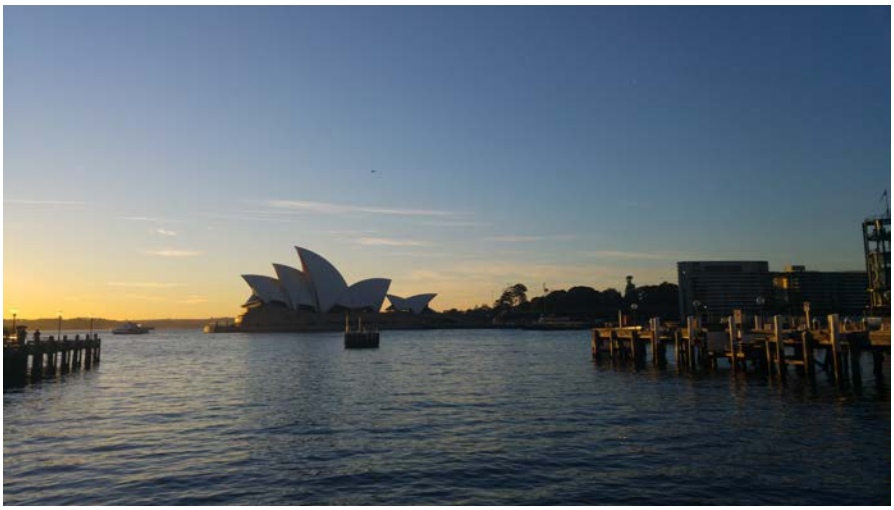
# National CGE Workshop 2018

August 13, 2018

Sydney, Australia



# National CGE Workshop 2018

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*Arrival and registrations from 8.30am. Workshop commences at 9am.*

| | | |
|---|---|---|
| 9:00 | Welcome | Amy Brown, Deputy Secretary, Commercial and Economic Group, NSW Department of Premier and Cabinet |

**Session 1: Keynote speaker** *Chair: Daniel Masters, NSW Department of Premier and Cabinet*

| | | |
|---|---|---|
| 9:20 | Andy Stoeckel | Trade wars: Implications for the World Economy and Australia |

**10:20 Morning tea**

**Session 2** *Chair: Dana Russell, NSW Department of Premier and Cabinet*

| | | |
|---|---|---|
| 10:40 | Taha Rashidi | A computable general equilibrium-based four-step travel demand model |
| 11:05 | Tony Meagher | Assessing and Anticipating Changing Skill Needs - a CGE Perspective |
| 11:30 | Xiujian Peng | Economic Consequences of Population Ageing and Policy Reponses in China |
| 11:55 | Louise Roos | Indonesia's moratorium on palm oil expansion from natural forest: Economy-wide impact and the role of international transfers |

**12:20 Lunch**

**Session 3** *Chair: Jordan Herd, Queensland Treasury*

| | | |
|---|---|---|
| 13:20 | Maureen Rimmer | Integrating a global supply chain model with a computable general equilibrium model: a prototype |
| 13:45 | Philip Adams | The Impacts of LNG Export Expansion in Queensland and of increased gas prices on the East Coast of Australia |
| 14:10 | Anthony Rossiter | For when things pan out differently: Using economy-wide models to inform budget sensitivity |
| 14:35 | Jason Nassios | Exploring the economic impacts of land tax in NSW |

**15:00 Afternoon tea**

**Session 4** *Chair: Jiao Wang, EY*

| | | |
|---|---|---|
| 15:20 | Paul Gretton | Achieving a stable long-term baseline for the global economy in the dynamic GTAP model |
| 15:45 | Michael Jerie | GEMPACK 12: latest developments |
| 16:10 | Chung Tran | Capital Income Taxation in a Life Cycle Economy with Firm Heterogeneity |
| 16:35 | Sebastian Wende | Treasury's Industry Model (TIM) |

*17:00 workshop end*

**18:30 workshop dinner, Bistro Guillaume**

# National CGE Workshop 2018

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***Abstracts***

## Trade wars: Implications for the World Economy and Australia

Andrew Stoeckel

A trade war has started, fueled by demands from President Trump for better deals on US trade. This address focuses on why this has happened, how events could unfold, the possible effects on the global economy and Australia, and finally, what should Australia do in response. The outcome is already costly, the tension between the US and China likely to be protracted with possible adverse implications for the world trading system and WTO.

## A computable general equilibrium-based four-step travel demand model

Edward Robson, Taha Rashidi, Vinayak Dixit and S. Travis Waller

Existing models in the four-step transport planning framework can simulate travel demands and networks to a high degree of detail, but many rely on fixed economic parameters. As simulators of entire economies, computable general equilibrium (CGE) models have been increasingly applied to estimate the magnitude and distribution of economic impacts from transport improvements both spatially and through markets, including GDP and welfare. Some CGE models are linked with transport network models, but none incorporate full networks or generate a complete set of travel demands, both of which are necessary in the four-step framework. This paper presents an integrated CGE and transport model that generates household trips and simulates a full road network for different time periods, such that the transport submodel can be calibrated and run as a conventional transport model. The model provides a tool for the rapid strategic assessment of transport projects and policies when economic responses cannot be assumed to remain static. In the model, the CGE submodel simulates the behaviour of households and firms interacting in markets, where their behaviour takes trip costs into account. The model then generates trips as a derived demand from agent activities and assigns them to the road network according to user equilibrium, before feeding back trip costs to the CGE submodel. The model is then tested by simulating the WestConnex motorway project under construction in Sydney, with results showing significant increases in welfare for regions close to the improvements. Further development of the model is required to incorporate land-use, mode choice and the generation of freight trips.

## Assessing and Anticipating Changing Skill Needs: A CGE Perspective

Tony Meagher

Centre of Policy Studies, Victoria University, Melbourne

When the skills supplied by the labour force are not well coordinated with the skills demanded by employers, skills mismatches and skills shortages will occur and may impose substantial costs on the economy. Policy intervention can help address such structural imbalances but effective policy requires good information on current and future skill needs. All OECD countries engage in skills assessment and anticipation exercises designed to identify such needs. Recently the OECD has conducted a major survey of the methodologies adopted in 29 of those countries, and reviewed (inter alia) the extent to which the associated exercises influence labour market, education and/or migration policy. Notwithstanding the ostensible comprehensiveness of the report, it contains no evaluation of the relevance of CGE modelling to the issues under consideration. This paper offers some redress to the omission.

