



2019 Asian Evaluation Week

Quality Evaluation for Better Results: Local,
National, Regional Perspectives

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Impact Evaluation of Energy and Transport Interventions

A review of the evidence

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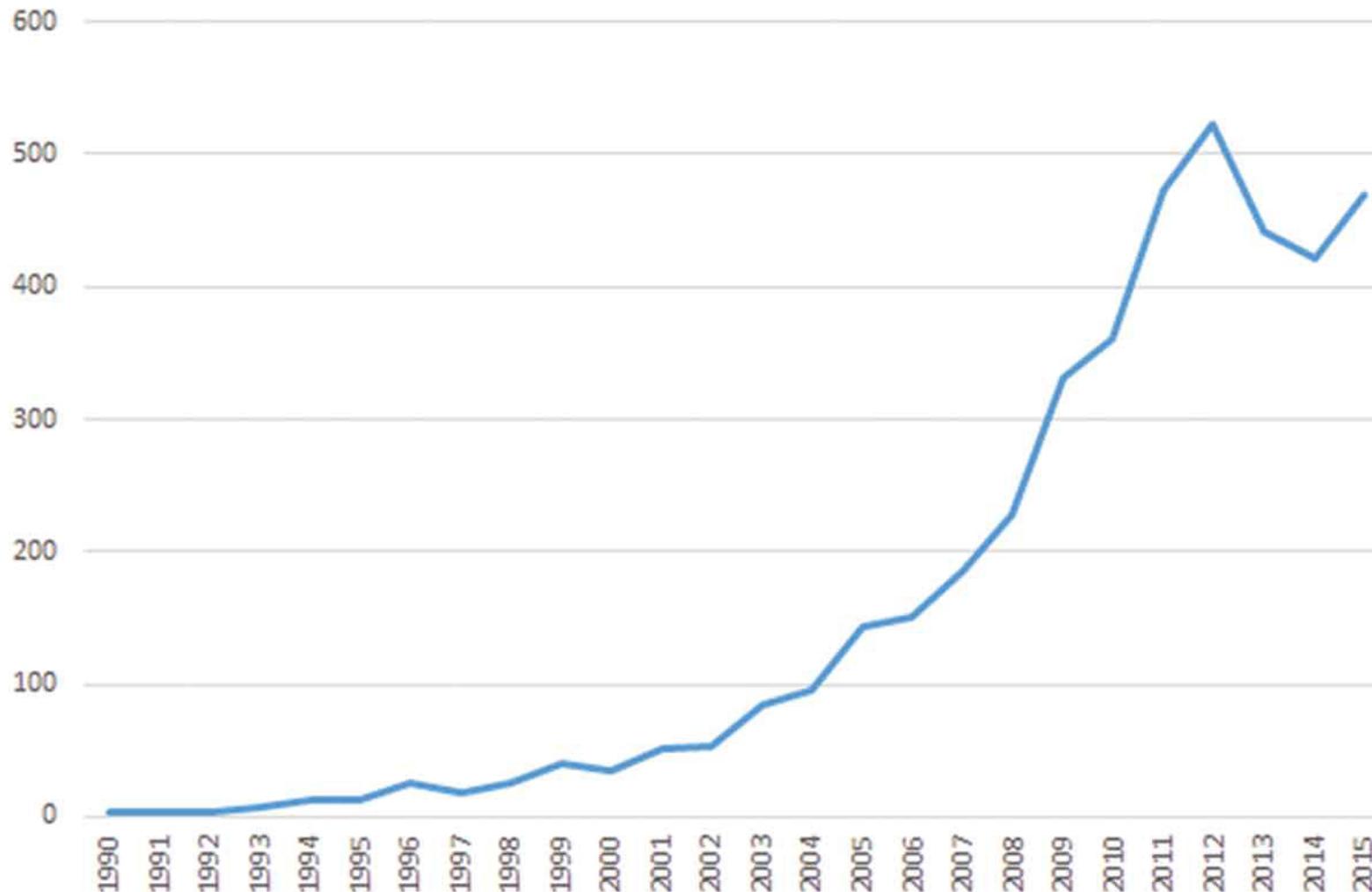
On behalf of coauthors Nina Blöndal and Jasmin Sibal



ADB

Prologue: growth of impact evaluation studies

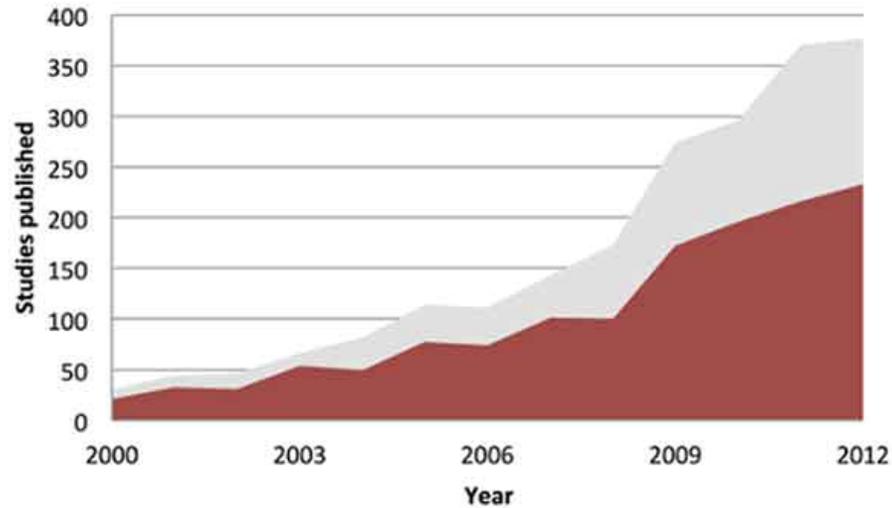
Number of development impact evaluations published annually



