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DESIRED RESEARCH AND TEACHING FIELDS:

PRIMARY	SECONDARY
Industrial Organization	Public Economics
Energy and Environmental Economics	

FIELDS OF CONCENTRATION:
Industrial Organization, Energy and Environmental Economics

DISSERTATION TITLE: *Essays in Industrial Organization and Environmental Economics*

Expected Date of Completion:	May 2017
Principal Advisor:	Professor Benjamin Handel
Other References:	Professors Kei Kawai and Reed Walker

PRE-DOCTORAL STUDIES:

	DEGREE	DATE	FIELD
Central European University	M.A.	2011	Economics
Corvinus University of Budapest	B.A. w/ Honors	2009	Economics

PROFESSIONAL EXPERIENCE:

RESEARCH:
Research Assistant, Lawrence Berkeley National Laboratory (Spring and Summer 2016)
Fellow, Compass Lexecon, Oakland (2014-2015)
Research Assistant for Prof. Walker, Haas School of Business, UC Berkeley (Winter 2013)
Research Assistant, CEU Labor Project, Central European University (Summer 2010)
Research Assistant, Regional Centre for Energy Policy Research (Summer 2009)

TEACHING:
Teaching Assistant, Department of Economics, UC Berkeley (2012-2015)
Undergraduate Public Economics, Undergraduate Economic Theory, Intermediate Macroeconomics
Instructor, Széchenyi István College for Advanced Studies, Budapest (2010)
Undergraduate Industrial Organization
Teaching Assistant, Department of Economics, Corvinus University of Budapest (2005-2008)
Intermediate Microeconomics, Undergraduate Industrial Organization

PAPERS:
Network Externality and Subsidy Structure in Two-sided Markets: Evidence from Electric Vehicle Incentives (Job Market Paper)

WORK IN PROGRESS:
Vertical Integration in the Electric Vehicle Market

FELLOWSHIPS AND AWARDS:

2016-2017	Doctoral Completion Fellowship, UC Berkeley
2013	Outstanding Graduate Student Instructor Award, UC Berkeley
2012	Graduate Division Summer Research Grant, UC Berkeley
2011-2015	Departmental Fellowship, UC Berkeley
2011	Outstanding Academic Achievement Award, Central European University
2010	Peter Hangartner Fellowship, Central European University
2010	Academic Pro-rector's Excellence Award, Central European University
2005, 2006	Scholarship of the Republic of Hungary

OTHER INFORMATION:

Languages:	Hungarian (native), English (fluent)
Citizenship:	Hungary

Research Statement

Katalin Springel *

As an applied microeconomist with interests in industrial organization, energy and environmental economics, economics of technology, and public economics, my research investigates the economics of industries where network externalities are significant, with a focus on the electric vehicle market. My work is concerned with the policy implications of market and firm organization in two-sided markets. In one line of research, I investigate the impact of subsidy allocation between the two sides of the market on economic outcomes, like electric vehicle adoption. Another line of research studies the impact of vertical arrangements in the electric vehicle market on the industry structure, technology adoption, the regulatory framework, and welfare. A third line of my research considers the spatial distribution of charging stations as an outcome of a network formation process. Below, I describe each course of research in greater detail.

"Network Externality and Subsidy Structure in Two-Sided Markets: Evidence from Electric Vehicle Incentives" (Job Market Paper)

My job market paper highlights the necessity for accounting for the network externalities present in the electric vehicle market due to its "two-sided" nature when designing electric vehicle supporting incentives. I empirically investigate the impact of price subsidies and charging station subsidies on electric vehicle sales using a two-sided market framework. I show that the most efficient side of the market to subsidize depends on key structural primitives, such as the own- and cross-price automobile demand elasticities, network effects on both sides of the electric vehicle market, and the elasticity of station entry with respect to the station subsidies. Thus, the effectiveness of the two types of subsidies is an open empirical question.

To examine consumer vehicle choices and charging station entry decisions, this study uses data from Norway on the universe of newly registered automobiles and its public charging station network. I adopt a structural approach in order to study policy counterfactuals comparing consumer readjustment in response to subsidies when feedback loops are present. Hence, I develop a modeling framework in which consumers make their car purchasing decisions by maximizing their utility across automobile models of all fuel types, with the outside option of purchasing no vehicle. Simultaneously, charging stations make an entry decision that is driven by their discounted stream of per-period profits and their sunk costs of entry.

