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NATURAL EXPERIMENTS IN MOBILE PHONE REGULATION: ESTIMATED EFFECTS OF PROHIBITING HANDSET BUNDLING IN FINLAND AND BELGIUM

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Abstract

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 Wireless, Handset Subsidies

JEL Codes: K23, L14, L50, L96

1 Introduction

Today, the efficiency benefits of vertical restraints are frequently questioned in the mobile phone sector. In particular, the practice of tying mobile phone subscriptions with handset sales—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 2013). These foreclosure concerns contrast with findings by economists and antitrust experts who note that vertical integration in mobile markets allow for pro-competitive efficiencies that benefit consumers (Faulhaber & Farber 2010; Heatley & Howell 2009; Liebowitz & Margolis 2008; Ford et al. 2009; Hahn et al. 2007; Schwartz & Mini 2007). Economists have noted potential efficiencies in upstream inputs of the mobile network (Mayo & Wallsten 2010), and economists conducting laboratory experiments have found that bundling is efficient, extending 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). Customers may lose some choices when differentiated goods are packaged into retail combinations (Liebowitz & Margolis 2008), but overall there is social welfare gain from bundled products. Importantly, there now exist natural experiments, or quasi-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, but later reversed the policies. The use, and then removal, of these regulations yield valuable evidence from European markets.

2 Handset Bundling and Subsidies in Mobile Service Contracts

Mobile telecommunications services are typically sold either pre-paid or post-paid. In the former, the customer generally buys a mobile phone and a card yielding a fixed supply of minutes. The mobile carrier is then obligated to deliver the service purchased. As minutes are used, new cards are bought. When the phone becomes obsolete, as per the introduction of newer models, the wireless user elects when to buy a new device, again paying for the unit directly. In the post-paid contract, the customer commits to paying a monthly bill over a period of time, often two years. In exchange, the mobile network commits to a given pricing schedule. In addition, the carrier typically subsidizes the cost of the handset or other device that the subscriber uses to access the network. When these handset subsidies are in place, the contract mandates a term of service, a period during which the carrier will be "paid back" for the phone. (Monetary payments – "early termination fees" – are included should the subscriber exit the contract early.) This form of contract combines the sale of handsets and wireless services, possibly achieving efficiencies. Alternatively, the "tying arrangement" may be part of a strategy by networks to foreclose competition in a complementary market (Farrell & Weiser 2003). The ambiguous nature of the theory calls for empirical investigation of the sort conducted in the analysis here.

We first note that there are some obvious and some not-so-obvious sources of bundling efficiency. Economies in joint provision, either through vertical integration or contract, of phones and services may exist due to the important coordination needed between handsets and cellular network infrastructure. Handsets – mobile radios which communicate with fixed base stations – are "part of the wireless network" (Jackson 2007, p. 1). To work properly, all network devices must be synchronized, using the same basic technology. They must also share network resources, including radio spectrum and innovation platforms (like "app stores"), so as to optimize usage. This introduces the possibility of externalities, from costs of coordination in quality and technology[1].

[1] As described in a recent antitrust opinion, *In re Wireless Telephone Services Antitrust Lit.*, 385 F.Supp.2d 403 (2005), http://www.leagle.com/decision/2005788385FSupp2d403_1752: "The quality of handsets available to subscribers is particularly

A carrier may internalize such inter-user effects, mitigating them by asserting some level of vertical control over the handsets used on its network. This includes the investment in new, complementary facilities or services. In this sense, the wireless operator internalizes externalities by contracting and coordinating with handset manufacturers to provide retail bundles (Liebowitz & Margolis 1994). In many retail goods and services, bundled products are pervasive, as opposed to fully unbundled inputs (Liebowitz & Margolis 2008). Changing demands, technologies and business models also impact the nature of vertical integration (Liebowitz & Margolis 2008). In 2013, the fourth-largest U.S. mobile carrier, T-Mobile, recently switched from a subsidy model to an unbundled, "bring your own phone," sales model[2]. The anti-efficiency explanation of handset bundling sees this form of organization as competitive foreclosure (Frieden 2007; Wu 2007; Crawford 2013). Strategic foreclosure theory says that a dominant firm excludes competing firms by tying an upstream product with a downstream product, resulting in less output and higher prices. This theory has been empirically tested in non-technology distribution networks (Cooper et al. 2005), and cable programming (Suzuki 2009).