## Economic Consequences of Population Ageing and Policy Reponses in China

Xuejin Zuo[1], Xiujian Peng[2], Xin Yang[1] and Meifeng Wang[1]

1 Shanghai Academy of Social Sciences
2 Centre of Policy Studies, Victoria University

China is experiencing rapid population ageing. According to UN's medium variant population projection, the proportion of population aged 65 and over will increase from10.5% in 2015 to 23.9% in 2050. Meanwhile its working age population aged 15 to 64 declined at 2015 and will continue to decline sharply. Using a dynamic CGE model of the Chinese economy this paper explores the challenges of population ageing on China's current pension system and economic growth. In the policy scenarios, the paper investigates whether new population policy and proposed retirement age extension policy can help China meet the challenges of rapid population ageing.

## Indonesia's moratorium on palm oil expansion from natural forest: Economy-wide impact and the role of international transfers

Arief A. Yusuf[1], Elizabeth. L. Roos[2] and Jonathan M. Horridge[2]

1 Universitas Padjadjaran, Bandung, Indonesia
2 Victoria University, Melbourne, Australia

Indonesia introduced a moratorium of conversion from natural forest to palm oil land. Using a dynamic, bottom-up inter-regional computable general equilibrium model of the Indonesian economy, we assess several scenarios of the moratorium and discuss its impact on the national as well as regional economy. We find moratorium reduces Indonesian economic growth, and other macroeconomic indicators, but international transfers can more than compensate the welfare loss. However, the impact varies across regions. Sumatera which is highly-dependent on oil palm; and its carbon stock of its forest is no longer high, receive fewer transfers and suffer a great economic loss. Kalimantan which is relatively less dependent on oil palm and its forest's carbon stock is still high, receive more transfers and get greater benefit. This implies that additional policy measures anticipating this unbalanced impact is required if the trade-off between conservation and reducing inter-regional economic disparity should be reconciled.

## Integrating a global supply chain model with a computable general equilibrium model: a prototype

Dixon, P.B. and M.T. Rimmer

Centre of Policy Studies, Victoria University

Economists have provided excellent analytical descriptions of global supply chain (GSC) trade, see for example: Koopman et al. (2014). The next challenge is to develop economy-wide models to help us understand how GSC trade affects welfare and its distributions between and within nations. The new model must recognize: fragmentation of production processes; economies of scale within each process, and decision making by global actors.

We describe a prototype GSC sectoral model and an associated CGE model. Then we show how the two models can be integrated. Via the integrated prototype we show that a GSC-CGE system has the potential to show how open trade policies can transform the economies of developing countries that have a pool of low-productivity labour. The next step will be to build a small number of GSC models using real data and integrate these models with a standard CGE model such as GTAP.

Reference:

Koopman, R., Z. Wang and S-J. Wei (2014), "Tracing value added and double counting in gross exports", American Economic Review, 104(2), 459-94.

## The Impacts of LNG Export Expansion in Queensland and of increased gas prices on the East Coast of Australia

Philip Adams

Centre of Policy Studies, Victoria University

The large Queensland LNG projects have started production. Exploiting previously unused reserves of coal seam gas, the LNG is exported at an international price that is projected to rise strongly from current levels. The new exports of LNG are likely to boost Australia's exports and terms of trade, leading to increased real GDP and welfare for the national economy.

However, this is only part of the story. Through competitive pressures, any price premium received for unconventional Queensland gas will lead to increased prices for gas throughout Eastern Australia. This will increase costs of production for energy-intensive industries. For those industries (and regions) which cannot pass on the cost increases, growth in production may fall.

In this paper, using the Victoria University Regional Model (VURM), we report on simulations designed to provide a balanced assessment of the costs and benefits of the new LNG projects, including the possibility of increased gas prices for local customers. Key findings are:

- During construction, the projects have boosted real GDP and national welfare, and have had a positive impact on most industries and most regional economies;
- During the mature, production phase, if local gas prices remain stable, then the national impacts are marginal. Real GDP is stimulated slightly, while national welfare is hardly affected.
- If local gas prices rise, then the national impacts turn negative. Some industries gain production, particularly electricity-related sectors that benefit from favourable price-induced substitution effects. Other industries lose production, due to the adverse cost impacts of increased gas and electricity prices.
- Because some industries gain, while other industries lose, so some regions gain real GSP and employment (Queensland), while other regions lose (notably Victoria and South Australia).

## For when things pan out differently: Using economy-wide models to inform budget sensitivity

Anthony Rossiter[1,2], Janine Dixon[3] and Grace Gao[1]

1 Economic Division, Department of Treasury and Finance, Victoria
2 Department of Econometrics and Business Statistics, Monash University
3 Centre of Policy Studies, Victoria University

Every year, governments make decisions predicated on forecasts and assumptions related to future economic, financial and operating conditions. As changes in these conditions can materially affect government finances, many governments seek insights into how credible departures from the forecast economic environment may affect their financial position. This presentation first outlines some well-established approaches Australian governments have used to assess budget sensitivity, before focusing on a relatively new approach adopted by the Victorian Government since the 2017-18 Budget. This new approach assesses the impact of alternative economic environments using the Victoria University Regional Model, providing a general-equilibrium framework for understanding the consequences of materially different economic circumstances. The value of this approach is demonstrated using case studies, with additional guidance provided around how this approach can be useful for assessing budget sensitivity in a more comprehensive and theoretically coherent framework.

