The Economics of Steering the Transition to a Low Carbon Economy

Monday 20th October: Understanding Climate Risk		
10.30 – 11.30	**Session 1:**	**A framework for the economics of low-carbon change**
11.30 – 12.00	*Break*	
12.00 – 13.00	**Session 2:**	**Exploring the Apparent Trade-Offs Between Reducing Climate Risk and Fostering Growth**
13.00 – 15.00	*Lunch*	
15.00 – 16.00	**Session 3:**	**The Dynamic Net Economic Costs of Transition**
16.30 – 17.00	**Session 4:**	**Wrap-up and Open Discussion**

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Exploring the Apparent Trade-Offs Between Reducing Climate Risk and Fostering Growth

Dimitri Zenghelis

Monday 20th October

Session Two

Exploring the Apparent Trade-Offs Between Reducing Climate Risk and Fostering Growth

Part I: Understanding costs - investment and economic

Part II: Traditional models and dynamic models

Part III: Costing policy failure

Part IV: Impact of confidence in business uncertainty
Potential future game changers. Expectations

Part V: Structural change and vested interests
- resistance to change

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Part I: Understanding costs - investment and economic (i)

Investment costs of a low carbon transition

- The infrastructure requirements for a high-carbon economy, across transport, energy, water systems and cities, are estimated at around US$6 trillion per year over the next 15 years (<10% GDP)
- Combining renewable energy with reduced fossil fuel investment, more compact cities, and more efficiently managed energy demand, low-carbon infrastructure NCE estimate investment requirements increases by only an estimated US$270 billion a year (~0.3% GDP)
- These higher capital costs could potentially be fully offset by lower operating costs, for example from reduced expenditure on fuel
- Incremental costs of transition very manageable – tweak what needs to be done anyway

Part I: Understanding costs - investment and economic (ii)

Full economy costs – how does transition effect total production of goods and services?

Must reflect full welfare or utility costs – not just partial equilibrium

General equilibrium considers full knock on costs transmitted through the economy

- Deadweight cost of distortion – resources wasted
- Impact of re-allocating fixed resources to less productive activities
- Pushes up costs across the economy
- Means a loss of consumer and producer surpluses (a measure of lost utility)
- Dynamic costs – productive investment forgone

Beyond GDP; Welfare

Part II: Traditional models (i)

- An economic model is essentially **a simplified framework for describing the workings of the economy**
- It exerts the discipline of forcing the modeller to formally articulate assumptions and tease out relationships behind those assumptions. Control for extraneous factors (assume fixed)
- Models are used for two main purposes: **simulating** (e.g. how would the world change relative to some counterfactual if we assume a change in this or that variable) and **forecasting** (e.g. what the world might look like in 2030)
- Economic models are great tools for simulations – given what we know about the behavioural workings of the economy, and taking these mostly as given, how might the economy respond to, say, an energy price spike?
- But models are much less effective at providing forecasts precisely because when making forecasts, very little can be taken as given
- The further out the forecast, the larger the structural uncertainties making model projections at best illustrative