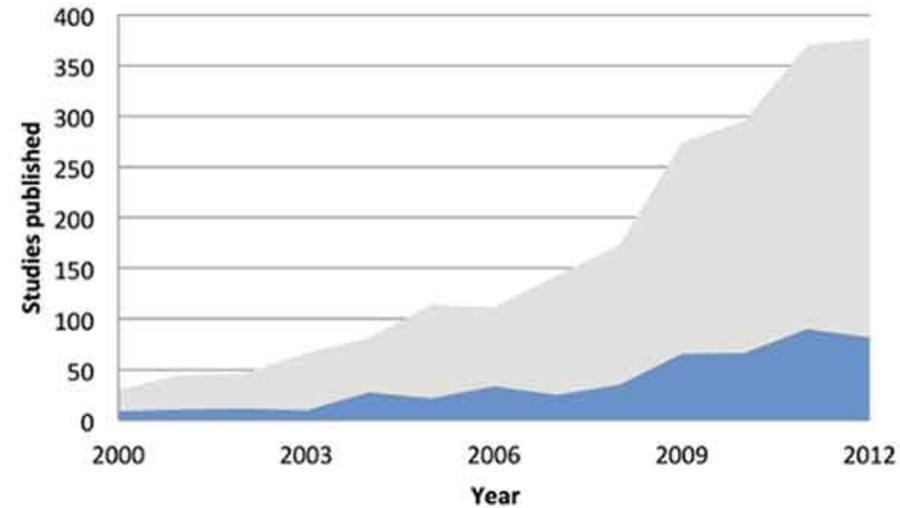
Cameron et al, 2016

Yet, impact evaluation coverage remains concentrated

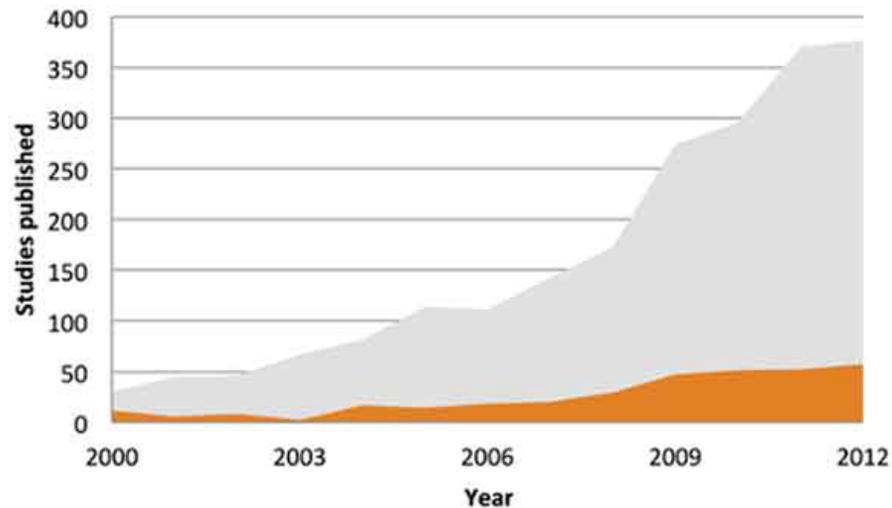
Health, nutrition and population



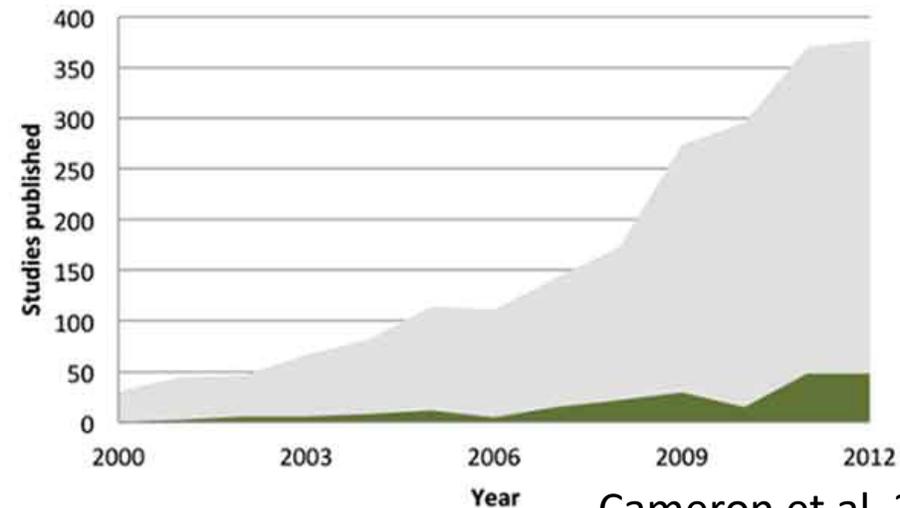
Education



Social protection



Agriculture



This presentation

- **Presents** reviews of impact evaluation questions, studies/evidence, and opportunities for interventions in under-evaluated sectors that receive substantial development finance:
 - Energy (mostly electricity)
 - Transport (mostly land transport)
- Impact evaluation here refers to empirical estimates of the magnitude and statistical significance of causal effects of interventions.
- **Goal** is to help guide future impact evaluations on energy & transport sector interventions, stimulate ideas
- **Approach:**
 - Review potential impact evaluation contributions to the sector
 - Characterize studies conducted to date
 - Methods
 - Interventions
 - Outcomes
 - Identify gaps and future directions

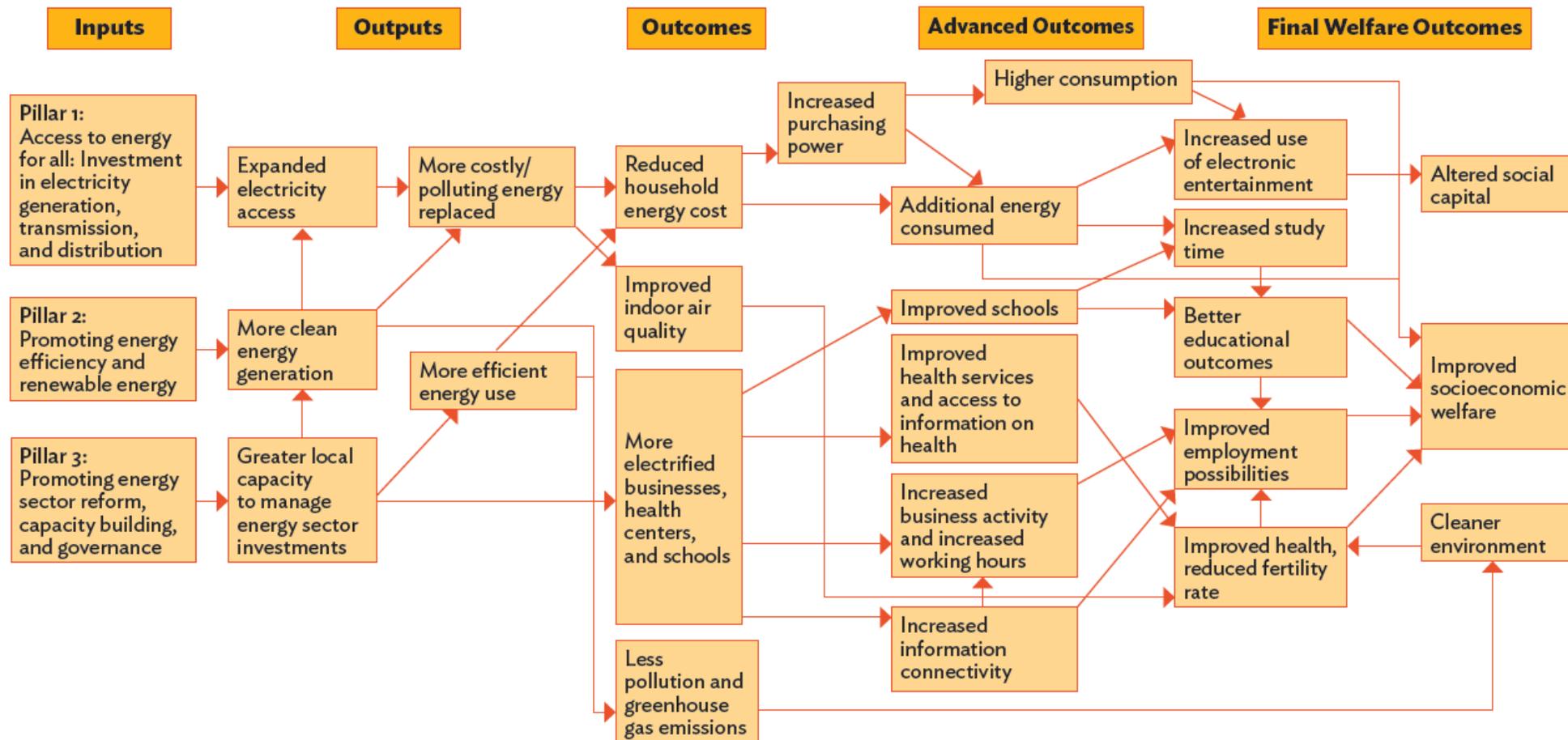
Energy sector interventions and impact evaluation