The counterfactual analyses examine the average impact of current subsidies and the marginal impact of increase to those subsidies. The findings suggest that between 2010 and 2015, every 100 million Norwegian kroner spent on station subsidies alone resulted in 835 additional electric vehicle purchases compared to a counterfactual

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in which there are no subsidies on either side of the market. The same amount spent on price subsidies led to only an additional 387 electric vehicles being sold compared to a simulated scenario where there were no electric vehicle incentives. However, this relation inverts with increased spending, as the impact of station subsidies on electric vehicle purchases tapers off faster. Additionally, I find that for a given level of government spending, policymakers can get the biggest "bang for their buck" with regard to electric vehicle adoption if they use a combination of the two policies.

I am interested in extending this project to analyze the consumer welfare impact of electric vehicle subsidies. In my job market paper, I conduct a positive analysis of the electric vehicle policies using electric vehicle adoption as the sole signal of welfare. This is in line with current policymaking's use of specific targets for electric vehicle sales in a given time period. I am planning to supplement this analysis by using the structural model developed in my job market paper to analyze welfare changes as a result of the electric vehicle incentives.

A standard measure of the change in consumer welfare used in the literature is the compensating variation. However, when the marginal utility of income varies for each individual, the calculation of the compensating variation is more involved and requires a simulation method. Moreover, a welfare analysis would need to account for the externality impact on the environment, and would require the understanding of the counterfactual environment without subsidies. For my future research, I plan to determine the welfare maximizing combination of electric vehicle policies and calculate the associated deadweight losses.

In my future work, I hope to explore the impact of local non-monetary electric vehicle incentives, like preferential lane access or toll fee exemptions, and measure rebound effects in electric vehicle purchases as a consequence of incentives reducing the cost of driving. I am also planning to investigate the impact of electric vehicle subsidies on the pricing of non-electric vehicles in a joint work with Morten Sæthre (Norwegian School of Economics). Additionally, I have recently acquired a state-level U.S. vehicle registry data that will allow me to juxtapose my Norwegian electric vehicle data with a brand new market. This will provide a richer understanding of optimal policy design in the electric vehicle market. Finally, by exploring the high resolution data on public charging station usage that I obtained for both the U.S. and Norway, I aim to supplement my current work with an analysis on the environmental impact of electric vehicle incentives.

Vertical Arrangements in the Electric Vehicle Market

Another line of my research concerns the analysis of vertical relationships in the electric vehicle industry and their implications for the regulatory framework. I am particularly interested in how these arrangements might change the impact of subsidies on economic outcomes, like buyer demand and welfare.

Building on my current modeling framework, which holds the vehicle manufacturers' side fixed throughout my analysis, I am developing a model that both incorporates the manufacturers' decision making problem and

provides an opportunity to analyze vertical arrangements in the electric vehicle sector. Vertical integration and exclusive contracting between vehicle manufacturers and charging stations is specific to the electric vehicle market and not the usual practice in the automobile industry. For example, Tesla Motors has built up a network of "superchargers" that can provide very fast charging, although these are exclusively available to Tesla automobile owners. Tesla Motors also provides cables with their vehicles that allow owners to also use most public charging stations.

Given that car manufacturers like Tesla Motors are making profit from car sales and not through charging provisions, an interesting trade-off arises. Exclusive arrangements can enable entrants to break into a market. It can additionally be used to effectively resolve the well-known "chicken-and-egg" coordination problem in two-sided markets. On the other hand, if these exclusive contracts foreclose other charging stations, then, through strong cross-group externalities, vertical relations might end up reducing car manufacturer's profits. Notably, in the electric vehicle market, car manufacturers need to weigh these factors against each other when determining the compatibility of their product with the complementary services provided by the charging stations, namely, battery charging.

Furthermore, it is not just car manufacturers making use of vertical arrangements with charging stations, but also establishments that have primary business activities outside of the vehicle industry, like restaurants, hotels, grocery stores, and shopping malls. The incentives for these firms to make use of vertical integration is likely to be different from car manufacturers' incentives. Taking into consideration the impact of subsidies and consumer welfare with regard to such vertical arrangements would enrich the present analysis.