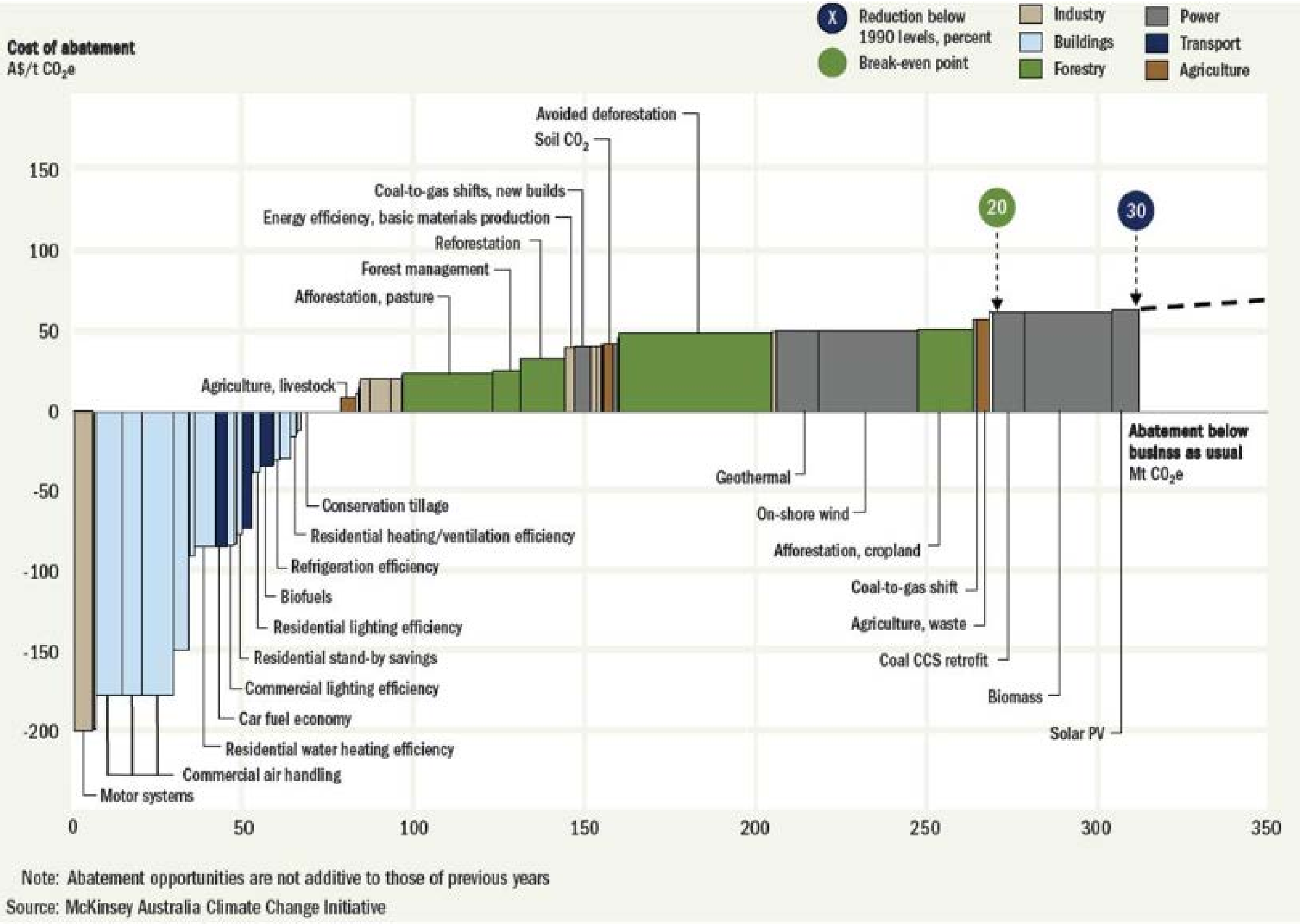
Part II: Traditional models (i)

Part II: Traditional models (ii)

- Variety of models. Most common is general equilibrium GE models
- Rich specification markets clear, utility maximising consumers make rational choices among goods and services and work and leisure and firms maximise profits
- Often a single consumption good is produced using capital and labour. The total productivity of these factors depends upon a single technology parameter, which is imposed and grows exogenously
- Most GE models start from the **assumption of an economy where resources are already efficiently allocated, for the good reason that it is not easy to model properly the real and dynamic world of multiple imperfections and numerous market failures** (tin opener?)

*IPCC, 2014. Summary for Policymakers (IPCC *AR5*, Working Group III). See Table SPM.2.

Part II: Static MAC curves



Note: Abatement opportunities are not additive to those of previous years

Source: McKinsey Australia Climate Change Initiative

- No spill overs; No interaction; No dynamics; No learning or induced innovation

Part II: Traditional models (ii)

- Static MACs deployed
- GE models '**struggle' to integrate the dynamic increasing returns** associated with disruptive technological change
- **'Struggle' to incorporate complementarities, integration effects and networks**
- Such models predict that the difference between global GDP in low- and high-carbon scenarios by around 2030 is only around 1–4%*
- Given how much the economy will have grown by then, that is not large: it is equivalent to reaching the same level of GDP 6–12 months later
- Those models which incorporate the impacts of climate change show GDP performs better in lower-carbon scenarios than in higher-carbon ones.
- Jobs impact ambiguous and depends on circumstance

*IPCC, 2014. Summary for Policymakers (IPCC *AR5*, Working Group III). See Table SPM.2.

Part II: Traditional models (iii)

- The effects of policy reforms are thus judged against the assumed **starting point of an efficient economy**. Such results, while interesting, need to be used cautiously as a guide to policy when one is judging the results of reform versus non-reform in a highly imperfect and inefficient world
- Such shortcomings have been examined, regarding the use of UK Treasury's CGE model to assess the short-run cost of UK climate policies (Ackerman 2014)*
- This analysis illustrated the limiting assumptions of the model
- It showed that including the values of health benefits from reduced air pollution and the value of carbon emissions that are not traded in the European Emissions Trading System (EU ETS), would reverse the model results - the benefits of the policy would exceed the costs.

*Ackerman, F. and J. Daniel, J., 2014. (Mis)understanding Climate Policy: The role of economic modelling. Synapse Energy Economics, Cambridge MA. Prepared for Friends of the Earth and WWF-UK. Available at: https://www.foe.co.uk/sites/default/files/downloads/synapse-misunderstanding-climate-policy-low-res-46332.pdf.