ENERGY INTERVENTIONS ARE INCREASINGLY BEHAVIORAL

- Increasing focus on **sustainability, climate change, energy access**
 - Clean energy
 - Off-grid solutions
 - Energy efficiency
- Achieving these solutions depends on shifting the **behavior** of
 - Utilities/power producers
 - Consumers
 - Public services
- Shifting behavior depends on measures **beyond hardware**
 - Policies
 - Prices
 - Information
 - Interactions with complementary interventions

IMPACT EVALUATION IS INCREASINGLY RELEVANT

- **Conventional economic** modeling of the energy sector relies heavily on behavioral **assumptions**
 - Price and substitution elasticities static and assumed
 - Smooth, perfectly competitive markets
 - Rational behavior
 - Actors with few objectives
- Impact evaluation, on the other hand, empirically measures the **causal effects** of interventions on outcomes of interest, while **minimizing assumptions**
- Especially important for understanding how **behavior** conditions effects
- Use of impact evaluation methods for energy interventions remains **limited, but is growing rapidly**



Assumptions				
Appropriate program design	<ul style="list-style-type: none"> Electricity is targeted and maintained. Clean energy matches load/demand characteristics. Capacity building is effective. 	<ul style="list-style-type: none"> Improved energy is less expensive than existing sources and substitutes for them. Efficient energy technologies are adopted. Public facilities make effective use of new energy. Clean energy replaces dirty energy. 	<ul style="list-style-type: none"> Businesses benefit from electricity. Electricity leads to increased study time. Public health services are effective. Improvement in air quality is sufficient to improve health. 	<ul style="list-style-type: none"> Increased study time and improved schools increase educational outcomes. Improved education and business opportunities are sufficient to improve employment. People make effective use of public health services and respond to increased information.

Challenges for evaluating impacts of energy interventions

1. **Core challenge:** to control for **confounding factors** to identify the effect attributable to an intervention in terms of magnitude and statistical significance
2. **Electricity projects** are affected by:
 - **Placement bias** – infrastructure put in places for specific reasons
 - **Selection bias** stemming from differences in the characteristics of households connected to improved energy and those that are not
3. “Small n” interventions (e.g., large-scale power generation and transmission lines) may have large **spillover and general equilibrium effects** making it difficult to capture unbiased treatment effects
4. **Networked power (gas) infrastructure**, so randomization difficult, transmission effects between treated and control

Energy impact evaluations to date in developing countries

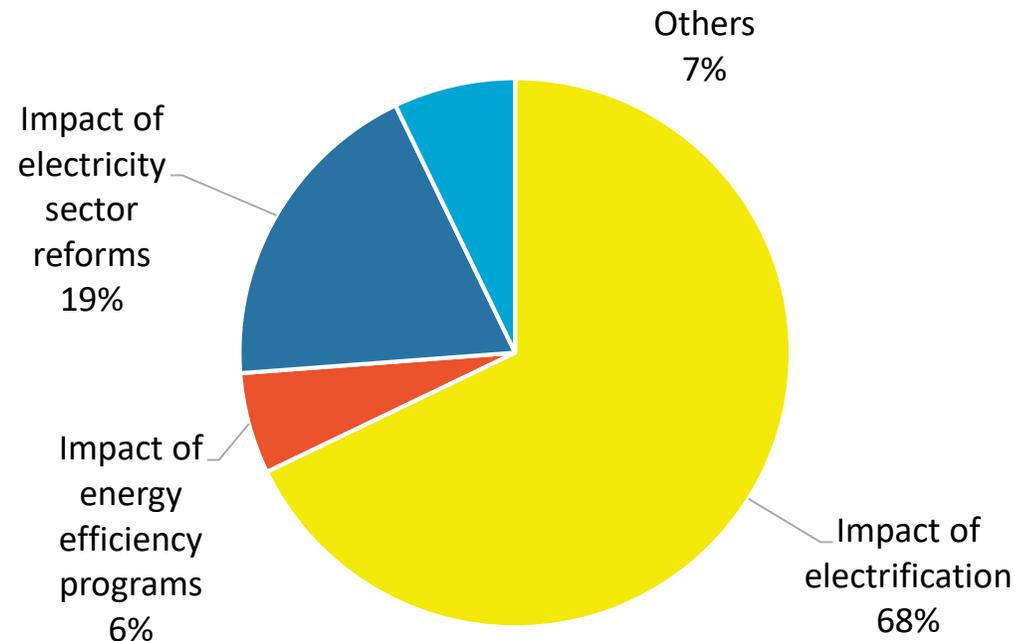
METHODOLOGY:

- **Scope:** empirical studies that attempt to control for selection/ placement bias and other confounding factors
- **Sources:** International Initiative for Impact Evaluation repository, EconLit database, “snowball” searches, other development partner websites

RESULTS:

- Total of 85 studies, 37 in Asia
- Over 60% published after 2012
- Vast majority assess the impact of electricity access (mostly rural grid electrification programs)