Local Market Structures in the Charging Station Network

A recently undertaken project with Eric Auerbach (UC Berkeley) considers a model of network formation to describe and predict firm entry decisions with regard to charging provision in the electric vehicle market. The decision of a firm to open a charging station at a particular location depends not only on electric vehicle ownership in the area, but also the spatial configuration of other charging stations nearby. The extent to which some configurations are more supportive of entry than others has implications for the proliferation of new electric vehicle ownership and understanding the social return to various public incentive and subsidy programs.

We are interested in studying the impact of spatially differentiated station subsidies on electric vehicle adoption, another dimension along which electric vehicle incentives can be optimized. Region-specific factors are likely to affect the need for public charging provision. For example, in counties with larger driving distances, colder winters, and more mountainous terrain, charging availability is expected to affect consumers' vehicle purchasing and operating decisions to a larger degree.

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November 1, 2016

Dear Colleague:

It is my pleasure to recommend **Katalin Springel** for an assistant professor position at your institution. Katalin (Kati) is a graduate student in the department of Economics at the University of California at Berkeley who will be completing her doctoral dissertation this year. Kati's primary fields are industrial organization, energy, and environmental economics, though her research also touches on important topics in public finance.

I am Kati's primary advisor, and have known her since she arrived at Berkeley. Kati took my graduate IO class during her second year, where she stood out as an exceptional student, skilled in both applied modeling and econometric inference. Since then, I have worked closely with Kati, meeting regularly to advise her on her research and to discuss economics more broadly. Additionally, I have supervised her as a teaching assistant for an undergraduate course I teach and she has been a regular, core participant in the student-faculty industrial organization reading group at Berkeley. I am extremely impressed with her ability as an economist and her motivation: her job market paper is a fantastic example of work that leverages sophisticated methods in industrial organization to study an important applied topic, in her case policy and market structure in the electric vehicle sector.

Kati is a very strong candidate and I recommend her enthusiastically and with no reservations. She is in the top group of students coming out of Berkeley this year and should be among the best applied microeconomists on the job market this year. She should get strong consideration from any economics department or business school, including the very best. Her project, in terms of implementation, sophistication, and topic, reminds me of recent successful IO / energy job market papers written by, e.g., Tom Covert (Booth), Tom Wollman (Booth), and Mike Abito (Wharton). Ryan Kellogg (Chicago) and Chris Knittel (MIT) are reasonable comparisons for the type / style of work in Katalin's paper, though of course it is difficult to compare directly to such senior, accomplished, scholars.

Kati's job market paper is an impressive study that investigates subsidy policy and market structure in the Electric Vehicle (EV) market. Governments around the world have implemented substantial subsidies related to this sector. There are a number of reasons for these subsidies. One is that electric vehicle adoption directly links to reduced emissions, i.e. the subsidy helps to correct the negative pollution externality of non-EV vehicles. Second, this is a two-sided market with positive membership externalities: the car manufacturer is the "platform" and the two sides of the market are charging stations for electric vehicles and consumers purchasing those vehicles. There are positive membership externalities because the more charging stations that exist, the higher consumers value electric vehicles, while, the more electric vehicles there are in the market, the more attractive it is to operate a charging station. It is well known that, in new markets with network externalities, subsidies to encourage initial participation are a fruitful approach to increase social welfare, when the product clearly has positive social value relative to the current market.

Kati's paper directly tackles the question of how the government should target subsidies in the EV market. She begins by developing a simple model, building on the two-sided markets literature, which shows that subsidies to the different sides of the EV market are "non-neutral" in the sense that one dollar of subsidy given to the charging side does not produce the same economic impact as one dollar given to consumers purchasing EVs. The model investigates the key micro-foundations that impact relative subsidy value to each side of the market. For example, if station entry elasticity with respect to a subsidy is high, or consumers have high EV purchase density with respect to station density, subsidizing charging stations is relatively preferable. Conversely, if demand for the class of electric vehicles is highly elastic with respect to non-electric vehicles, then for a given charging station market structure direct to consumer subsidies is relatively preferable.