Part II: Traditional models (iii)

Because they simplify, most standard models miss one or all of the following, especially where they constitute a market failure

Pollution externalities

- NCE shows that in 15 countries with the highest greenhouse gas emissions, the damage to health from poor air quality, largely associated with the burning of fossil fuels, is valued at an average of over 4% of GDP; In China this rises to more than 10% of GDP

Congestion which dents economic productivity

Inefficiency non-price sensitive behaviour exacerbated by existing price distortions e.g. fossil fuel subsidies

Energy security - reduced energy price volatility due to lower fossil fuel use

Liveable cities

Fiscal reform

- If developed countries used carbon pricing to implement emissions cuts as pledged in Cancun under the United Nations Framework Convention on Climate Change, they could raise more than US$400 billion annually by 2020

Implementation of the policies and investments proposed in NCE could deliver 50-90% of the reductions in emissions needed by 2030 to lower the risk of dangerous climate change.

Part II: Dynamics and Costs of Delay

Costs are also likely to rise sharply with delay

- If global action to reduce emissions is delayed until 2030, global CO_2 emissions would have to decrease by 6-7% per year between 2030 and 2050 in order to have a reasonable chance of staying on a 2°C path
- Such rates of reduction are likely to be expensive
- Estimates of delay suggest an average annual consumption growth loss of around 0.3% in the decade 2030 to 2040, compared to a loss of less than 0.1% over the same period if we act now*
- So static cost benefit in sufficient. The problem is dynamic – the approach must be based on options
- Lock-in can be **technological, physical or behavioural** and usually all three interact!

*Bertram, C., Petermann, N., Jakob, M., Kriegler, E., Luderer, G.~~,~~ and Edenhofer, O., 2014 (forthcoming). Relating Near-term Energy Policies to Long-term Climate Stabilisation: Insights from Recent Integrated Assessment Modelling Studies. New Climate Economy contributing paper. Potsdam Institute for Climate Impact Research, Potsdam.

Part II: Dynamics and Costs of Delay

Part II: Dynamics and Costs of Delay

Dangers of locking in lack of resilience. Urban planning and the recent **financial market crash**:

- **Sprawling suburbs** such as Victorville, 100 miles northeast of downtown Los Angeles* entirely dependent on private cars to connect homes to work and services.
- Such neighbourhoods **unviable** when fuel prices rose from $2 early in the decade to $4 in 2008.
- The unsustainable nature of resource-intensive planning manifests itself in the short- as well as the long-term.

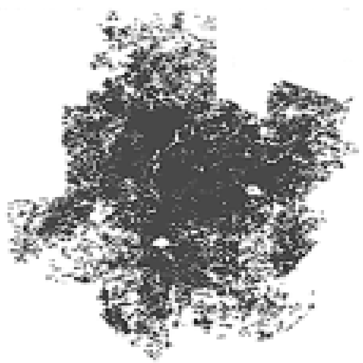
*See Karlenzig (2011) 'The Death of Sprawl'

Lock in: Choices today create path dependencies for decades to come

Atlanta and Barcelona have similar populations and wealth levels but very different carbon productivities

ATLANTA

Atlanta's built-up area



Population: 5.25 million
Urban area: 4,280 km²
Transport carbon emissions: 7.5 tonnes CO_2 per person (public+ private transport)

