (3.402) | -28.19*** (3.032) |
| ln(GDP) | | 1.08 (4.405) | -6.32 (5.028) | | 15.59*** (1.762) | 12.66*** (1.571) |
| ln(Density) | | -7.90*** (1.537) | -6.30*** (1.149) | | -3.08*** (1.038) | -3.19*** (0.841) |
| 2G Connections | | | -0.73*** (0.071) | | | -0.49*** (0.036) |
| Constant | 26.64*** (1.184) | 320.26*** (63.402) | 460.98*** (57.066) | 22.29*** (0.806) | 173.86*** (30.193) | 256.19*** (26.967) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.297 | 0.348 | 0.490 | 0.274 | 0.376 | 0.493 |

Robust standard errors in parentheses

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

Table B6. Regression Results for ln 3G Connections in Finland

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|---------------------------|---------------------|---------------------|---------------------------|---------------------|---------------------|
| Indicators | ln 3G Connections | | | | | |
| | EU 15 (excluding Finland) | | | EU 27 (excluding Finland) | | |
| <i>Country*Policy</i> | 0.92 (0.669) | 0.66 (0.657) | 0.69 (0.669) | 1.09 (0.660) | 0.84 (0.650) | 0.83 (0.669) |
| <i>Policy</i> | 3.58*** (0.174) | 3.58*** (0.166) | 3.52*** (0.182) | 3.41*** (0.139) | 3.48*** (0.129) | 3.43*** (0.136) |
| <i>Country</i> | -0.62 (0.644) | -1.27* (0.645) | -1.16* (0.661) | -0.48 (0.635) | -0.86 (0.633) | -0.78 (0.657) |
| ln(HHI) | | -2.42*** (0.428) | -2.40*** (0.428) | | -1.63*** (0.214) | -1.65*** (0.211) |
| ln(GDP) | | 0.93*** (0.348) | 0.85** (0.378) | | 1.16*** (0.106) | 1.08*** (0.117) |
| ln(Density) | | -0.45*** (0.069) | -0.41*** (0.078) | | -0.14*** (0.051) | -0.12** (0.049) |
| ln(2G) | | | -0.53** (0.250) | | | -0.97*** (0.170) |
| Constant | -0.16 (0.167) | 17.21*** (3.761) | 19.55*** (4.010) | -0.30** (0.133) | 8.33*** (1.886) | 13.19*** (2.147) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.611 | 0.657 | 0.660 | 0.559 | 0.642 | 0.655 |

Robust standard errors in parentheses

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

**Table B7. Regression Results for ln 3G Connections in Belgium
(Bundling Period 2010Q3 – 2012Q4)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|---------------------------|----------|----------|---------------------------|----------|----------|
| Indicators | ln 3G Connections | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | 0.85* | 0.80* | 0.54 | 0.91** | 0.91** | 0.79* |
| | (0.442) | (0.430) | (0.456) | (0.435) | (0.427) | (0.428) |
| <i>Policy</i> | 2.28*** | 2.24*** | 2.56*** | 2.22*** | 2.16*** | 2.31*** |
| | (0.112) | (0.113) | (0.241) | (0.082) | (0.083) | (0.130) |
| <i>Country</i> | -1.56*** | -1.12** | -1.11*** | -1.40*** | -1.61*** | -1.61*** |
| | (0.434) | (0.435) | (0.422) | (0.426) | (0.424) | (0.416) |
| ln(HHI) | | -1.99*** | -1.89*** | | -1.29*** | -1.22*** |
| | | (0.619) | (0.625) | | (0.312) | (0.316) |
| ln(GDP) | | 0.69 | 0.83* | | 0.91*** | 0.97*** |
| | | (0.487) | (0.504) | | (0.139) | (0.146) |
| ln(Density) | | -0.26*** | -0.29*** | | -0.01 | -0.02 |
| | | (0.086) | (0.092) | | (0.063) | (0.064) |
| ln(2G) | | | 0.97* | | | 0.59** |
| | | | (0.516) | | | (0.290) |
| Constant | 1.87*** | 15.87*** | 10.23 | 1.71*** | 8.18*** | 4.70 |
| | (0.109) | (5.467) | (6.662) | (0.078) | (2.650) | (3.299) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.276 | 0.300 | 0.306 | 0.293 | 0.348 | 0.352 |