## Exploring the economic impacts of land tax in NSW

J. Nassios, J. A. Giesecke, P. B. Dixon and M. T. Rimmer

Centre of Policy Studies, Victoria University

In NSW and various other Australian states/territories (except the Northern Territory), land tax is levied on the aggregate unimproved value of household or business land holdings. Various exemptions apply, such as the primary production land (PPL) and principal place of residence (PPR) exemptions, together with exemptions for land held by charities, municipal and public land, health centres, and residential care facilities. Because of these exemptions, the land tax base is not as broad as other types of land tax levied in this country, such as NSW council rates (levied on unimproved land values with very few exemptions). In this paper, we present a discrete choice model of the buy-versus-rent decision facing households in NSW, and parameterise this model in a way that facilitates an examination of the allocative efficiency impacts of the PPR exemption in NSW. We outline a neoclassical analogue of this model, and describe how this analogue is embedded in a CGE model of Australia's states and territories, the Victoria University Regional Model with Tax detail (VURMTAX). Using this CGE model, we quantify the efficiency impacts of NSW land tax and council rates via the derivation of marginal and average excess burden of the taxes. We illustrate how the PPR exemption is responsible for the majority of the relative efficiency differences, and conclude with a discussion of the impact of the NSW land tax system on key state and national macroeconomic variables, and NSW industries.

## Achieving a stable long-term baseline for the global economy in the dynamic GTAP model

Paul Gretton

A dynamic version of the GTAP model of the global economy became available in 2012. The dynamic version known as GDyn, introduced partial adjustment mechanisms for capital accumulation and a dynamic accounting of capital-finance and related income flows between regional households and firms, and a global trust. In long-run equilibrium, the model rates of return are to be equal and constant over time. In practice, illustrative results presented with the release of GDyn show the equilibrium conditions are not satisfied. Model stability has been achieved through further development within the GDyn framework to satisfy the stated longer-run neoclassical equilibrium conditions. This development involved setting as exogenous a target national rate of return determined by factors exogenous to the model and a theoretic treatment of the borrowing and lending in global financial markets. The revised model - GDyn-F – is used to project an illustrative baseline of the global economy for six regions comprised of five individual country economies and one multi-country region. Some key issues for further baseline development in GDyn-F are identified together with some matters for further research.

## GEMPACK 12: Latest Developments

Mark Horridge, Michael Jerie, Dean Mustakinov and Florian Schiffmann

Centre of Policy Studies, Victoria University

We present improvements and new features available in GEMPACK release 12.0. As a result of an extensive revision of the underlying code release 12.0 GEMPACK provides a complete 64-bit suite if programs, many productivity enhancements in the Tabmate editor, enhanced sorting in Viewhar, more stable and responsive AnalyseGE and RunDynam programs. The TABLO language has some extensions including loops and left-hand-side mappings in formulas. TABLO-generated programs and GEMSIM are now faster for simulations although the speed up is model dependent. This improvement is the result of a modified LU decomposition algorithm which offers the user some options for tuning performance. We report executions times for some well-known models. Other minor speed improvements have been made including support for optimized math libraries and a recent release of the GCC GFortran compiler.

## Capital Income Taxation in a Life Cycle Economy with Firm Heterogeneity

Chung Tran and Sebastian Wende

We quantify the aggregate and distributional effects of capital tax reforms using a lifecycle model with heterogeneous firms facing idiosyncratic productivity shocks and financing constraints. We calibrate the model to match the US data. Our marginal excess burden (MEB) analysis indicates that corporate tax is more distorting than capital gains and labor income taxes, but not dividend tax. Corporate tax cuts yield opposing welfare effects across skills, ages and generations. In particular, replacing the corporate tax with the dividend tax or a mix of dividend and capital gains taxes leads to welfare gains for young and future generations, but welfare losses for majority of current working and old households. These findings highlight the importance of accounting for the distributional effects and inter-generational equity. Finally, we show that the effects of capital tax reform vary significantly when abstracting from life cycle structure, firm heterogeneity, financial constraints, and corporate finance policy.

# Treasury's Industry Model (TIM)

Sebastian Wende, Melissa Hinson, and Phillip Womack

Treasury is developing a neoclassical growth model with rich industry detail for industry policy analysis. This approach has benefits over the recursive dynamic computational general equilibrium (CGE) models that are commonly used to inform industry policy decision in Australia. For instance, while Treasury's Industry Model (TIM) has similar detail to many of the recursive dynamic CGE models, harnessing the neo-classical growth model framework allows us to model anticipated policy changes via internally consistent saving and investment decisions that are derived from optimisation behaviour.

Moreover, by incorporating a well-defined long-run we can analyse both temporary and permanent shocks. In this presentation we will describe in detail the method used to solve the model, the model calibration and other challenges faced in developing a baseline projection. Finally, the presentation will demonstrate the current functionality of TIM via a simulated economic shock.

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# *Trade Wars: Implications for the World Economy and Australia*

Dr Andrew Stoeckel

Visiting Fellow, CAMA, ANU and Chief Economist, Centre for Economic Development

*CoPS Conference, Sydney, August 2018*

1

## This paper...

- Examines the implications of the trade war underway.
  - Protectionist trend since start of President Trump
  - Solar panels, washing machines, lumber, steel, aluminum, rescind TPP, renegotiate NAFTA
  - Tariffs on Chinese imports (US$50bn then US$200bn, maybe US$500bn)
  - Retaliation underway
- Important issue in its own right
- Also demonstrates challenges and importance of CGE modelling - but who does it, how it is done and how used matters

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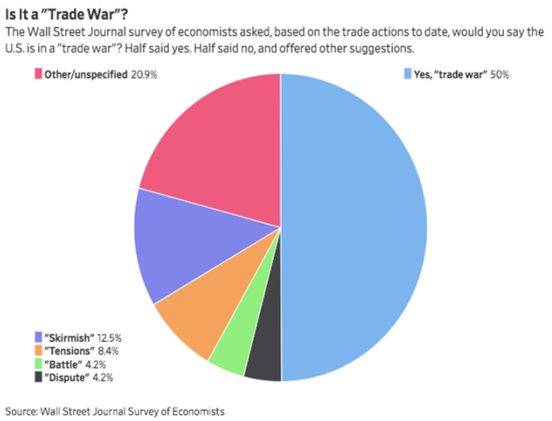
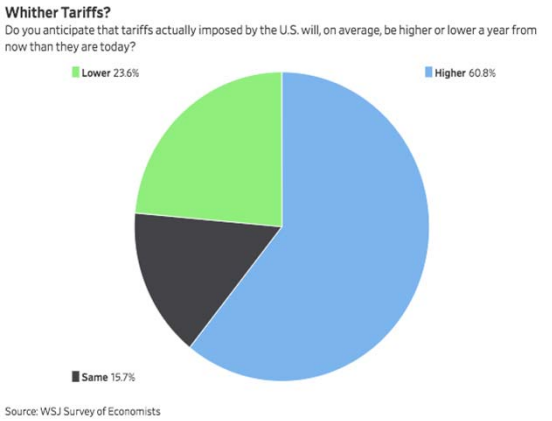
# A survey of economists