Thus, how to structure subsidies in a given EV market is an empirical question that depends on these foundations. Kati studies this question empirically in the context of the Norwegian EV market. Her dataset is fantastic to study this question. She has micro-data on all vehicle purchases in Norway from 2010-2015, over which time EV market share rose from close to 0% to almost 20%. She has also assembled data on charging station entry and usage, linked to precise locations. She thus observes, with a great degree of precision, the evolution of both sides of the EV market in Norway, at a granular location level. Finally, Norway implemented a range of different EV subsidies, primarily on the consumer side, beginning just before the start of Kati's data and changing in scheduled manner over her data time frame. It is hard to imagine a better context / dataset to study her questions.

After presenting descriptive statistics for the Norwegian market, Kati presents some reduced-form evidence illustrating the responsiveness of (i) consumer demand with respect to charging station density (ii) consumer demand with respect to EV price and (iii) charging station entry with respect to EV share. These analyses clearly highlight some of the key relationships between these sides of the market, that Kati then goes on to explore in more detail in a structural framework that models both the demand-side and the charging station side. This structural approach is crucial for studying counterfactual subsidy structures: while reduced-form analysis can provide useful hints at which side of the market to subsidize, the structural approach incorporates modeling assumptions about both demand heterogeneity and charging station market structure that are important for understanding the complex implications of subsidies to either side of the market.

Kati's empirical model has two main components (i) consumer demand and (ii) charging station supply. Throughout, manufacturer model entry and pricing decisions are taken as given (more on this later). She models consumer demand with a mixed-logit approach reminiscent of BLP (1995) and Nevo (2000), with some essential modifications, e.g. the fact that consumer demand depends on other consumer EV purchases, given the feedback through charging station entry. In her main approach, Kati assumes that consumers are myopic, in the sense that at the time of purchase, they factor in the current charging station infrastructure rather than its expected evolution. In some sense, this can be thought of as a reduced form of the fact that consumers decide whether to purchase a car now vs. in the next period.

Katalin must deal with two identification challenges in estimating demand. The first is typical in this literature: vehicle demand and prices are determined simultaneously. She deals with this issue using a hybrid of the BLP and Nevo approaches: she includes location-specific fixed effects as in Nevo but uses the BLP instruments of other product characteristics because those characteristics are changing over time. This is especially reasonable, if, e.g., manufacturers make decisions about models that are not closely related to the Norway market specifically. Her second issue is that EV market share and charging station entry are determined simultaneously. Here, she uses the magnitude of charging station entry incentives to instrument for the station network consumers face. These subsidies are scheduled in advance and are modeled above and beyond county-specific fixed effects. They shift charging station share independently of consumer demand.

The charging station entry model is a static entry model where stations are symmetric and have fixed entry costs. Free entry implies that stations are indifferent between entering now vs. next period. In the current version of the model firms have complete information about the flow of future profits in the market (i.e. they correctly perceive the future EV base and future charging station market structure). I expect Kati to continue to make progress studying the underlying assumptions about firm beliefs here, at least as a robustness analysis.

Similarly, in the charging station entry model, there is an endogeneity issue related to the simultaneously determined charging station entry and EV market share. To deal with this issue, Kati instruments for EV market share with gas station density. The assumption is that gas station density is negatively related to EV demand, due to its positive impact on non-EV vehicle demand, but is unrelated to charging station entry otherwise. Given the model setup on both sides of the market, Kati performs estimation using a GMM routine similar to that found in the literature.

Kati's sophisticated approach to studying the EV market leads to a number of very interesting results in the paper. On the demand side she estimates the magnitude of the positive feedback charging station presence has on EV demand, an important empirical quantity. In the spirit of BLP (1995) and Nevo (2000), she illustrates the impact that measuring this feedback has on own and cross price elasticities between vehicles. Specifically, she quantifies the additional magnitude by which the network externality increases the magnitude of the own price elasticity. For example, for a 1% price increase the market share of Nissan Leaf is reduced by more than it would have been otherwise, because of the reduced charging station entry that results. A very interesting result is that cross-price elasticities are generally negative implying that EVs are complements relative to one another, rather than substitutes as is typical. This is a stark example of the difference between a typical market and one with membership externalities. It also opens up questions about manufacturer interactions that are currently beyond the scope of this paper.