Robust standard errors in parentheses

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

Table B8. Regression Results for ln 3G Connections in Belgium (2)
(Bundling Period 2011Q1 – 2012Q4)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|---------------------------|----------|----------|---------------------------|----------|----------|
| Indicators | ln 3G Connections | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | 0.84* | 0.81* | 0.73 | 0.90** | 0.91** | 0.86** |
| | (0.432) | (0.420) | (0.449) | (0.425) | (0.416) | (0.420) |
| <i>Policy</i> | 2.18*** | 2.12*** | 2.23*** | 2.13*** | 2.05*** | 2.12*** |
| | (0.109) | (0.111) | (0.247) | (0.079) | (0.081) | (0.134) |
| <i>Country</i> | -1.50*** | -1.05** | -1.05** | -1.35*** | -1.57*** | -1.57*** |
| | (0.426) | (0.428) | (0.425) | (0.419) | (0.416) | (0.413) |
| ln(HHI) | | -2.08*** | -2.05*** | | -1.43*** | -1.40*** |
| | | (0.645) | (0.648) | | (0.321) | (0.323) |
| ln(GDP) | | 0.66 | 0.70 | | 0.88*** | 0.90*** |
| | | (0.502) | (0.537) | | (0.144) | (0.154) |
| ln(Density) | | -0.26*** | -0.27*** | | -0.01 | -0.01 |
| | | (0.090) | (0.095) | | (0.065) | (0.066) |
| ln(2G) | | | 0.30 | | | 0.27 |
| | | | (0.521) | | | (0.302) |
| Constant | 2.02*** | 16.90*** | 15.16** | 1.87*** | 9.68*** | 8.11** |
| | (0.105) | (5.694) | (6.898) | (0.075) | (2.716) | (3.354) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.222 | 0.247 | 0.247 | 0.236 | 0.292 | 0.293 |

Robust standard errors in parentheses

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

**Table B9. Regression Results for ln 3G Connections in Belgium (3)
(Bundling Period 2012Q1 – 2012Q4)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------|---------------------------|---------------------|---------------------|---------------------------|---------------------|---------------------|
| Indicators | ln 3G Connections | | | | | |
| | EU 15 (excluding Belgium) | | | EU 27 (excluding Belgium) | | |
| <i>Country*Policy</i> | 0.82** (0.414) | 1.12*** (0.426) | 0.83** (0.402) | 0.87** (0.407) | 0.91** (0.397) | 1.01** (0.405) |
| <i>Policy</i> | 2.00*** (0.104) | 1.46*** (0.222) | 1.90*** (0.112) | 1.96*** (0.077) | 1.84*** (0.081) | 1.66*** (0.133) |
| <i>Country</i> | -1.39*** (0.411) | -0.85** (0.426) | -0.89** (0.415) | -1.25*** (0.404) | -1.47*** (0.401) | -1.44*** (0.407) |
| ln(HHI) | | -2.48*** (0.677) | -2.40*** (0.693) | | -1.80*** (0.335) | -1.85*** (0.332) |
| ln(GDP) | | 0.41 (0.590) | 0.57 (0.530) | | 0.82*** (0.153) | 0.76*** (0.167) |
| ln(Density) | | -0.23** (0.098) | -0.28*** (0.097) | | -0.00 (0.070) | 0.00 (0.069) |
| ln(2G) | | -1.19*** (0.440) | | | | -0.65** (0.295) |
| Constant | 2.28*** (0.098) | 26.86*** (6.806) | 20.28*** (6.070) | 2.14*** (0.070) | 13.16*** (2.817) | 16.71*** (3.244) |
| Observations | 543 | 543 | 543 | 913 | 913 | 913 |
| R-squared | 0.119 | 0.159 | 0.147 | 0.122 | 0.186 | 0.191 |

Robust standard errors in parentheses

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

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