Source: WSJ https://blogs.wsj.com/economics/2018/08/09/the-debate-that-evenly-divides-economists-is-this-a-trade-war/?guid=BL-REB-38719&mod=searchresults&page=1&pos=4&dsk=y

## Four questions

1. Why have things come to this?
2. How could events unfold
3. What effect could a trade war have on the global economy and Australia?
4. What should be done about this and, particularly, what should Australia's response be?

## Effects on the global economy

- What do we want to know?
  - Tariffs (taxes) distort resource allocation
    - So dynamic or static? Capital accumulation (Hertel et al CGE vs Frankel and Romer)
    - "Trade appears to raise incomes by spurring the accumulation of physical and human capital and by increasing output for given levels of capital"
    - Macro effects, capital flows, NAFTA, Mexican Peso crisis
  - Protection, competition & productivity (recent HM Treasury analysis Brexit)
  - Policy uncertainty and risk premia (again HM Treasury analysis of Brexit)
  - Wolf (2018) – CGE models "ignore the disruption and uncertainty" and "fail to account for the lost dynamism, as global competition is reduced"



## How could events unfold – what to simulate

- **Country scope**
  - US 'war' concentrated on China, but most majors variously targeted
  - US/ China has largest bilateral trade deficit (and growing) albeit the wrong basis for trade action
- **Product coverage**
  - Concentrated on manufactures but retaliation on agriculture. Services threatened and FDI has been made more difficult
- **Size of tariffs**
  - 25% common, some at 10%. (40% threatened in campaign). 20% reasonable assumption on goods and 5% on services
- **How much retaliation**
  - All majors with some retaliation in tit-for-tat response on 'sensitive' areas
  - Also consider others do the right thing, call Trump's bluff and liberalise trade.

## What to simulate cont.

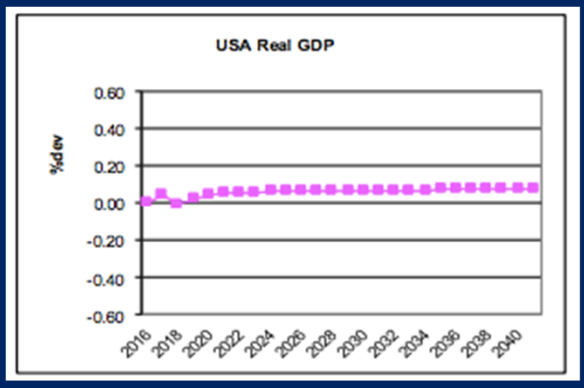
- **What duration**
  - Temporary versus permanent? 'Truce' with EU for now, but agriculture will be a sticking point. Most 'tiffs' with majors likely to be negotiated away (say 2 -3 years)
  - US/ China different
    - Large trade deficit won't go away (McKibbin-Stoeckel (2018) show large fiscal stimulus worsens trade deficit)
    - Argument over intellectual property, SOE's etc. China has Lenin/Marxist tilt under President Xi so hard to deliver here.
    - Politically popular to 'bash' China in the US with mid-term election 2018, Presidential 2020
    - Geopolitics: Who to blame if Kim Jong Un 'plays' Trump? China has backed Iran.
    - 'Made in China 2025' seen as threat to US tech leadership. China won't give up.
  - Assume US/China is permanent

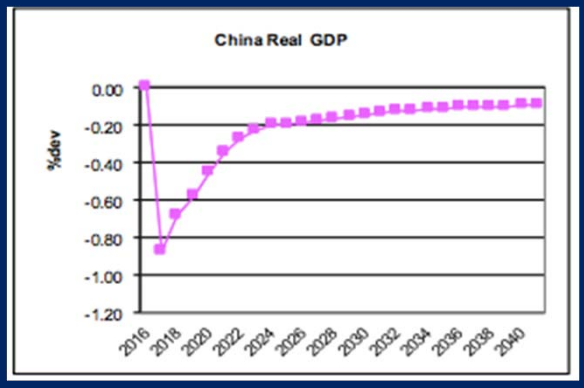


## What to simulate cont.

- **Productivity**
  - Is low productivity puzzle due to growing tail of inefficient industries (Haldane 2018)? Protection keeps 'zombie' companies going
  - HM Treasury analysis of 'hard' Brexit ( a mini trade war) concluded a productivity elasticity of 0.2 to 0.3 [1 percentage point increase in trade/GDP ratio increases GDP per capita by 0.2% to 0.3%
    - Major source of long term cost of 'hard' Brexit
- **Uncertainty**
  - Few empirical studies here despite obvious link between uncertainty and incentive to invest
  - Stoeckel, Tang & McKibbin (2000) estimated link between openness and country risk premia. But country risk is relative. Better is equity risk premia
  - HM Treasury concluded extra 180 bpts equity risk premia for 'hard' Brexit – enough to send UK into recession

# Effects of US tariffs on China

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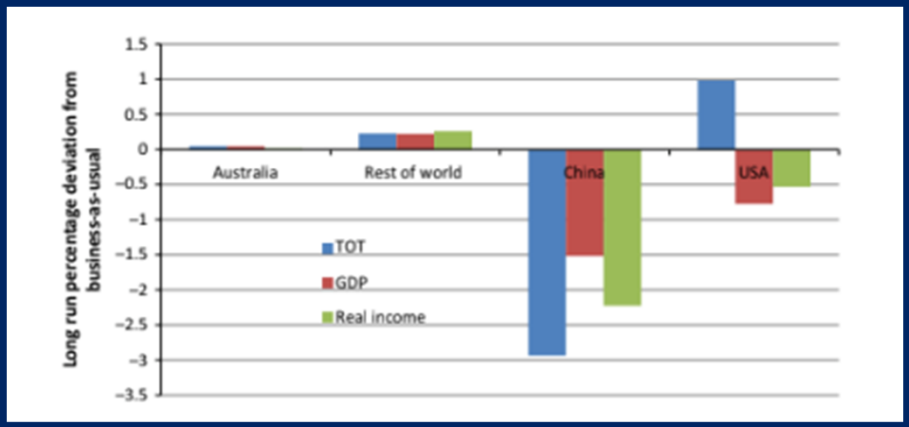
9