3 Anti-Bundling Regulation in Finland and Belgium

The standard manner in which wireless carriers market 3G services involves the sale of a bundled contract: the customer is offered a 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. 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.

3.1 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). Unsubsidized phones meant high upfront outlays for handsets, relative to the alternative, and demand was reportedly diminished by consumer frustration with service, which resulted from the anti-bundling policy (Saarikoski 2006, p. 64). Consumers had a difficult time connecting their handsets to the wireless network, given the forced independence—and lack of coordination—between device manufacturers and mobile carriers. When consumers did have issues, the OEMs instructed consumers to contact the carriers, and the carriers would often blame the OEMs (*Id*.). This lack of coordination between carriers and OEMs also meant it was the responsibility of the consumer to know if there was service availability in his area for particular handset models. 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. That year, the Finnish communications regulator asked the Finnish parliament to change to the law to allow for bundling. Deregulation went into effect in April 2006[3] (Tallberg et al. 2007, p. 652).

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important to the service providers because the use of 'outmoded' handsets not only affects the quality of that subscriber's service, but also diminishes the quality of service to other subscribers. As a result, at least two of the defendants, Verizon Wireless and AT&T Wireless, subject or have subjected handset models to an approval process involving testing and maintain a list of models approved for use with their respective services."

[2] T-Mobile USA Reports First Quarter 2013 Results, 8 May, 2013. http://newsroom.t-mobile.com/phoenix.zhtml?c=251624&p=irol-newsArticle&ID=1816790.

[3] *See generally* KPN/BASE Facts, Why 3G Was Put on Hold, Corporate Affairs Department, 3 May, 2011. http://www.kpnbasefacts.be/network/why-3g-was-put-on-hold/.

3.2 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 generally 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[4]. Hence, tying a mobile handset with a subscription was illegal. The law was ostensibly intended to promote competition and protect consumers from being lured into purchasing products like subsidized phones[5]. With the release of the iPhone 3G in 2008, Belgians saw that their European neighbors were purchasing far cheaper advanced phones. Headlines, in fact, declared Belgium home to "The World's Most Expensive iPhone"[6]. The source of Belgians' discontent is apparent, as they paid higher upfront costs relative to consumers in other countries in 2008 as listed in Table 1. Popular opinion and political momentum shifted to lift bundling restrictions.

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.**
Portugal	Vodafone	-	-	$47	100	100	250MB	24 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.

*Table 1. iPhone 3G Prices and Plans (Van Beijnum 2008)[7]. *Belgium did not allow bundling in 2008. **estimated.*

Policymakers believed that the absence of handset bundles in Belgium depressed consumer demand for advanced mobile handsets. In July 2008, Vincent Van Quickenborne, a Belgian economics minister, aggressively sought the elimination of the bundling ban, citing expensive handset prices[8]. Industry

[4] De Wit, John, Senaat Stemt Nieuwe Wet Op Consumentenbescherming. Gazet Van Antwerpen, 29 March, 2010.
[5] Mobistar to Sell Unlocked iPhone. Reuters, 8 July, 2008. http://www.reuters.com/article/2008/07/08/us-mobistar-iphone-idUSL0859270920080708.
[6] Belgium Has the World's Most Expensive iPhone, Flanders News.be, 2008. http://www.deredactie.be/cm/vrtnieuws.english/news/1.339616. *See also* Quirk in Belgian Law Drives iPhones near $1,000, USA Today, 9 July, 2008. http://usatoday30.usatoday.com/tech/products/2008-07-09-75332351_x.htm.
[7] Van Beijnum, Iljitsch. Unlocked iPhones in Belgium Make Locking Look Good. Ars Technica, 8 July, 2008. http://arstechnica.com/apple/2008/07/unlocked-iphones-in-belgium-make-locking-look-good/.
[8] Deckmyn, Dominique. Van Quickenborne: Verbod Koppelverkoop Zorgt Voor Dure iPhone (trans., Google Translate). ZDNet.be, 8 July, 2008. http://www.zdnet.be/iphone/87894/van-quickenborne-verbod-koppelverkoop-zorgt-voor-dure-iphone/.

analysts attributed slow uptake of mobile handsets to the anti-bundling law[9]. No tying meant difficulties for carriers to offer bundles of services (amounts of voice, SMS, data) with handset subsidies to increase subscription rates[10]. Van Quickenborne's campaign against the bundling regulations worked. 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 law that prohibited combined offers to consumers[11] (EC 2013). On March 18, 2010, the Belgian Senate repealed the Fair Trade Practices Act and approved a New Consumer Protection Act[12]. Belgian mobile carriers were free to offer handsets combined with wireless service.