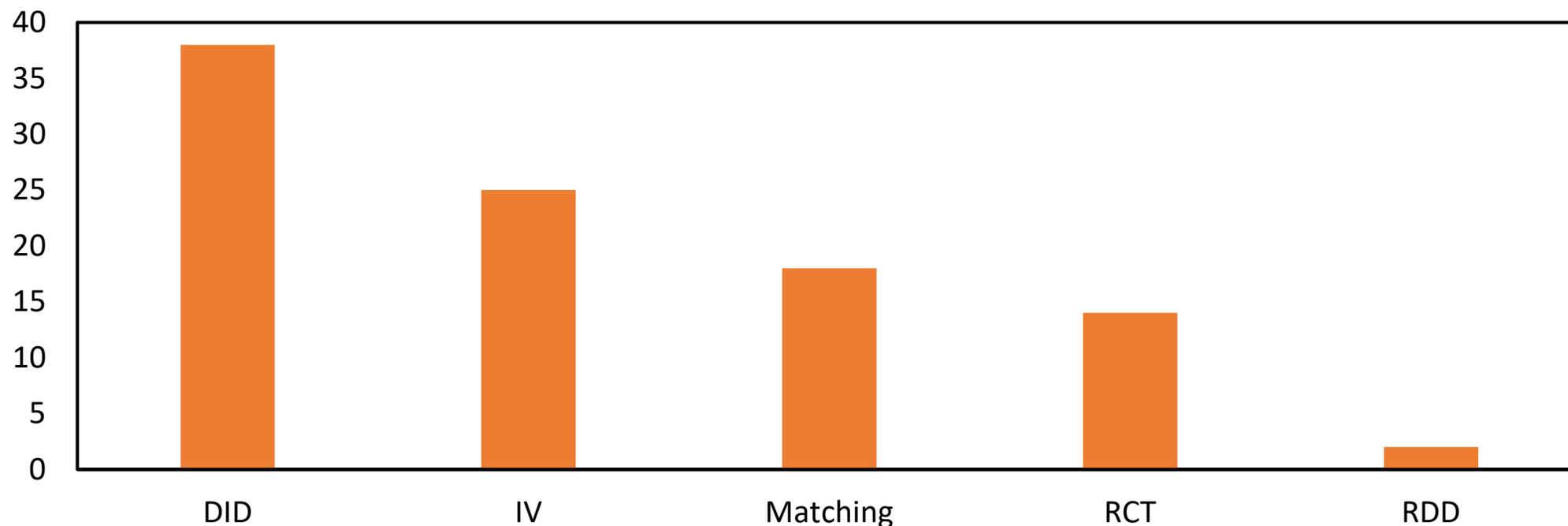
Interventions Evaluated in Energy Impact Evaluations (% of studies)



*Note: Percentages are out of 85 studies identified.
Source: Authors*

Common energy impact evaluation designs

Overview of Methods for Energy Sector Studies
(number of studies)



DiD = difference in differences, IV = instrumental variables (including endogenous treatment regressions), RCT = randomized controlled trial, RDD = regression discontinuity design. Note: Studies may use more than one method.

Source: Authors.

Selected recent randomized evaluations

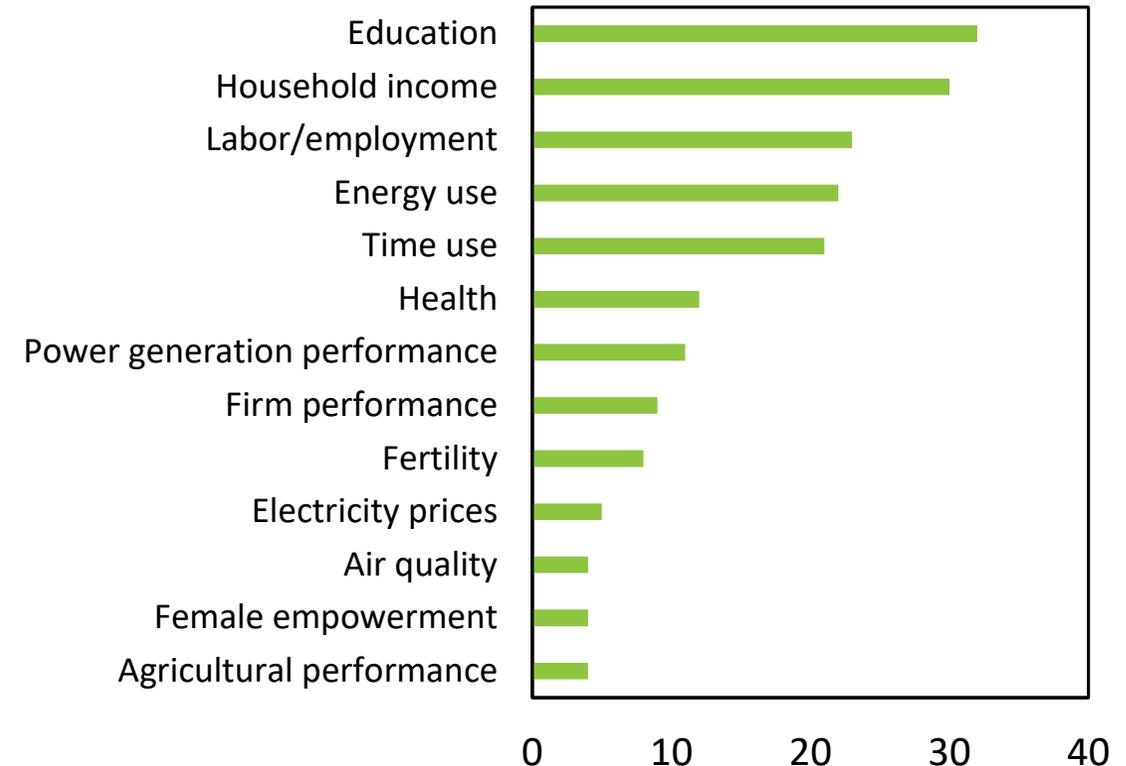
Intervention	Author & Country	Outcome	Experiment
Information nudges and electricity pricing	Sudarshan et al. 2017. (India)	Electricity use	Randomly assigns measures for energy efficiency, including (i) reports with peer comparisons of electricity use; (ii) as treatment i, plus monetary incentives to reduce consumption; and (iii) monetary incentives.
Solar microgrids	Aklin et al. 2017. (India)	Energy use, time use, employment, education, income	Villages are randomly selected to be offered a subsidized solar microgrid with sufficient electricity for lighting and mobile phone charging.
Rural grid electrification/ discount vouchers	Barron and Torero. 2014. (El Salvador)	Indoor air pollution, time use, health, educational outcomes, and income	Randomly assigns discount vouchers to a subset of households that being offered to connect to the electricity grid to introduce exogenous variation in take-up.