# Dixon (2017) also finds small effects on Australia from US tariffs on China




Source: Dixon (2017)

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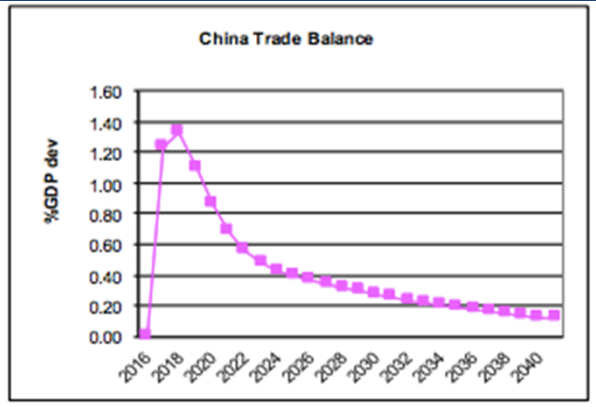
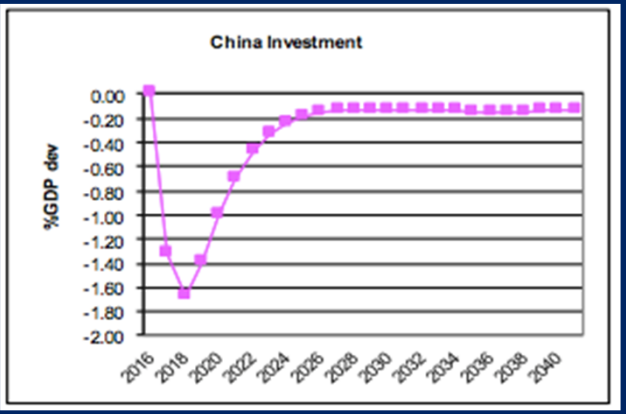
10

## One interesting aspect – importance of capital flows




Source G-Cubed Model from McKibbin and Stoeckel (2009) and McKibbin and Stoeckel (2017);

Source G-Cubed Model from McKibbin and Stoeckel (2009);

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## What about a global trade war?

- Possible under the demise of WTO system
- 10% tariff everywhere to illustrate effects

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## Illustrative GDP consequences of 10% trade war in first year, % deviation from baseline (as yet, no productivity or risk effects)

| | Source of Tariff Change | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Global | USA | Japan | Europe [1] | OOECD[2] | China | India | EEFSU | ODCs[3] |
| United States | -1.3 | -0.3 | -0.1 | -0.3 | -0.3 | 0.0 | 0.0 | 0.0 | -0.3 |
| Japan | -1.7 | -0.4 | -0.6 | -0.1 | 0.0 | -0.1 | 0.0 | 0.0 | -0.4 |
| Euro Area | -2.9 | -0.3 | 0.0 | -1.8 | -0.2 | 0.0 | 0.0 | -0.2 | -0.3 |
| Canada | -2.2 | -1.8 | 0.0 | -0.3 | -0.2 | 0.0 | 0.0 | 0.0 | 0.1 |
| Australia | -1.4 | -0.3 | -0.2 | -0.3 | -0.2 | -0.1 | 0.0 | 0.0 | -0.3 |
| ROECD | -3.7 | -0.4 | -0.1 | -1.7 | -1.2 | 0.0 | 0.0 | -0.2 | -0.1 |
| China | -4.3 | -0.9 | -0.3 | -0.3 | 0.1 | -1.1 | 0.0 | -0.1 | -1.6 |
| India | -1.5 | -0.2 | 0.0 | -0.2 | 0.0 | 0.0 | -0.6 | 0.0 | -0.5 |
| Other Asia | -3.9 | -1.0 | -0.2 | -0.3 | 0.0 | -0.4 | 0.0 | 0.0 | -1.9 |
| Latin America | -1.6 | -1.3 | 0.0 | -0.3 | 0.1 | 0.0 | 0.0 | 0.0 | -0.1 |
| Other LDC | -1.4 | -0.5 | 0.0 | -0.6 | 0.1 | 0.0 | 0.0 | -0.2 | -0.1 |
| EEFSU | -3.5 | -0.6 | -0.1 | -2.0 | -0.1 | -0.1 | 0.0 | -0.6 | -0.1 |
| OPEC | -4.4 | -0.9 | -0.4 | -1.0 | -0.2 | -0.2 | -0.1 | -0.1 | -1.6 |

Notes: Source G-Cubed Model from McKibbin and Stoeckel (2009); and McKiubbin and Stoeckel (2017)
[1] Europe is UK, Germany & Euro Area; [2] OOECD is Canada, Australia & ROECD; [3] ODCs is other Asia, Latin America other LDC and OPEC

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13

## Other studies

- **Dixon (2017)**
  - US / China at 40%, ROW at 20%
  - Uses GTAP
  - All countries lose, now Australia has 4% loss of GDP
- **Productivity Commission (2017)**
  - Global increase in tariffs of 15 percentage points
  - Uses PC Global model
  - Finds would put world into recession, global GDP falls by nearly 3% and Australia 1% lower each year tariffs in force
  - Significant detail on industries and households.
- **But how likely is a trade war?**

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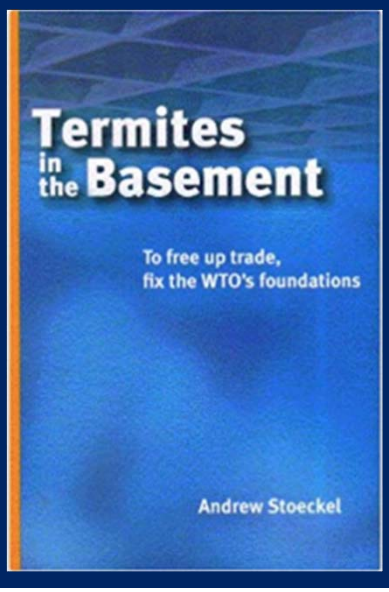
14

## The Battle of Seattle 1999 – the rot has set in long ago


"The inconsistencies, loopholes and flawed rules plus mercantilist thinking are, like termites in the basement, gnawing away at the foundations of the WTO system.