4 Empirical Approach

4.1 Inferences from Consumer Adoption

This study infers the welfare effects of mobile bundling policy through 3G subscribership over 40 quarters (2003Q1 to 2012Q4) in 27 countries. Output effects from increased uptake can provide evidence of efficiencies from non-price vertical conduct. Here, we investigate whether change in output is observed following deregulation of anti-bundling rules. If change in output is positive, 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 3G penetration levels as a standard measure of output, where consumers are more likely to adopt services with handset bundles. Price effects are not measured here since the variety of components within a handset-service price bundle has changed over time. As seen in Table 1 above, prices and quantity for voice minutes, SMS text, data, contract length, and handset models vary widely. Price bundles have adjusted to shifts in consumer preferences between 2003 and 2012, where consumer demand has changed rapidly with respect to user applications and behavior (FCC 2013). Our model does not define or track changes within bundles, and limits its observations to 3G penetration rates.

4.2 Simple Time Series Data

In Figure 1, we observe quarterly 3G subscribership from 2003 to 2012, a time frame that focuses on the post-iPhone 3G era. The figure shows 3G connections per 100 people for each EU 15 country. The Wireless Intelligence Database of the GSM Association includes quarterly data on 3G connections and covariates for 27 EU countries for 1,080 observations. We designate control groups as EU 15/27 countries excluding Finland or Belgium. EU 15 countries have higher mean gross national product in current prices than the remaining EU 27 countries. Finland and Belgium are both EU 15 countries, which also include Austria, Denmark, France, Germany, Greece, Ireland, Italy, United Kingdom, Netherlands, Poland, Portugal, Spain, Sweden, and the United Kingdom. The remaining EU 27 countries include Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Luxembourg, Malta, Romania, Slovakia, and Slovenia.

[9] S&P: Belgacom S.A., Reuters, 2012, http://www.reuters.com/article/2012/12/06/idUSWLB188620121206.

[10] Van Beijnum, Iljitsch, Unlocked iPhones in Belgium Make Locking Look Good. Ars Technica, 8 July, 2008. http://arstechnica.com/apple/2008/07/unlocked-iphones-in-belgium-make-locking-look-good/.

[11] Van de Velde, Antonia, EU Court Orders Belgium to Allow Retail Bundling. Reuters, 23 April, 2009. http://in.reuters.com/article/2009/04/23/belgium-sales-court-idINL2627016820090423.

[12] NautaDutilh, New Commercial Practices and Consumer Protection Act, 29 March, 2010. http://www.newsletter-nautadutilh.com/EN/xzine/intellectual_property/new_commercial_practices_and_consumer_protection_act.html?cid=4&xzine_id=4401.

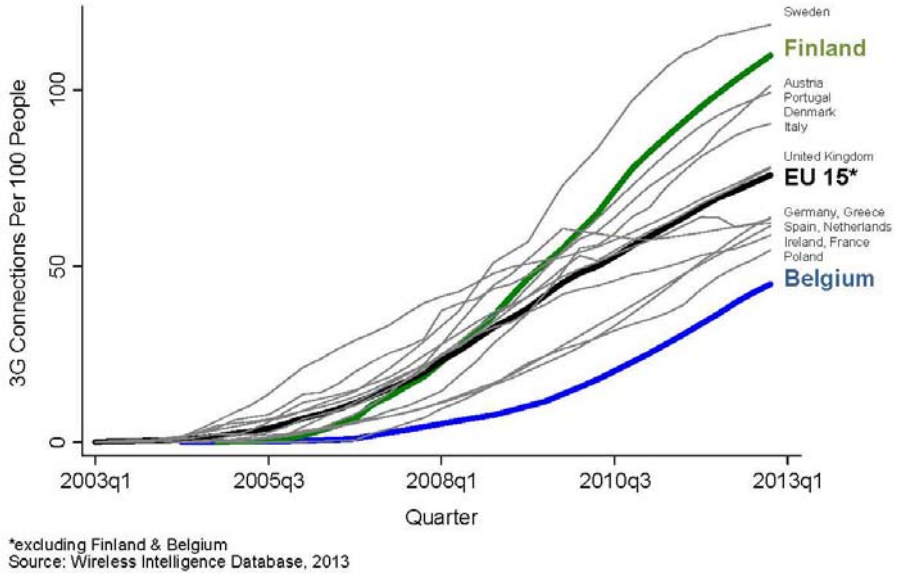

Figure 1. Quarterly 3G Connections in the EU 15 from 2003Q1 – 2012Q4.