Outcomes measured (all studies)

The studies have found the following effects:

- Electrification can lead to substantial changes in **time use and** improved **educational outcomes** for children
- Educational outcomes of electrification can reinforce **gender equality**
- Electrification can impact **female empowerment**
- Electrification can affect **labor outcomes**
- Access to electricity can lead to increased **household income, consumption, and expenditure**
- Electricity can help improve **indoor air quality and human health**
- Electricity access can reduce **fertility**
- Energy efficiency interventions can have important effects on **energy consumption**, but can also encounter large rebound effects
- Market-based power sector reforms have limited observed effects on end users

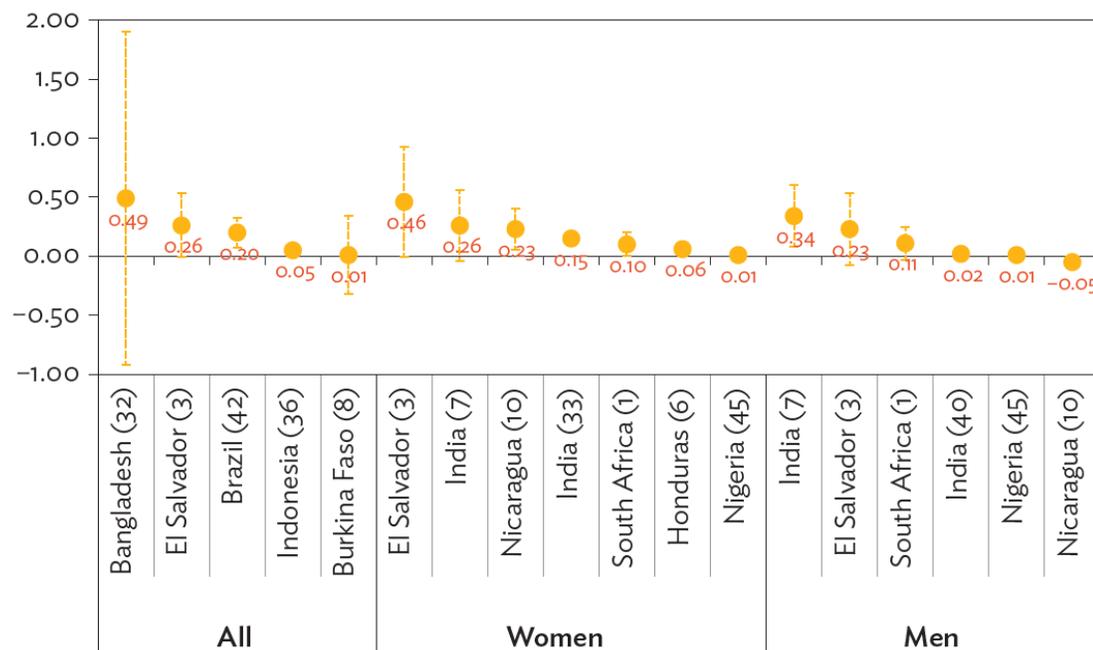
Outcome Variables in Energy (number of studies)



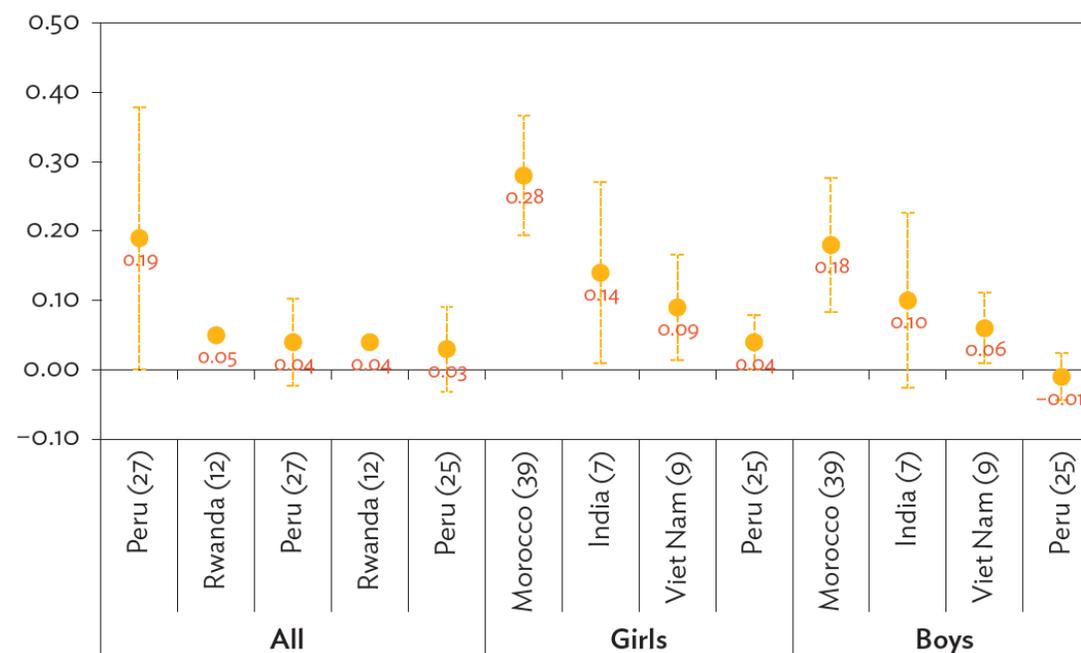
Note: Studies may evaluate more than one outcome.
Source: Authors.

Outcomes measured (cont'd)

Electrification can affect employment outcomes



Electrification can lead to improved school enrollment outcomes for children



Note: Estimated effects are expressed as proportional changes with respect to the control mean, with the standard errors represented by whisker lines. X-axes indicate the country where the study took place.

Source: Adapted from Jimenez (2017).

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Source: Adapted from Jimenez (2017).

Energy evidence gaps

Coverage gaps

Coverage is lacking on the following areas:

- **Improvement of electricity supply** (electricity quality and urban electricity enhancement)
- **Deployment of on-grid clean energy** (solar and wind)
- **Incentives for clean energy development** (tax incentives, green energy options, etc.)
- **Measures to enhance grid efficiency** (smart grids)
- **Tariff and payment structures**
- **Electricity programs for agriculture** (pricing and availability)
- **Bioenergy** (other than improved stoves)
- **Non-electricity energy infrastructure**
- **Promotion of energy efficiency** (labeling, subsidies for efficient units, information campaigns, etc.)