On the supply side, the results clearly indicate that the circulating base of EVs is important for charging station entry decisions. This plays an important role in the counterfactual analysis investigating which side of the market to subsidize to achieve different EV adoption targets.

The policy counterfactuals that investigate the relative effectiveness of subsidizing each side of the market are the "payoff" for all of the modeling and machinery developed in the paper. Thinking about the impact of subsidies across the different sides of the market is a much more involved question than typical subsidy analysis, because of the feedback of each side of the market on the other.

First, Kati shows that with the current subsidy structure, station subsidies were responsible for approximately 9 new EVs purchased per extra million subsidy dollars, while car purchase subsidies were responsible for approximately 4 new EVs purchased per extra million in subsidy dollars. During this time period (and currently), Norway had specific government targets related to the market share of EVs they wanted to reach as a country each year: Kati shows that on average the station subsidies were more effective in helping them achieve these targets.

Next, Kati investigates the marginal impact of new subsidies on either side of the market. The impact depends on how much new government the government can allocate: for any subsidy amount up to 200 million Norwegian KR (about 50 million $) allocating these subsidies entirely to charging stations would be better for maximizing EV share than directly incentivizing vehicle purchases. However, if the government has more than 200 million KR to commit, incentivizing entirely consumer purchases would be better for achieving this goal than incentivizing charging station entry. This relates directly to the feedback between both sides of the markets that Kati models: on the immediate margin relative to the status quo charging station subsidies are more valuable, but at some point there are diminishing marginal returns to subsidizing station entry as opposed to EV purchases.

Kati has already done a lot with this paper. She received the data set for this work about 10 months ago, and still has a number of important issues she is in the process of considering. Some of these may be done by the time you interview her in January (she has made very fast progress). These include:

- Counterfactual analysis of subsidy policies that can split a fixed government budget between both sides of the market. Right now, she is studying either / or for these incremental subsidies. I know that she already has preliminary results related to this, so this will certainly be ready by January and may even be included in the final draft sent out in mid-November.

- She is working on a model of vertical integration, where the EV manufacturers can also build charging stations. This would be a substantial addition to the current paper and would involve explicitly modeling manufacturer behavior and linking it to joint charging station entry. If she is able to successfully add this, it would bring the paper up to a level of very successful recent papers such as Lee (2013) on the video game industry or Crawford and Yurokoglu (2012) on the cable TV industry. This could end up being a separate paper, but is clearly a fruitful next step.

- She is working on a welfare framework that specifies social welfare as an objective function for her counterfactuals, rather than total EV market share (currently an explicit government goal in Norway). This is subtle, as past papers in the auto industry have noted, especially when considering emissions in the criterion.

Going forward, I expect Kati's agenda to be focused on IO / energy / environmental, with an emphasis on the EV market. She has a number of follow up projects she is thinking about in this space, and the data to do it. I think the Norwegian dataset is clearly a foundation for two substantive papers (including the JMP) and she has recently gained access to a similar dataset for EVs and charging stations in the US, which presents the opportunity to extend this style of work to a larger market where modeling the manufacturer decisions may be more relevant. I have very high hopes for this agenda: the questions and data are compelling and she has made tremendous progress on a complex topic in a relatively short time since she received the data.

I supervised Kati as a teaching assistant for my undergraduate health economics class in 2014. She excelled in this role, and I have no doubt she will be an excellent and well-organized instructor. More generally, she is a pleasure to be around and will be a major contributor to your department as a research collaborator and provider of public goods. She could easily teach a Ph.D. course in industrial organization, and could also do so in energy / environmental, though I know such courses are rarer. I have not seen her interact with MBAs or policy masters students, though I suspect she would be an effective instructor in both domains.

I give Kati my highest recommendation; please do not hesitate to contact me for any further information, I would be happy to discuss her candidacy or different aspects of her profile further at any point.