4.3 Finland

Almost immediately after reforms allowed handset bundling as of 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 3G phones, mobile carriers saw a 32% increase in sales over previous year sales[13]. After the law change, consumers acquired more advanced handsets and consumed more data (Repo 2006). In turn, operators built out their 3G networks. Greater speeds and coverage led to more demand for 3G handsets (Tallberg et al. 2007; Kivi 2007; Okholm 2008; Howell & Sangekar 2008). By 2012, Finland had regained its reputation as a European leader in mobile technology with 109.9% penetration in 2012Q4, trailing only Sweden in per capita connections (Wireless Intelligence 2013).

4.4 Belgium

In 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 the second quarter of 2008, prior to its policy change in the second quarter of 2010, 3G penetration in Belgium trailed at 26% of the EU 15 average (6.09 / 23.45). In the fourth quarter of 2012, penetration remained at 65% of the EU 15 average (44.87 / 69.37). The relatively slow uptake compared to the EU 15 may be associated with unique constraints on Belgian mobile carriers. Two additional events may explain output effects in Belgium. In 2011, the Belgian legislature prescribed constraints on standard bundles—a re-regulation of a sort.

[13] Poropudas, Timo, 3G-kännykät vetävät myyntiä (trans., Google Translate), Digitoday, 16 November, 2006. http://www.digitoday.fi/mobiili/2006/11/16/3g-kannykat-vetavat-myyntia/200620745/66. One scholar also 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).

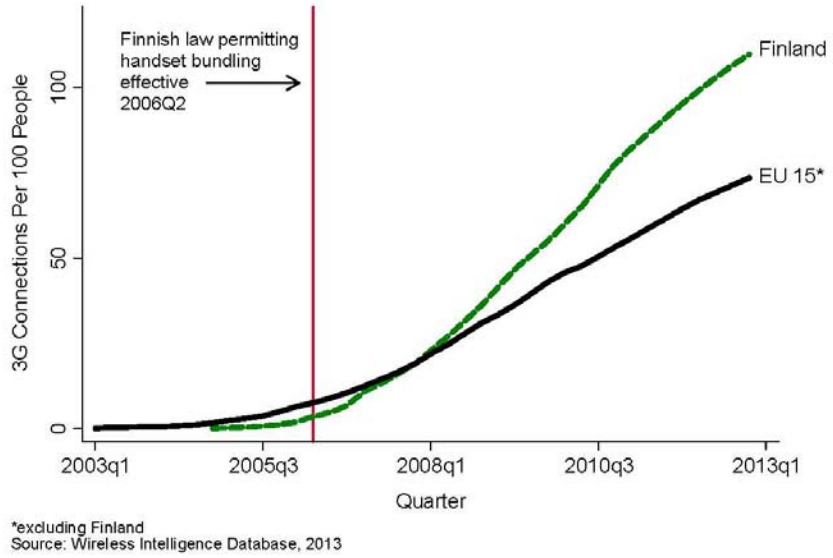

Figure 2. Finland's 3G Connections & EU 15 Average.