BARCELONA

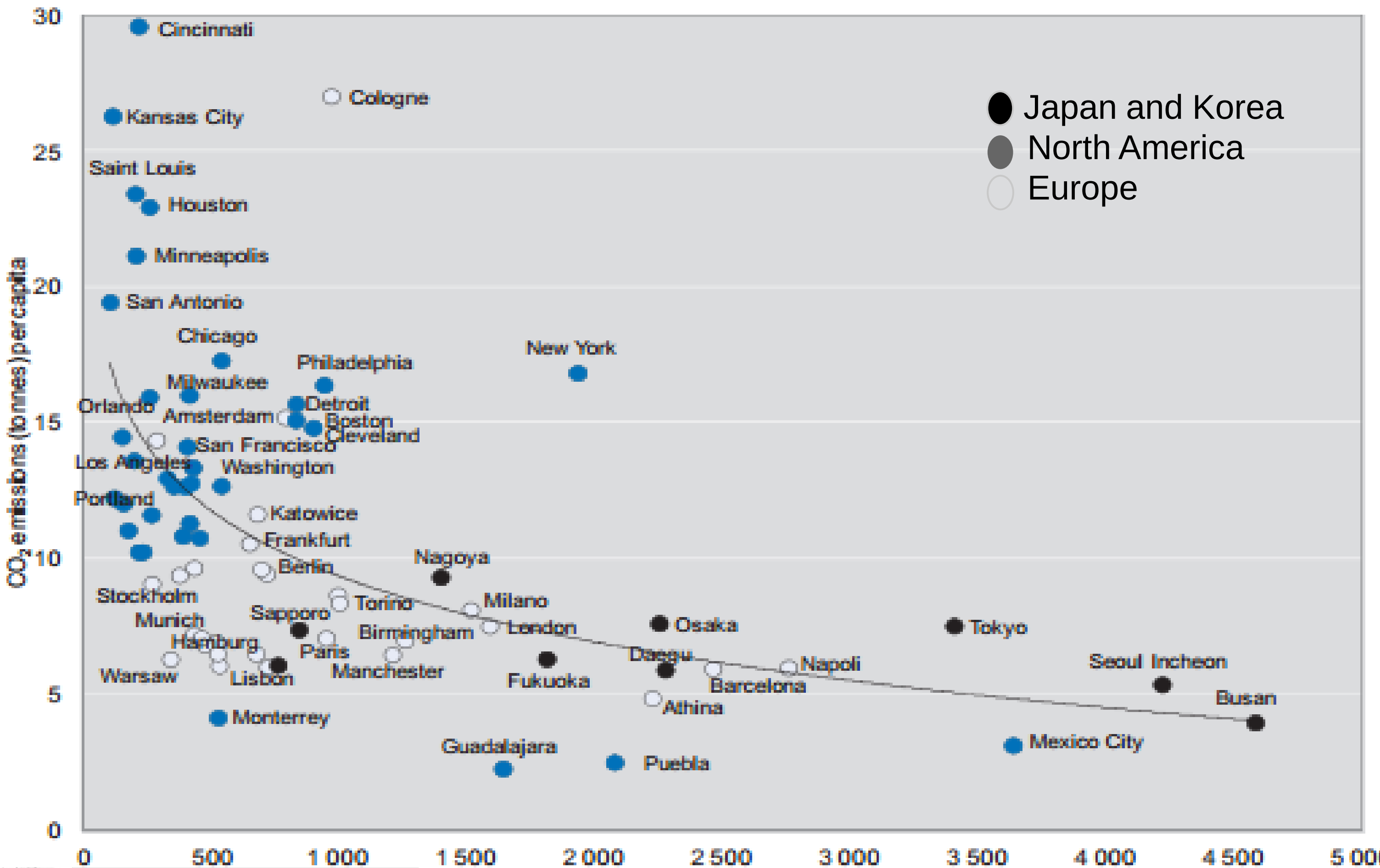
Barcelona's built-up area

Population: 5.33 million
Urban area: 162 km²
Transport carbon emissions: 0.7 tonnes CO_2 per person (public+ private transport)

Source: Transit and Density: Atlanta, the United States and Western Europe, Bertaud and Richardson, 2004

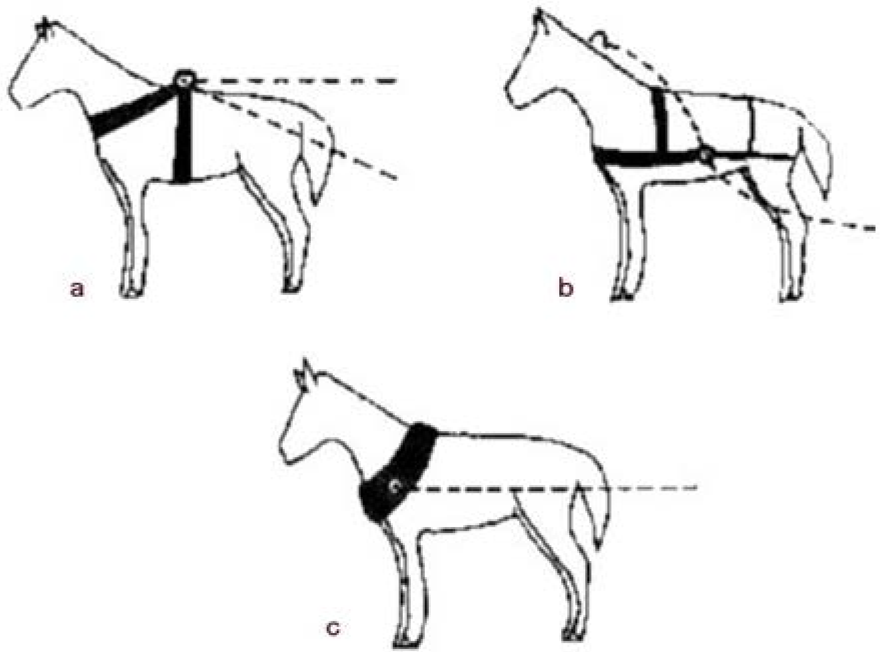
Cities with higher density tend to have lower carbon emissions