Best regards,

Benjamin Handel
Associate Professor of Economics
University of California at Berkeley



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Assistant Professor
Kei Kawai
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Dear Recruiting Committee,

I am writing this letter in support of Katalin Springel's application for a position at your institution. Katalin is a Ph.D student graduating from Berkeley's economics department specializing in Industrial Organization and Energy/Environment. I have had the opportunity to work with her for about one year. While my involvement in her research has come at a somewhat late stage, I am very excited about the line of research she is pursuing. She has assembled a great dataset on electric vehicle transactions, ownership, and detailed individual owner information from Norway, which is currently the leading market of electric vehicles. She also obtained detailed data on electric vehicle charging stations and information regarding various incentive schemes that are targeted to promote electric vehicle sales. She has recently gained access to a similar dataset for the U.S. She has a number of exciting projects that take advantage of the rich dataset. I think she is on track to making multiple high impact contributions to the area of IO/Energy. Katalin is in the top group of students graduating from Berkeley this year, and I expect her to be among the strongest students on the job market in Industrial Organization. I am delighted to recommend her to all places.

Let me now briefly describe Katalin's job market paper. Her paper studies the design of government subsidies aimed at promoting electric vehicle sales. Given concerns about greenhouse gas emissions, many countries have already adopted, or in the process of adopting various incentive measures to increase electric vehicle sales. Some subsidies are targeted at buyers of electric vehicles in the form of tax credits, discounts on registration fees etc. However, given that consumers value the number of charging stations, another way to induce electric vehicle purchases is to subsidize charging stations. She first shows theoretically that the structure of various subsidies is non-neutral, and that the efficiency of subsidies depends on own/cross price demand elasticities and on network effects. She then estimates a model of consumer demand and charging station entry to back out

these primitives. She finds that there is a strong network externality due to the complementarity between electric vehicle sales and charging station network. That is, an increase in electric vehicle sales induces entry of charging stations, which, in turn, further increases electric vehicle sales. She finds that station subsidies are twice as effective as consumer subsidies given the current level of government spending.

The data that she uses for the analysis come from Norway, which is currently the leading market of electric vehicles; electric vehicles account for more than 20% of all new vehicle sales. Norway has introduced a variety of policies that promote electric vehicle sales, some targeting consumers and others targeting charging stations. She has detailed data on vehicle registration, charging station network and various government incentives.

She uses these data to estimate a model of consumer demand and charging station entry. Her model of consumers is similar to BLP with the addition of consumers receiving utility from charging station network. She models the entry decision of charging stations as a trade-off between the sunk cost of entry and the stream of profits. The cumulative number of electric vehicle sold and the number of competitors affect the period profit of the charging stations. Subsidies that target charging stations lower the sunk cost of entry. She identifies the value of charging stations to consumers by using charging station subsidies as an instrument. She identifies the effect of electric vehicle sales on station profits by using variation in gas prices and gas station density as instruments.

The estimation results imply that complementarities between electric vehicle sales and station entry are sufficiently strong so as to make models of electric vehicles complements. In other words, she finds that if a price of an electric vehicle *j* rises, it has a negative effect on station entry, which, in turn, has a sufficiently negative impact on the demand of electric vehicle *j'* – which is not fully compensated by simple consumer substitution from *j* to *j'*. The cross price elasticities and the strength of the network effects also inform the effectiveness of various subsidies.

Katalin uses the parameter estimates to study the effectiveness of counterfactual subsidy policies. She first finds that, at current spending levels, station subsidies are more than twice as effective in increasing vehicle purchases as direct consumer subsidies. She also finds however, that the effectiveness of station subsidies decrease quite rapidly. She finds that policy makers can maximize the impact of subsidies by using both types of subsidies.

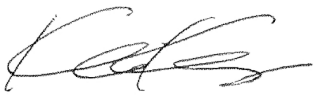
Overall, I think the paper is a great combination of interesting economics and important policy question. I'm also very impressed with the way Katalin took a very complicated setting and condensed it to a tractable model - I

think her model captures the essential features of the industry while keeping it quite simple. I think Katalin has identified a great research question and executed very nicely.