Outcome gaps

Evidence is lacking on the following areas:

- **Intermediate impact channels** (mechanisms by which changes occur)
- **Effects on public services** (teacher and health staff absenteeism, knowledge and use of public services)
- **Effects on health** (family planning, adverse effects of electricity accidents)
- **Effects on firm performance** (productivity, market access, or diversification of business)
- **Effects on social capital and socio-emotional skills**
- **Environmental effects** (energy efficiency outcomes, effects of clean energy on pollutant or greenhouse gas emissions)
- **Effect heterogeneity** (for more studied outcomes with substantial variation in effects found)

Methodological gaps/opportunities for energy

- Exciting potential for randomized evaluations
 - Designs on pricing
 - Connection fees, tariffs, financing
 - Pipeline randomization
 - End user connections, improvements
 - Information treatments
- Quasi-experimental methods with promise:
 - Regression discontinuity designs (assignment or application criterion with cutoff)
 - Understanding, formalizing prioritization processes
 - Interrupted time series (high frequency data with sudden intervention effectiveness)
 - Synthetic controls (time series observations for at least one treated unit and multiple comparison units)
- More ability to use billing and administrative data

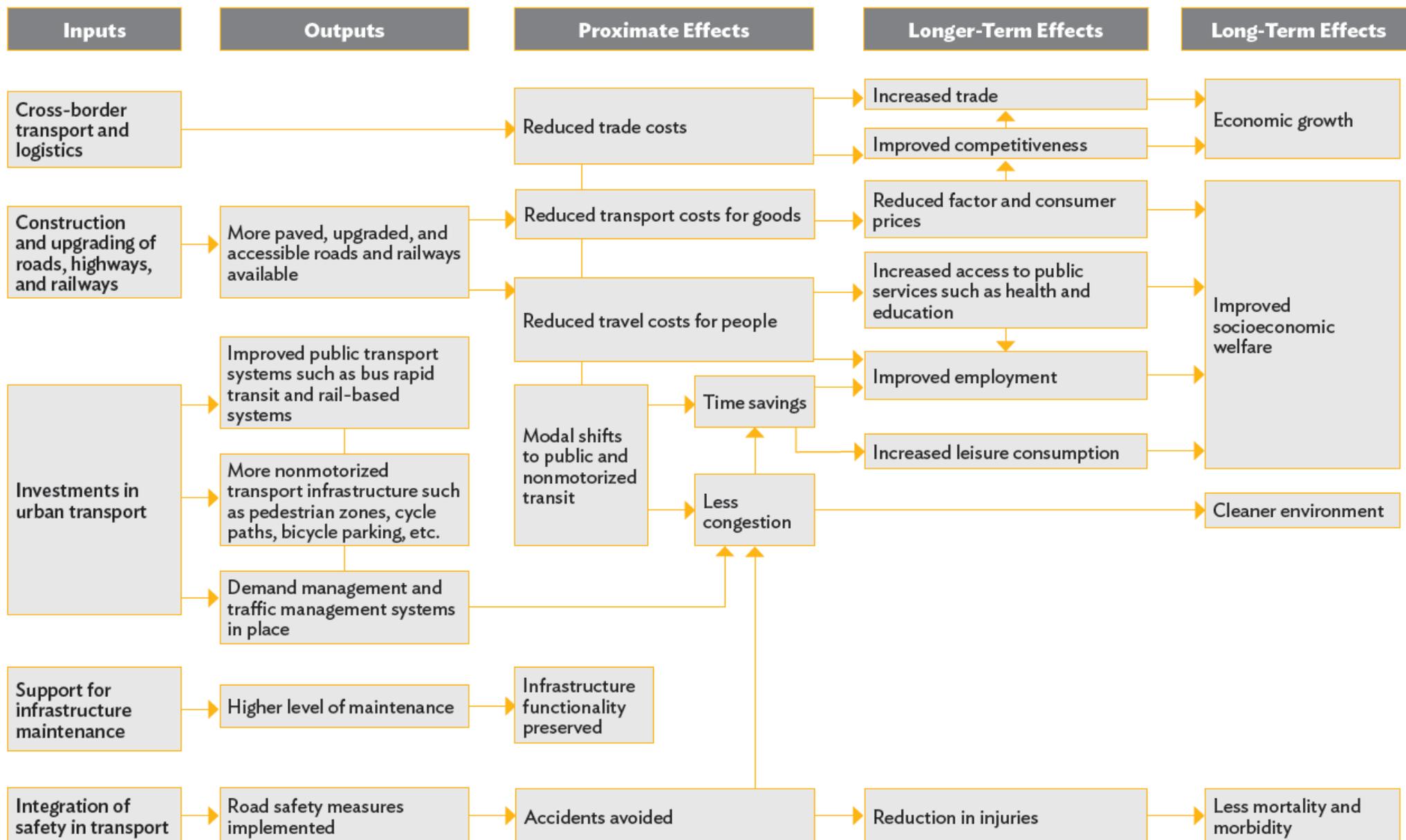
Transport sector interventions and impact evaluation

TRANSPORT INTERVENTIONS ARE INCREASINGLY BEHAVIORAL

- Transport is a **key sector**: transport operations reached over 20% of total ADB investment in 2017
- Recent trend: emergence of **transport policies** as an investment focus
- Transport development is often considered as an **integral part** of other development processes (i.e., development of economic corridors, etc.)
- Investment in transport is increasingly oriented toward **innovation and behavior change** (i.e., avoid-shift-improve approach)

IMPACT EVALUATION STUDIES ARE INCREASINGLY RELEVANT

- Effects of transport sector projects have mostly been modeled using **unverified assumptions** about how people and markets behave
 - Price and substitution elasticities static and assumed
 - Smooth, perfectly competitive markets
 - Rational behavior
 - Actors with few objectives
- Impact evaluation, on the other hand, empirically measures the **causal effects** of interventions on outcomes of interest, while **minimizing assumptions**
- Especially important for understanding how **behavior** conditions effects
- Use of impact evaluation methods for transport interventions remains **limited, but is growing rapidly**



Challenges of evaluating impacts of transport interventions

1. **Core challenge:** to control for **confounding factors** to identify the effect attributable to an intervention in terms of magnitude and statistical significance
2. Some types of transport sector interventions are “**small n**” and involve few treated units
3. Transport interventions are often **part of larger networks** and impose spatially variable levels of “treatment”, as well as network transmission effects.
4. Location/treatment is **endogenous**, at least over longer time horizons (Boarnet 2007), as people and firms can move.
5. Violation of the **stable unit treatment value assumption** that is central to conventional impact evaluation (e.g., assuming no spillover effects from treated to untreated groups)