Population density and CO2 emissions per capita in 73 OECD metropolitan areas, 2006



Source: Call for evidence contribution by the OECD

Part II: Innovation



Source: Needham J. (2005), “Science and Civilisation in China,” Vol. 4, part 2, Cambridge University Press

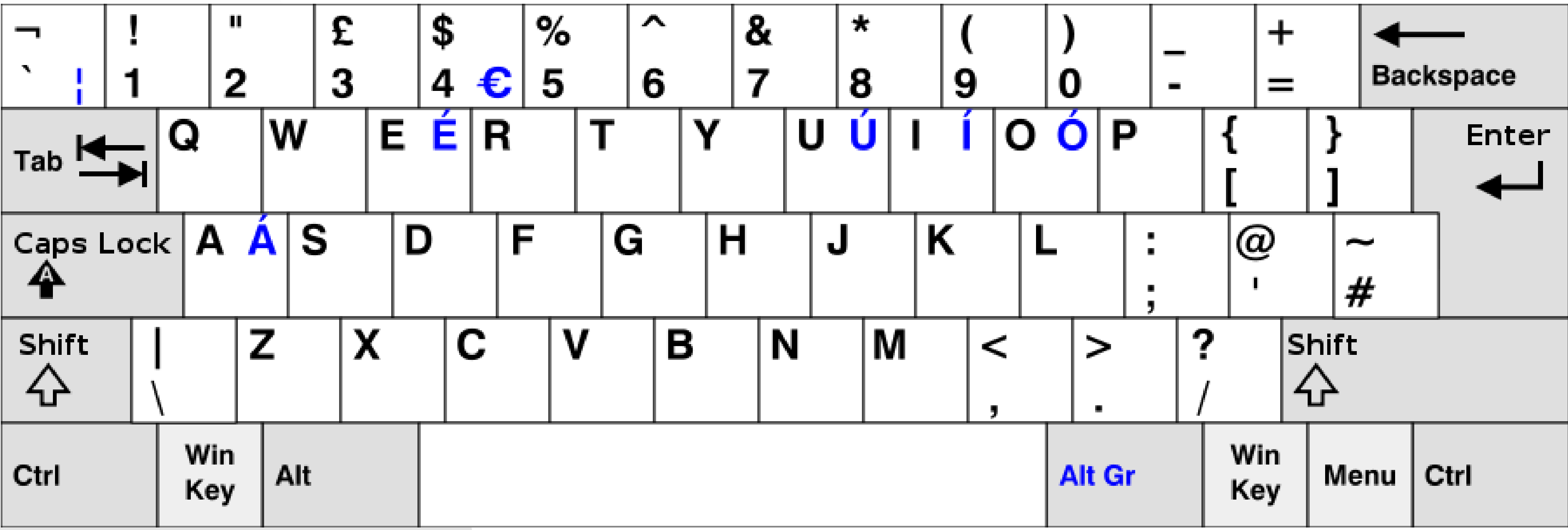
Part II: Endogenous models (i)

Many standard models do not adequately model the drivers of innovation

- Some have attempted to incorporate innovation, however, they miss firm-level and sector-specific process with **complex spillovers and interactions** across sectors, institutions and behaviours
- These could lead to a number of complementarities and scale economies which enhance the low-carbon impact of innovation
- Hence, predictions of models are biased towards innovations that seem more likely from the point of view of today, so underestimating their likely impact on costs.
- **Policymakers need to consider the complex inter-relationships**
- **Properly accounting for path-dependencies makes early intervention in the innovation system more desirable**, even under the higher discount rate assumptions made by some economists
- This is because if we delay intervention, then as time progresses, conventional technologies will become more entrenched and making a low-carbon transition more expensive

= path dependency and multiple equilibria

Part II: Lock in (i)



Part II: Lock in (i)