Now I briefly discuss her other projects. One research project studies the electric vehicle market in the U.S. with a focus on exclusive contracts. The project is motivated by the fact that Tesla Motors is both a manufacturer of electric vehicles and owner of charging stations which are exclusively available to Tesla automobile owners. While a vertically integrated firm can internalize the network externality inherent in two-sided markets, exclusive contracts also hurt efficiency through eliminating network externalities across electric vehicles of different manufacturers. Using detailed registration data of electric vehicles similar to the one she uses in her job market paper, the project studies the welfare implications of vertical integration/exclusive contracts as well as implications for government subsidies. I think this project is also a nice combination of interesting economics and important policy question. Katalin also has a third project with a fellow classmate (Eric Auerbach) that studies more carefully the geographic competition of charging stations.

To conclude, I think Katalin is on track to making multiple high impact contributions to the area of IO/Energy. I recommend Katalin to all schools without reservation. I hope that you will give her application full consideration,

Sincerely,



Kei Kawai

Assistant Professor of Economics, U.C. Berkeley

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November 1, 2016

Dear Colleague:

I am writing to recommend **Katalin Springel** (Kati) for a position at your institution. Kati is a PhD student in the Department of Economics at UC Berkeley whom I have known for 3+ years. Kati's primary research interest sits at the intersection of industrial organization and energy/environmental economics. Her job market paper fits firmly within this area, exploring issues that arise in the "two-sided" electric vehicle market. The paper is both rich on economic content and well executed – a winning combination in my opinion. Kati is an exceptionally strong researcher, and I enthusiastically recommend her to all schools. She is in the top group of graduate students coming out of Berkeley this year, and she should be among the best applied microeconomics candidates on the market this year.

Kati's job market paper explores the issues that arise in the market for electric vehicles (EVs) when we have one side of the market (automobiles) dependent on the availability of the other side of the market (charging stations). The presence of network or membership externalities makes the economics of electric vehicles even more interesting; the more charging stations that exist, the greater demand for electric vehicles, and the more electric vehicles in the market, the more attractive it is to install a charging station. The main empirical exercise is to determine which side of the market to subsidize if policy makers are interested in minimizing environmental externalities via air pollution (vis-a-vis maximizing electric vehicle adoption). One might imagine that an important component of demand for electric vehicles depends on the availability of charging stations. Similarly, the price, net of any vehicle subsidy, should also influence demand. On the other side of the market, the availability of more electric vehicles influences charging station entry, and more charging stations intuitively feed back into vehicle demand. These channels naturally lead a researcher to ask, "If a policy maker and/or regulator wanted to reduce environmental externalities associated with driving, how best should one go about doing this (i.e. subsidizing charging stations and/or electric vehicle drivers)?" This is the fundamental question that Kati explores in her paper.

The empirical context for this project comes from the Norwegian electric vehicle market. Norway has the highest market share of EVs among new car sales, with EVs accounting for more than 20% of new vehicle purchases in 2015. To put this number into context, no other country has yet reached double-digit market share for EV sales. Partly, this high market share of electric vehicles is driven by the aggressive subsidy policy of the Norwegian government, and this variation in subsidies, both in the cross-section and over time, is what forms the basis of Kati's empirical analysis.

Kati obtained vehicle registration data from the Norwegian Public Roads Administration (NPRA) which contains the universe of car purchases in Norway from 2010 to 2015. Each registration record contains

information on the owner's name, type (private or corporate), and street address, the date of registration as well as the vehicle specification defined by make, model, and trim. Kati obtained additional information on product characteristics and price from another vendor (OFVAS). She has also assembled data on charging station entry and usage, linked to precise locations. All of these datasets are extremely rich and took a tremendous amount of entrepreneurial effort from a graduate student (especially a graduate student who is not Norwegian!). I know of no other comparable sources of data in other countries, although Kati is in the process of putting together similar data for the United States. I am confident that a number of interesting papers will come from this data, and I have talked with Kati already about a few (more below).

Kati's paper begins by writing down a stylized model of the market that she is studying. This model delivers clear and concise insights as to the tradeoffs that policy makers face in this two-sided market. For example, if the elasticity of station entry with respect to a subsidy is high, or consumers have high demand for EV with respect to station density, subsidizing charging stations is going to generate a lot of EV takeup. Conversely, if demand for electric vehicles is highly elastic with respect to the price of non-electric vehicles, then direct consumer subsidies may be preferable.

Kati then provides useful "reduced-form" evidence illustrating:

1. The relationship between EV demand and charging station density,
2. The relationship between EV demand and EV price, and
3. The relationship between charging station entry and EV market penetration.