Transport impact evaluations to date in developing countries

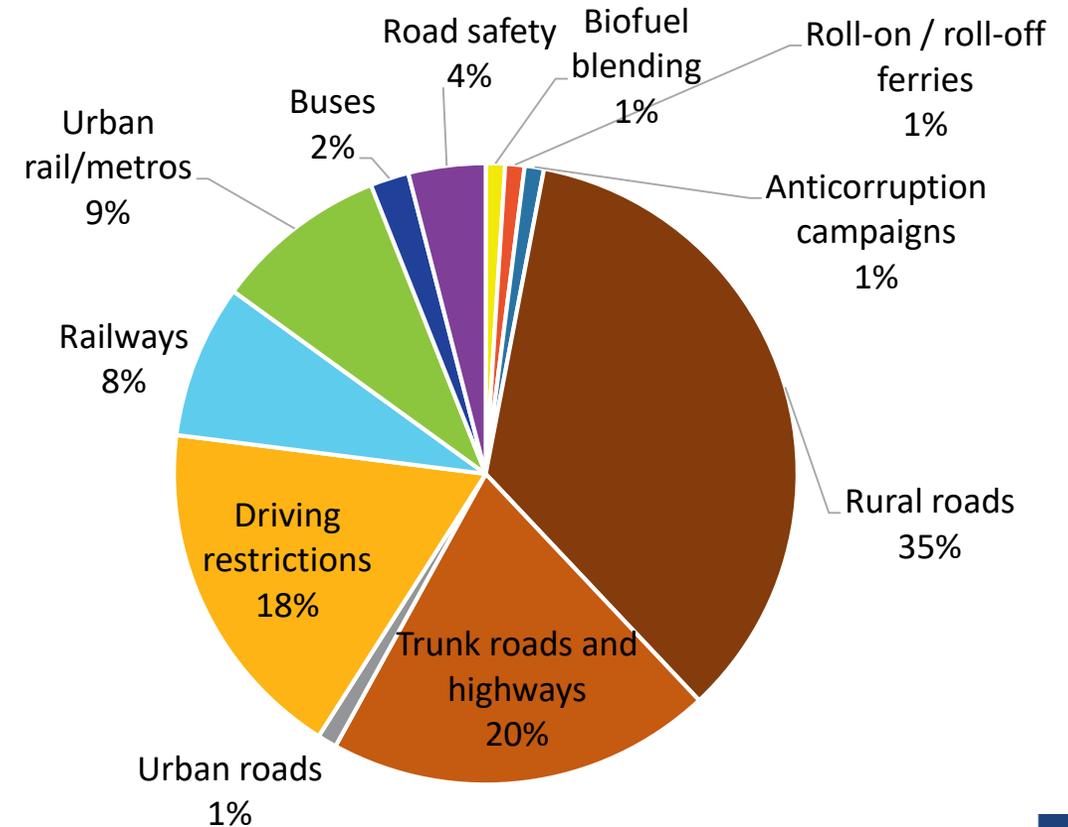
METHODOLOGY:

- **Scope:** empirical studies that attempt to control for selection/ placement bias and other confounding factors
- **Sources:** International Initiative for Impact Evaluation repository, EconLit database, “snowball” searches, other development partner websites

RESULTS:

- Total of 91 studies, 59 in Asia
- 65% produced after 2012
- Some interventions are subject of multiple impact evaluation projects (i.e., Prime Minister’s Rural Roads Scheme in India)

Interventions Evaluated in Transport Impact Evaluations (% of studies)

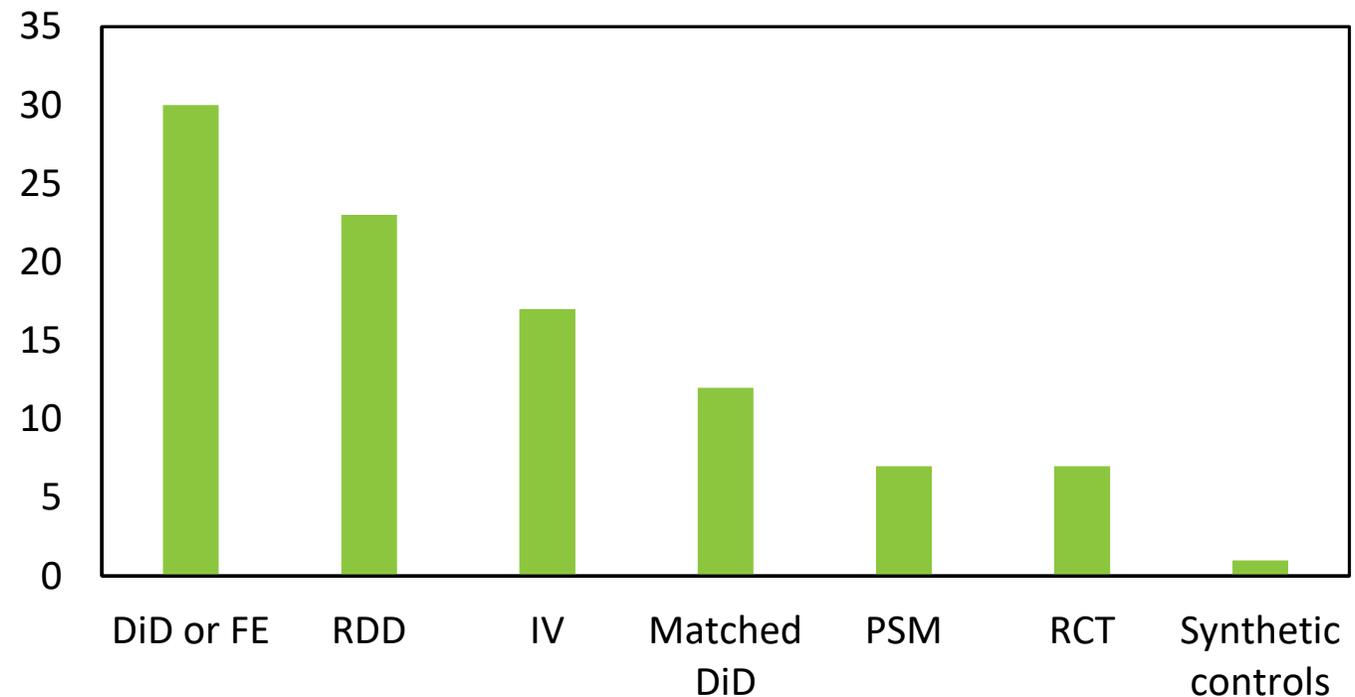


Note: Percentages are out of 91 studies identified.
Source: Authors

Common transport impact evaluation designs

- Designs include both **experimental** and **non-experimental**
- Existing studies have mainly used a range of **non-experimental** methods
- Many of the studies have used **secondary data** from before and after transport interventions in areas with and without the interventions

Overview of Methods for Transport Sector Studies
(number of studies)



DiD = difference in differences, FE = fixed effects, IV = instrumental variables (including endogenous treatment regressions), PSM = propensity score matching, RCT = randomized controlled trial, RDD = regression discontinuity design. Note: Studies may use more than one method.

Source: Authors.