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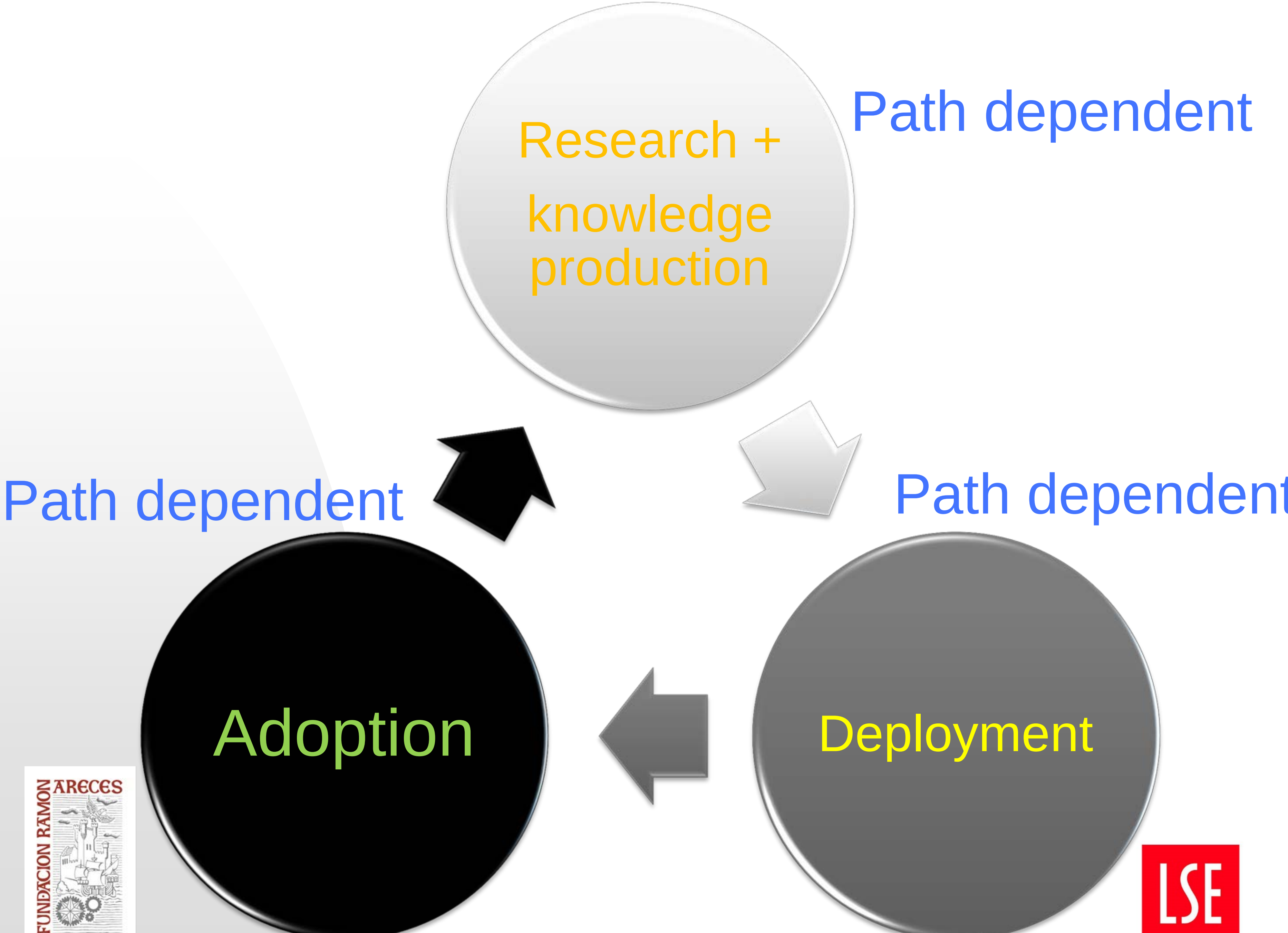
Every stage of innovation is path dependent


Research +
knowledge
production
Path dependent
Path dependent
Path dependent
Adoption
Deployment

Path dependence

Many equilibria

Part II: Endogenous models (ii)

Which pathway is more likely?