These results come from careful empirical work, exploiting model-specific variation in vehicle subsidy amounts within a county-month, controlling for county-by-model fixed effects and other time-varying controls. She also presents several compelling, indirect tests of the identifying assumptions from these models – examining both pre-trends as well as "placebo" type tests to show that EV subsidies are not correlated with unobserved trends in preferences for environmentally friendly vehicles (e.g., hybrid cars). These results demonstrate a strong relationship between subsidies, EV adoption, and station entry, and these results do not seem to be driven by differential trends and/or other time-varying, correlated unobservables.

The heart of Kati's paper is comparing the effectiveness of price and station subsidies for given levels of government spending. This requires conducting counterfactual simulations that involve out-of-sample predictions and thus rely on a more structured modeling approach. Additionally, the key feature of the EV market, the positive network externalities and the resulting feedback loops, call for estimating a system of equations, rather than a simple reduced form relationship. Hence, Kati develops and estimates a model that encompasses the simultaneous interaction between consumer vehicle choice and charging station entry in a two-sided market framework.

In practice, this amounts to combining a demand system, in the spirit of Berry, Levinsohn, and Pakes (1995) and Nevo (2000), with a model of charging station entry. In the model, consumers make a vehicle purchasing decision by maximizing their utilities across vehicle models of all fuel types and the outside option of not purchasing any vehicle. Vehicle demand is modeled using a mixed-logit, allowing for heterogeneity in consumer valuation of both product attributes and the station network. Simultaneously, charging stations make an entry decision determined by their sunk entry costs and discounted stream of profits. The number of charging stations in a market is the outcome of a complete information entry game where the installed base of cumulative EVs determines the market size.

This relatively straightforward setup gives rise to a rich and interesting set of policy tradeoffs. For example, the presence of positive feedback effects amplifies the impact of both types of subsidies (i.e.

vehicle and station subsidies), but the importance consumers place on charging availability further magnifies the effect of station subsidies. Thus, if the charging network plays a key role in consumers' vehicle purchasing decision then subsidizing charging stations may be more effective at stimulating EV demand. Alternatively, if demand for EV models is highly elastic, and there is less substitution between EV models then a price subsidy may be preferable. Finally, if the station entry decision is highly elastic with respect to the station subsidy then again funding stations may be the more effective way to increase EV demand.

The analysis has many interesting results. First, the presence of network externalities means that the own-price elasticity of electric vehicles is larger than in a conventional marketplace. This stems from the positive feedback effect between charging station presence and EV demand (another result from the paper) – as price declines, more charging stations enter, and demand expands even further. The headline finding stems from counterfactuals which compare vehicle subsidies to charging station subsidies. Kati finds that charging station subsidies increase vehicle adoption more than the same dollar amount spent on vehicle subsidies, although as the market becomes more saturated with stations, vehicle demand responds more strongly to vehicle subsidies (i.e., diminishing marginal returns begin to kick in with respect to charging station entry).

I see a number of interesting directions to take this paper, many of which Kati has already made some progress on. Some of these ideas may naturally turn into standalone projects. The first extension would be to consider the more normative question as to the optimal level of subsidies in this market. The paper is currently setup to consider the most efficacious way to increase electric vehicle adoption, but one might also be interested in the welfare implications of various subsidy choices. There are also interesting questions that touch on issues of organizational economics, such as the extent to which EV firms should vertically integrate in this marketplace. These are two extensions to the current project that I know Kati has been pursuing recently. Given that she only recently obtained access to the data for the project, the amount of progress she has made thus far makes me optimistic about her career going forward.

Aside from doing interesting research, Kati is quite articulate as a speaker and presenter. She has taught well while in the graduate program and won an Outstanding GSI award. She is also a pleasure to be around. We have had many formal and informal conversations over the past three years, and they have all been enjoyable and engaging. To sum up, I think very highly of Kati, and I think that she is going to have a strong market. I encourage all Economics departments, Business Schools, and Policy Schools to look closely at her application.

Please do not hesitate to contact me with questions. I believe that Kati's work studies important topics, she is a very well trained applied microeconomist, and she would make a great and energetic addition to your group.

Best regards,



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