Unless fixed, at best we could witness the slow demise of the WTO system.

At worst would be the disintegration of the system into a chaotic plethora of discriminatory trade arrangements, bilateral and regional, with trade conflicts breaking out all over – the very thing the multilateral trading system was formed to prevent. "

(Stoeckel 2004)

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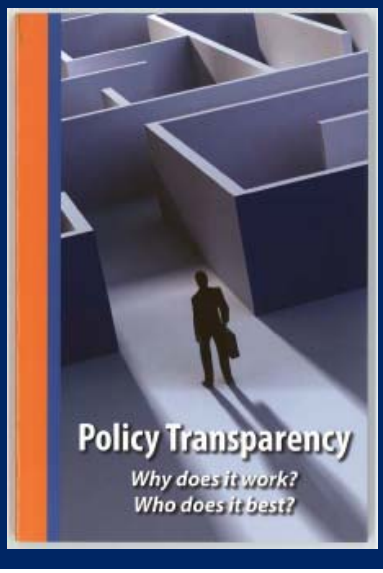
16

## Some 'termites'

- One rule says 'discrimination bad', another 'discrimination OK'
- Preferential treatment for some also violates 'non-discrimination'
- One rule says 'dumping is bad', another agreement says 'its OK'
- Negotiations are economic nonsense " exports good, imports bad"
- Dispute settlement, if ruled in your favour lets you hurt yourself!
- Anti-dumping cases only look at injury – the costs – not benefits
- Numerous exemptions (national defense, balance of payments)
- Outright hypocrisy – EU, Japan, Korea – want 'competition' policy in trade agreements but not for their highly protected agriculture
- Antidote to nonsense is common sense! Need transparency

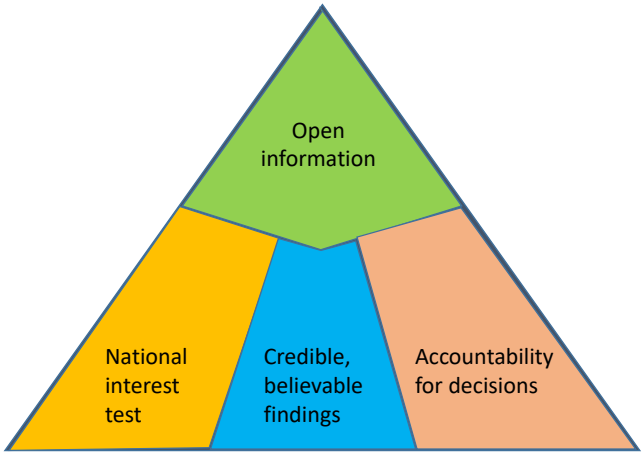





"publicly accepted decisions in the national interest cannot be made if people do not know what is in the national interest"

(Stoeckel and Fisher 2004)

## Transparency comprises several inter-related elements

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19

# Conclusions

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20

## Main points

- US/China bilateral stoush not likely to affect Australia greatly, even though expected to be 'permanent'
- Worry is if it leads to global trade war with demise of the WTO system
  - Scenario possible since system in slow demise for some time
  - Root cause is sloppy thinking and lack of understanding of gains and losses from trade policies
  - Inconsistent rules, exceptions, loopholes and wrong rules are like 'termites' eroding foundations
  - Global trade war could easily tip world into recession, even before considering losses from productivity and uncertainty
    - Based on earlier work (Stoeckel, Tang, McKibbin 2000) could increase losses by half



## Main points

- Definitely don't copy others
  - Makes ourselves worse off
  - Krugman and Bhagwati: "if others throw rocks in their harbours, don't throw rocks into your own"
- Solution is transparency
  - Matters how and who does this – several core requirements
- Bottom line: to make a decision in the national interest need to measure what is the national interest
  - Goes to the core of all CGE, DSGE analysis
    - which variant to use depending on purpose, capital flows important for understanding macro policy.

# Further reading


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# A computable general equilibrium-based four-step travel demand model

**Taha Rashidi**

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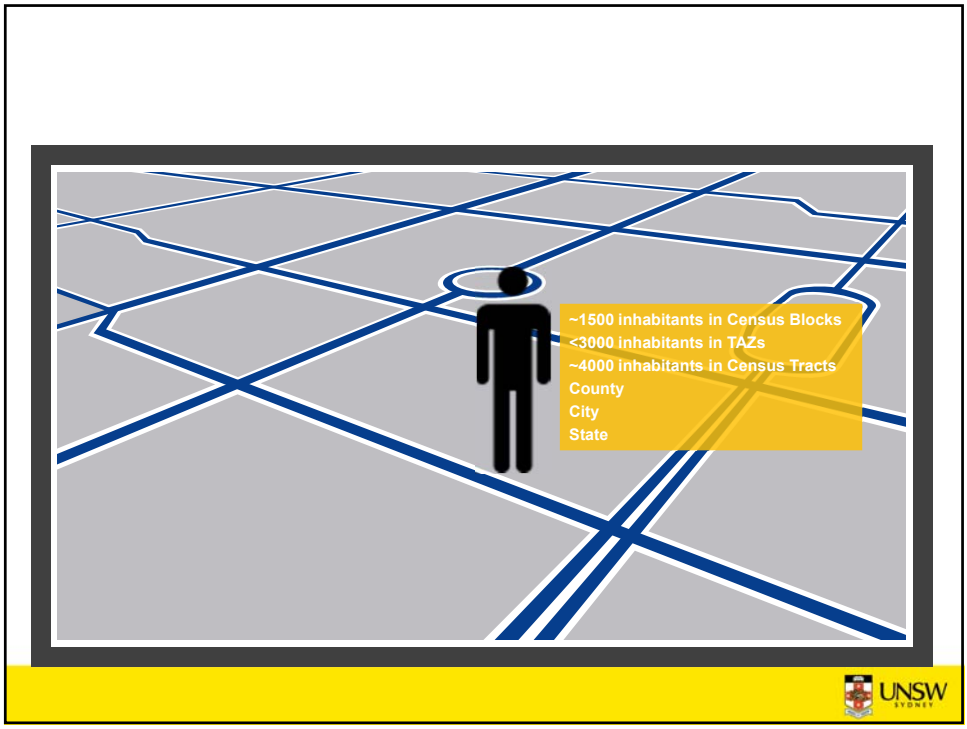
Research Centre for Integrated Transport Innovation (rCITI)
UNSW Sydney