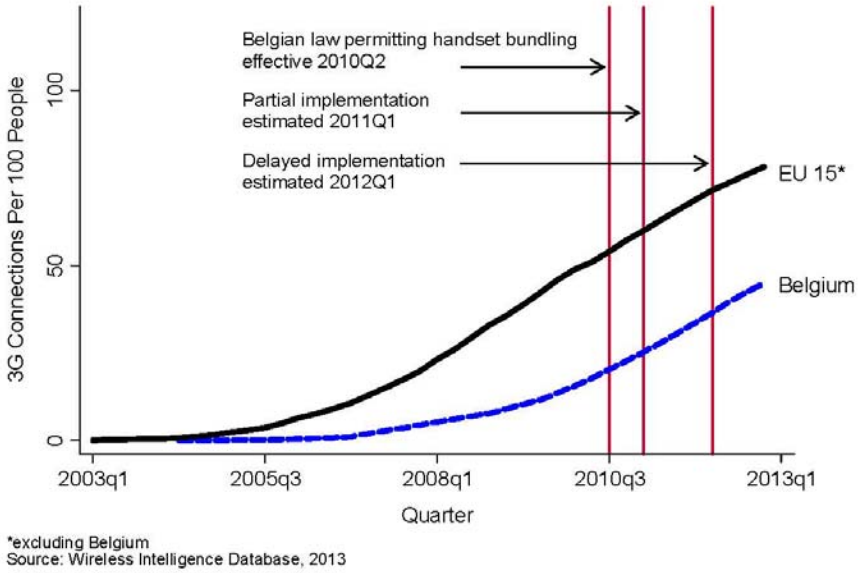

Figure 3. Belgium's 3G Connections & EU 15 Average.

Belgium required carriers to provide customers with a 6 month contract termination without penalty[14]. This mandated contract term is an outlier among developed nations, where international contracts range from 12 to 36 months, with 24 months the mode (OECD 2013, pp. 35-37). This law implemented the 2009 EU Regulatory Framework for electronic communications (EC 2010, p. 104). Until 2012, Belgian carriers also faced other challenges. From 2010 to 2013, the three mobile carriers were slow to offer handset

[14] Belgacom Group, Investors FAQ 2013. http://www.belgacom.com/be-en/annex_investors/Inv_FAQ.page; Belgium's Telecom Law Goes Into Effect, Telecompaper, 1 October, 2012. http://www.telecompaper.com/news/belgiums-telecom-law-goes-into-effect--899053.

bundles, and Mobistar did not offer subsidized handsets until 2012[15]. During those years, the three carriers also litigated increased license renewal fees imposed by the Belgian government, a matter they lost in 2012[16], and 40% base station standards imposed by Brussels regulators[17].

4.5 Difference-in-Differences Approach

Difference-in-differences (DD) measure economic effects with respect to country and bundling policy. We measure 3G connections and log 3G connections in two models:

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

for all i = 1 to 27 countries and t = 1 to 40 quarters, where $Country_{it}$ = 1 for Finland/Belgium, 0 for EU 15/27 excl. Finland/Belgium, $Policy_{it}$ = 1 for after bundling, 0 for before bundling, and $Country_{it}*Policy_{it}$ = 1 for the interaction term of Finland/Belgium after bundling. Vector Ω_{it} of covariates includes ln(HHI) = HHI concentration per quarter, ln(GDP) = GDP in PPS per year, ln(Density) = population density per quarter, 2G = 2G Connections and ln(2G) = ln(2G Connections) per quarter. If handset bundling is part of a vertical scheme to foreclose competition, the implication is that bundling permissions will be correlated with lower output. To test this hypothesis, we set the null hypothesis, H_0, as predicting that bundling restrictions have no effect on output, or H_0: $\beta_3 = 0$. Alternatively, H_1, predicts the effect of bundling prohibitions on 3G connections to deter or promote output, or H_1: $\beta_3 \neq 0$. The difference-in-differences estimator, $\beta_{3,}$ will indicate the direction of differences in 3G connections as decreasing or increasing after the policy event. A caveat is warranted about policy endogeneity in quasi-experiments where observational studies may be limited by selection bias. Here, we compare particular countries with EU peers. Policy endogeneity may exist in Finland or Belgium if bundling permissions were instituted in expectation of an anticipated rise in 3G subscribership, and not to generate greater subscribership otherwise depressed by regulatory restrictions. This explanation says that as connections were expected to increase, regulators determined that bundling prohibitions were no longer needed. Hence, deregulation would occur simultaneously with an increase in consumer demand. Such an explanation that regulators were merely anticipating increased uptake is problematic however. The stated intentions of regulators indicate that lagging adoption necessitated a change in local law. Unique conditions in Finland and Belgium may also weaken the external validity of results for generalization to other jurisdictions. Matching of Nordic or Baltic states may provide closer regional and economic comparison. We incorporate variation in local conditions with covariates that specify gross domestic product, population density, and market concentration to account for regional similarities.

5 Results

In the difference-in-differences analysis, we find that output effects were positive in consumer uptake of bundled offers relative to unbundled offers in Finland, with mixed results in Belgium. The case of Belgium is described further below.