Selected recent randomized evaluations

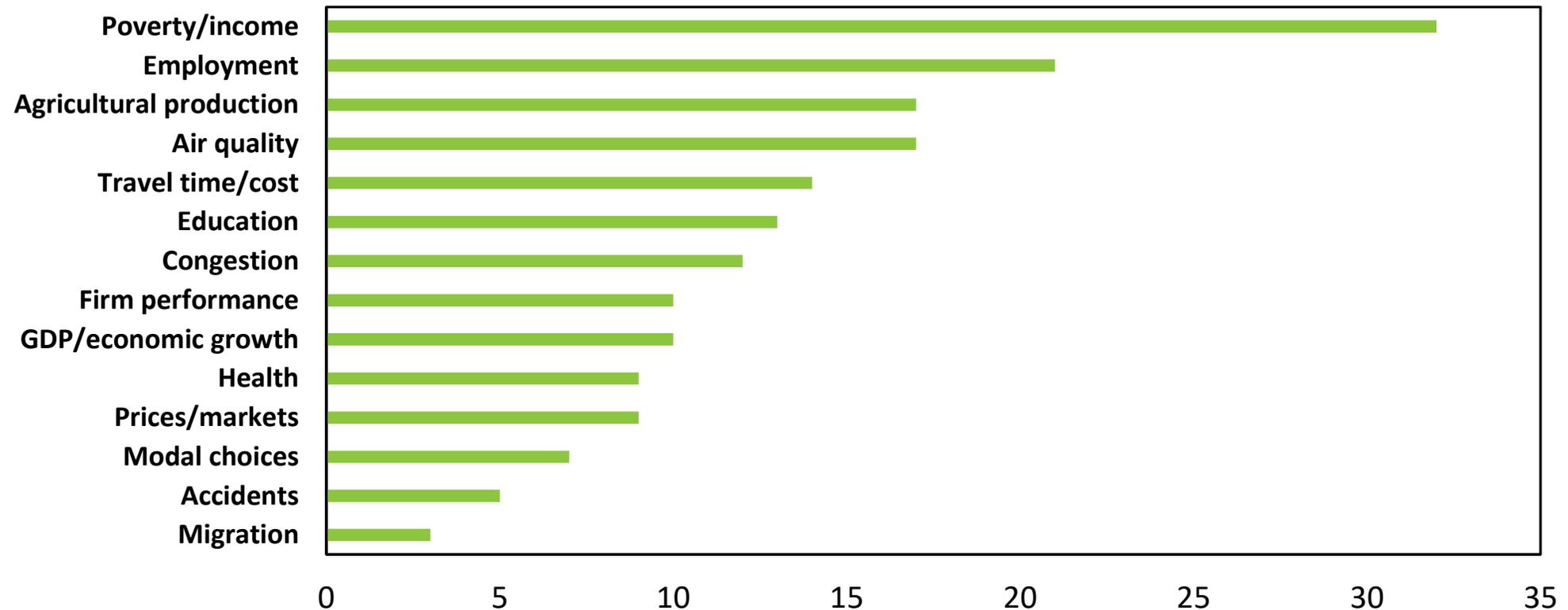
Intervention	Author & Country	Outcome	Experiment
Urban street paving	Gonzalez-Navarro and Quintana-Domeque. 2016. (Mexico)	Property prices, credit, and consumption	Randomly assigns 28 of 56 urban streets for paving in Acayucan, Mexico
Transport subsidies	Franklin. 2015. (Ethiopia)	Employment outcomes	Randomly assigns temporary transport subsidies to unemployed youth living in spatially dislocated areas of Addis Ababa.
Anti-drunken driving program	Banerjee et al. 2014. (India)	Accidents, deaths, incidents of drunken driving	Randomly assigned 12 variations of an anti-drunken driving program, which varied: (1) the frequency of police roadblocks, (2) the location of the roadblocks, and (3) the personnel carrying out the roadblocks.

Quasi-experimental examples

Intervention	Author & Country	Outcome	Experiment
Driving restriction	Davis. 2017. (Mexico)	Air quality	RDD on restriction cutoff times, analysis of hourly air quality data
Urban metro	Goel, D. and S. Gupta. 2015. (India)	Congestion and air quality	RDD on time of opening of metro stations
Rural roads	Asher and Novosad. 2018. (India)	Employment, income, firm performance, time use	RDD on rural roads program targeting only villages with more than 500 inhabitants
Roads	Volpe Martincus. and Blyde. 2013. (Chile)	Firm exports	Natural experiment from earthquake, difference in differences

Outcomes measured (all studies)

Outcome Variables in Transport Impact Evaluations
(number of studies)



GDP = gross domestic product.
 Note: Studies may evaluate more than one outcome.
 Source: Authors.

Transport evidence gaps

Coverage gaps

Limited coverage on:

- **Urban transport** (limited to few countries and evaluate roads and rural roads only)
- **Non-road transport** (limited studies on rail, urban mass transit, and sea or air travel)
- **Complementary interventions** (limited studies on road safety, gender disparities in transport)
- **Behavioral and efficiency-enhancing measures** (limited studies on congestion-reducing measures)
- **Improvements to logistics, ports, and trade facilitation** (little evidence on airports, seaports, border facilities nor on trade and logistic-related policy reforms)
- **Operations and maintenance** (no studies on impact of different maintenance funding or contracting systems)

Outcome gaps

Limited attention has been given on effects on:

- **Infrastructure quality** (how contractual mechanisms affect longevity of infrastructure)
- **Travel time and vehicle operating costs** (real world driver behavior and road congestion)
- **Access to intermediary services** (health and education including staff absenteeism)
- **Employment search process and commuting patterns** (time use and attempt to access new employment options)
- **Businesses** (sales, revenue, etc. and broader effects on competitiveness or trade)
- **Social capital** (participation in groups and community activities)
- **Female empowerment** (female decision-making roles, independence, empowerment)
- **Environmental effects other than on air quality** (land-use change, poaching)

Methodological gaps/opportunities for transport

- Exciting potential for randomized evaluations
 - Encouragement designs on pricing instruments
 - Random assignment of complementary measures, policies
- Quasi-experimental methods with promise:
 - Regression discontinuity designs (assignment or application criterion with cutoff)
 - Interrupted time series (high frequency data with sudden intervention effectiveness)
 - Synthetic controls (time series observations for at least one treated unit and multiple comparison units)
- New data sources are becoming available, which may enable better application of impact evaluation methods (i.e., georeferenced data, spatial data such as luminosity and air quality, “big data”)

Session Takeaways

- Many evidence gaps to address through impact evaluation
 - Increasing relevance of impact evaluation to “hard sectors”, as more behavioral interventions
 - Limited coverage of many types of interventions
 - Energy interventions other than rural electrification
 - Transport interventions other than roads
 - Limited coverage of many outcomes and impact channels
- Growing opportunities to generate more evidence
 - More pricing instruments, complementary interventions => More possibilities for experiments, including rapid tests
 - “New” and underutilized quasi-experimental approaches -> discontinuities as opportunities
 - Ever more (“big”) data available

Thank you!