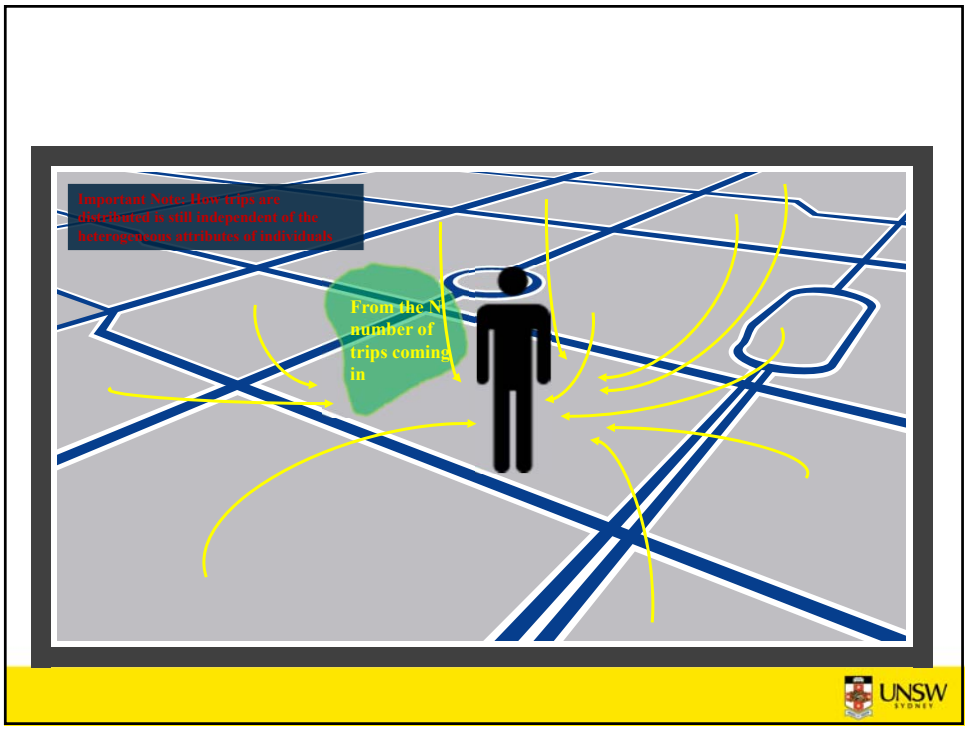
## Introduction

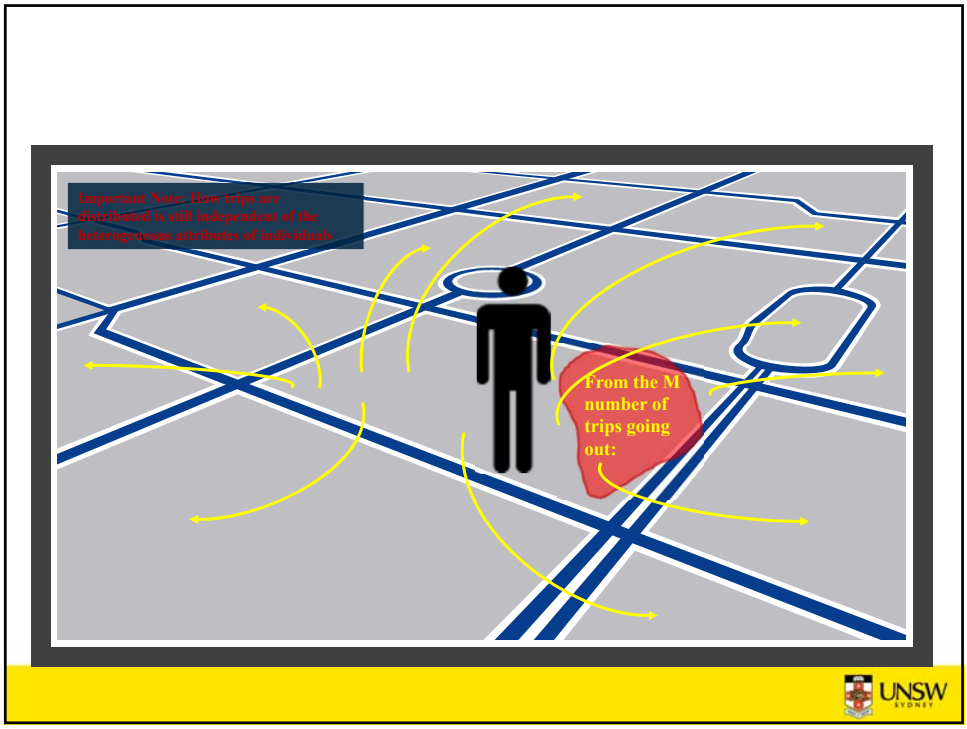
- Current practice in transport modelling
  - Simple four-step models assume that origin–destination (OD) demands remain static
  - Land-use transport interaction models can allow for the partial equilibration of land markets, but still rely on many fixed economic parameters
- CGE modelling of transport
  - Recently applied to quantify WEIs and other economic impacts, normally via productivity gains from freight improvements
  - Transport costs are static parameters from a transport model
- Research problem
  - Some models have feedback such that a CGE model generates transport demand and a transport model generates transport costs, but they either do not generate a complete set of trips or only represent a sketch network
  - This provides a basis for an extended four-step planning model that can generate trips as a derived demand from households and businesses
  - We propose an integrated CGE and transport model that generates household trips and simulates a full road network for different time periods