[15] Mobistar Annual Report 2011, http://corporate.mobistar.be/en/pdf/annual_report_2011a_en.pdf; Mobistar, 2013, iPhone 4S – 16GB wit. http://www.mobistar.be/nl/aanbod/shop/smartphone/iphone-4s-16gb-wit; Martens, John, Mobistar Won't Start Handset Subsidies Before Law is Enacted. Bloomberg, 22 April, 2010.

[16] Opinion of the Advocate General, Jaaskinen. 2012. Case C-375/11: Belgacom SA, Mobistar SA, KPN Group Belgium SA v. Etat Belge. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:62011CC0375:EN:HTML.

[17] GSMA, Brussels' Mobile Base Station Restrictions Hurting the Economy, 2013. http://www.gsma.com/publicpolicy/brussels-mobile-base-station-restrictions-hurting-the-economy.

5.1 Finland

In Finland, a dramatic rise in 3G connections over the EU average is seen in the difference-in-differences analysis in Table 4.

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

Table 4. *3G Connections in Finland with Bundling from 2006Q3 – 2012Q4. EU 15/27 controls exclude Finland. Robust standard errors in parentheses. *** p<0.01 ** p<0.05, * p<0.1*

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 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.

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, and the alternative hypothesis, H_1: $\beta_3 \neq 0$ is accepted. 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.

5.2 Belgium

In Belgium, the penetration of 3G connections is below the EU average measured by difference-in-differences, as seen in Table 5.

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

*Table 5. 3G Connections in Belgium with Bundling from 2010Q3 – 2012Q4. EU 15/27 controls exclude Belgium. Robust standard errors in parentheses. ***p<0.01 **p<0.05, *p<0.1*

Column (7) shows a difference-in-differences estimator of -20.59 connections per 100 people and -12.63 connections per 100 people over the EU 15 and EU 27 average. 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. Examination of equation (2) indicates a different result, however. The 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, and the alternative hypothesis, H_1: $\beta_3 \neq 0$ is accepted, with R^2 values 0.276 and 0.293. An important explanation of this result is the rate of change in Belgium over time. The change in ln 3G connections exceeded that of the EU average. In a natural log transformation, regressions provide a view of growth that incorporates relative changes over time. In Belgium, the severe lag in 3G adoption below its EU 15 peers warrant closer analysis due to local events in bundling constraints. Several reasons can explain the unusual deficit in Belgian uptake. 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. The delay by Belgian operators to implement handset subsidies after 2012 also may explain Belgian outcomes.

6 Conclusion

These two episodes in Europe demonstrate output effects from handset bundling policy. We find that the bundling of handsets and mobile service does not have negative consumer welfare effects in 3G penetration rates in Finland and mixed results in Belgium. We see that bundling appears to allow firms to realize efficiency gains and increase consumer adoption of 3G connections. In the opinions of European regulators, trends in the wireless marketplace required policy reversals to improve consumer adoption of 3G subscriptions between 2003 and 2012. Natural experiments in Finland and Belgium appear to suggest light regulatory touch in wireless ecosystems.

7 Appendix: Data Sources and Descriptive Statistics

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 EU countries. 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, 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. ***3G Connections***: Third-generation (3G) network technologies include, CDMA2000 1xEV-DO, CDMA2000 1xEV-DO Rev. A, CDMA2000 1xEV-DO Rev. B, WCDMA, WCDMA HSPA, and TD-SCDMA. A connection is 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). ***Covariates: 2G Connections***: Second-generation (2G) network technologies include cdmaOne, CDMA2000 1X, GSM, PDC, PHS, iDEN, and TDMA. ***Herfindahl-Hirschman Index***: Quarterly measure of market concentration from 0 (even competition) to 10,000 (no competition). ***Population***: Quarterly population data, from United Nations, Population Division World Population Prospects, for all residents at the end of each period. ***GDP in PPS***: Eurostat provides GDP per capita in Purchasing Power Standards (PPS), code tec00114, 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.

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
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

Table 6. Descriptive Statistics for 27 countries over 40 quarters from 2003Q1 – 2012Q4. Source: Wireless Intelligence Database, 2013 and Eurostat, 2013.

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
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
Romania	No	18.5	68.4	3725	42	21,625,851	91
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

Table 7. Mean Values for select countries from 2003Q1 – 2012Q4. Source: Wireless Intelligence Database, 2013, Eurostat, 2013, World Bank World Development Indicators (WDI), 2013.

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