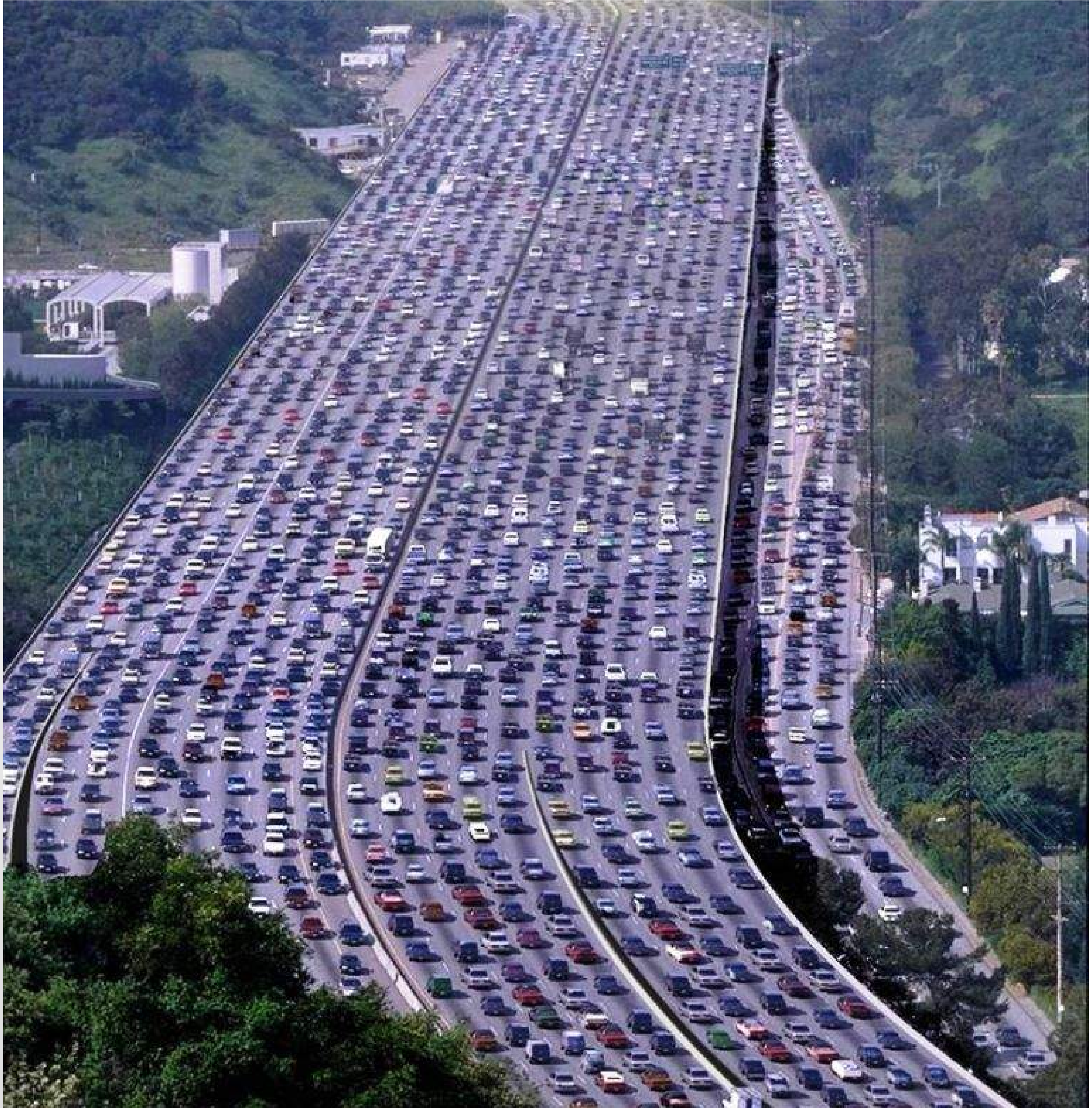
- Economic theory indicates the pathway we select will depend on the *expectations* about technologies & the *initial conditions* of the innovation process (Krugman, 1991; Cooper, 1999)*.
- Firms' expectations of a large clean-energy market in the future would be a sufficient incentive to invest in it.
- As enough players shift investment, the costs of green technologies would be expected to fall as would the cost of capital in what were formerly considered niche markets
- The development of new skills as well as supportive institutions and behaviours would be expected to further reduce unit costs
- Naturally, if green technologies are reasonably well developed, this change in expectation is more likely to occur = tipping sets and critical masses
- Government has a role both in shifting the expectations (e.g. by credibly committing to climate policy) or changing the initial conditions (e.g. by investing in green infrastructure or funding clean energy research) in order to reduce the risk of clean technology investment and thereby help shift the economy to the low-emission equilibrium

Krugman, P. (1991), History versus expectations, *Quarterly Journal of Economics*, 106(2), pp. 651-667.
Cooper, R. (1999), *Coordination Games*, Cambridge University Press.

Path dependence

Many equilibria

Equilibrium selection depends on **history** and **expectations** (Krugman, 1991)

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HYBRID

Part II: Endogenous models (iii)

- Thus the knowledge that innovation is path-dependent should be an incentive for early action.
- Inadequate modelling of innovation has the potential to significantly over-estimate the cost of future low-carbon technologies
- Costs depend on innovation in many dimensions — how well new clean technologies integrate with each other and into new networks, working with new institutions, financial models and a newly skilled labour force
- Business confidence matters in setting the cost of capital
- Policy risk is very costly; could raise costs substantially
- Institutional arrangements e.g. Public Investment Bank can reduce policy risk (also convening power from trusted institution)
- Path dependencies and therefore multiple equilibria suggests an enhanced role for leadership and directed technical change, especially given the importance of expectations

Bosetti V., Carraro, C., Galeotti, M., Massetti, E. and Tavoni, M., 2006. WITCH: A World Induced Technical Change Hybrid Model. *The Energy Journal*, 27. 13-37. Available at: http://www.jstor.org/stable/23297044.
Gillingham, K., Newell, R.~~,~~ and Pizer, W. 2008. Modeling endogenous technological change for climate policy analysis. *Energy Economics,* 30 (6). 2734-2753.

Part III: Costing policy failure

- On the other hand, many of the modelling scenarios assume the immediate implementation of an efficient, globally co-ordinated policy response
- For example, most models assume a uniform global carbon price is implemented simultaneously across all countries and all technologies specified in the model assumptions are available
- In fact, risks of policy failure and higher costs of transition are very real
- Here, standard models grossly understate the likely true cost of climate policies

Part III: Costing policy failure

- Indeed, case for intervention increases the risk that governments, can over-reach themselves or be influenced by vested interests
- The story of endogenous growth and lock-in potentially amplifies the consequences of policy failure
- Path dependence makes the costs of ‘picking losers’ substantial
- Helm (2012)* forcefully argues that the EU 2020-20-20 framework has created ‘bad’ path dependence including large rents for vested parties and significant lock-in of expensive offshore wind and current generation solar at the expense of new renewables with brighter prospects. He also argues that this has caused renewed demand for coal
- Rent-seeking and ‘technology pork barrel’

*Helm, D. (2012), *The Carbon Crunch: How We’re Getting Climate Change Wrong – and How to Fix It*, Yale University Press

Part III: Costing policy failure

- Careful design of policy instruments is required to limit lobbying, rent seeking, and government capture by the green industry – sometimes called the 'technology pork barrel'
- Need for transparent, accountable institutions and policy instruments: market-based, transparent and non-discriminatory, e.g. use carbon pricing
- Rather than picking winners with research grants, the government could offer relatively favourable tax treatment to firms involved in green technology, underwrite national green infrastructure projects, and support *basic* scientific clean energy research
- EU climate policies place too much emphasis on deployment and too little on R&D (Zachmann et al 2014, Fischer, Newell & Preonas 2014*)

*Georg Zachmann *Elements of Europe's energy union,* Bruegel, September; Fischer, C., R. G. Newell, L. Preonas, (2014), 'Environmental and Technology Policy Options in the Electricity Sector: Interactions and Outcomes', Nota di Lavoro 67.2014, Milan, Italy: Fondazione Eni Enrico Mattei.

Part III: Costing policy failure

- **However, strategic choices must be made**, especially where multiple policy objectives exist in addition to reducing climate risk (for example energy security, particulate pollution, improved efficiency, reduced congestion and fiscal reform through lower fuel and energy subsidies and carbon pricing)
- Publicly funded, publicly run and publicly accountable research institutes can make good strategic choices, spurring profitable innovation in sectors considered too risky by the private sector
- Public research institutes have also shown a good track record in spurring profitable innovation in sectors considered too risky by the private sector
- Technology spillovers from public spending on defence R&D are commonly credited as responsible for the Internet, the touch screen, GPS and Apple's Siri technology, among other things (Mazzucato, 2011).

Conclusion and summary so far

- Need to model whole-economy costs
- Standard models not suited to long term projections
- They assume the structure of the economy as given, when it is the key question we seek to answer and influence
- Endogenous growth, complementarities, networks and path dependency are features of the real world. They:
  - drive innovation in technologies, institutions and behavior
  - therefore drive growth
  - determine how we decouple from resource intensity
- Next session: we examine the political economy. If early change is cost-effective given uncertainty and path-dependency, then why the slow progress and acrimony? What makes this problem so ‘wicked’ and what can we do to improve institutional responsiveness?

Key reading

Ackerman, F. and Daniel, J., 2014. *(Mis)understanding Climate Policy: The role of economic modelling*. Synapse Energy Economics, Cambridge MA. Prepared for Friends of the Earth and WWF-UK. Available at: https://www.foe.co.uk/sites/default/files/downloads/synapse-misunderstanding-climate-policy-low-res-46332.pdf.

Aghion, P.; Howitt, P.; (2009) *The economics of growth*. Massachusetts Institute of Technology (MIT) Press: Cambridge, US. http://discovery.ucl.ac.uk/17829/

Aghion, P., Hepburn, C., Teytelboym, A.~~,~~ and Zenghelis, D., (2014). *Path-dependency, innovation and the economics of climate change*.

Simon Dietz & Nicholas Stern, (2014). *Endogenous growth, convexity of damages and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions*, GRI Working Papers 180, Grantham Research Institute on Climate Change and the Environment. http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/06/Working-Paper-159-Dietz-and-Stern-2014.pdf

Global Commission on the Economy and Climate, 2014. *Better Growth, Better Climate: The New Climate Economy Report,* Chapter 5, Available at http://newclimateeconomy.report

Mazzucato, M. (2011), *The Entrepreneurial State*, London: Demos.

Stern, N (2007): *The economics of climate change*, Cambridge University Press, Cambridge