## Literature review

- CGE models for transport:
  - Urban CGE models: simulate urban-scale effects such as land-use and congestion
  - Regional CGE models: focus on inter-regional freight costs, including
    - » Spatial CGE models (spatial extensions of conventional CGE models)
    - » Spatial price equilibrium (SPE) CGE models
    - » New economic geography (NEG) CGE models, simulating urban agglomerations through imperfect competition and increasing returns to scale industries
  - Congestion and externality CGE models: represent travel commodities and household travel demand in detail (non-spatial)
- Some examples:
  - RELU-TRAN (Anas and Liu, 2007): separate CGE and traffic assignment submodels
  - Rutherford and van Nieuwkoop (2011): CGE and traffic assignment submodels formulated as a single mixed complementarity problem, using a multi-commodity flow (MCF) form of user equilibrium (UE) assignment
  - Mayeres (2000): detailed household travel demands, but non-spatial and cannot capture network behaviour


~1500 inhabitants in Census Blocks
<3000 inhabitants in TAZs
~4000 inhabitants in Census Tracts
County
City
State
UNSW


Important Note: How trips are distributed is still independent of the heterogeneous attributes of individuals
From the N
number of
trips coming
in
UNSW


Important Note: How trips are distributed is still independent of the heterogeneous attributes of individuals
From the M number of trips going out:
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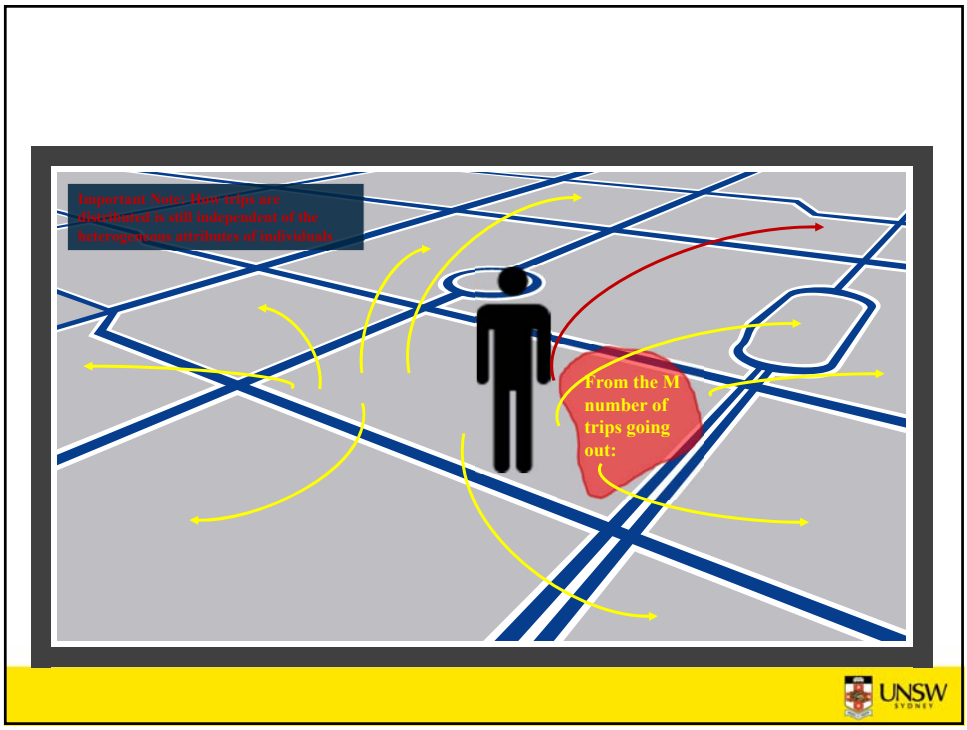
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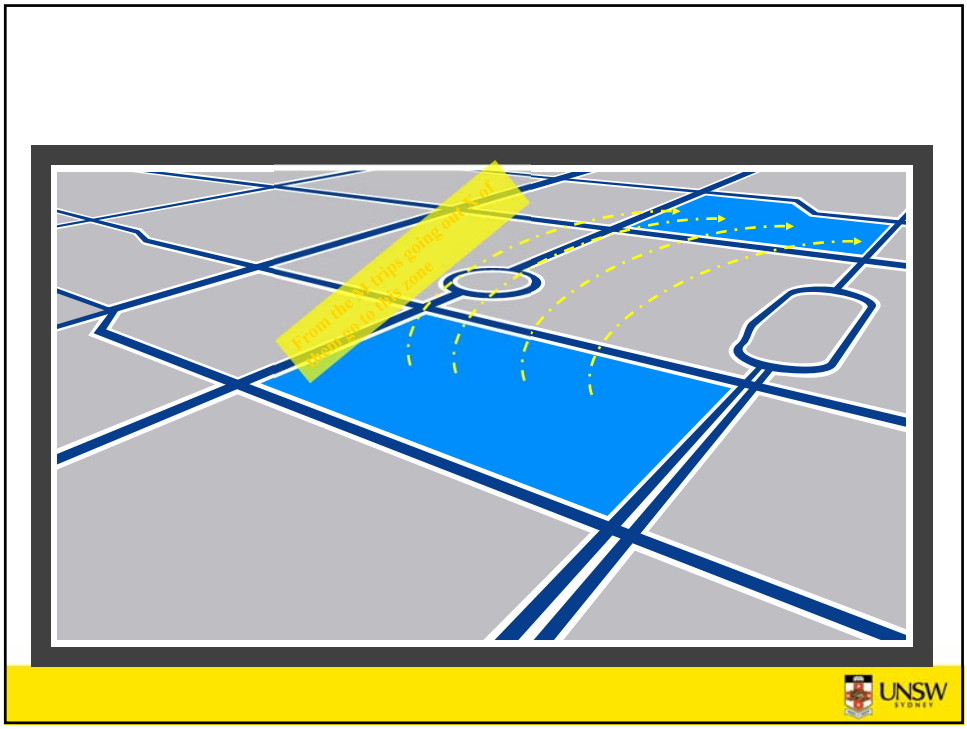
From the CBD trips going out of
towards to the zone
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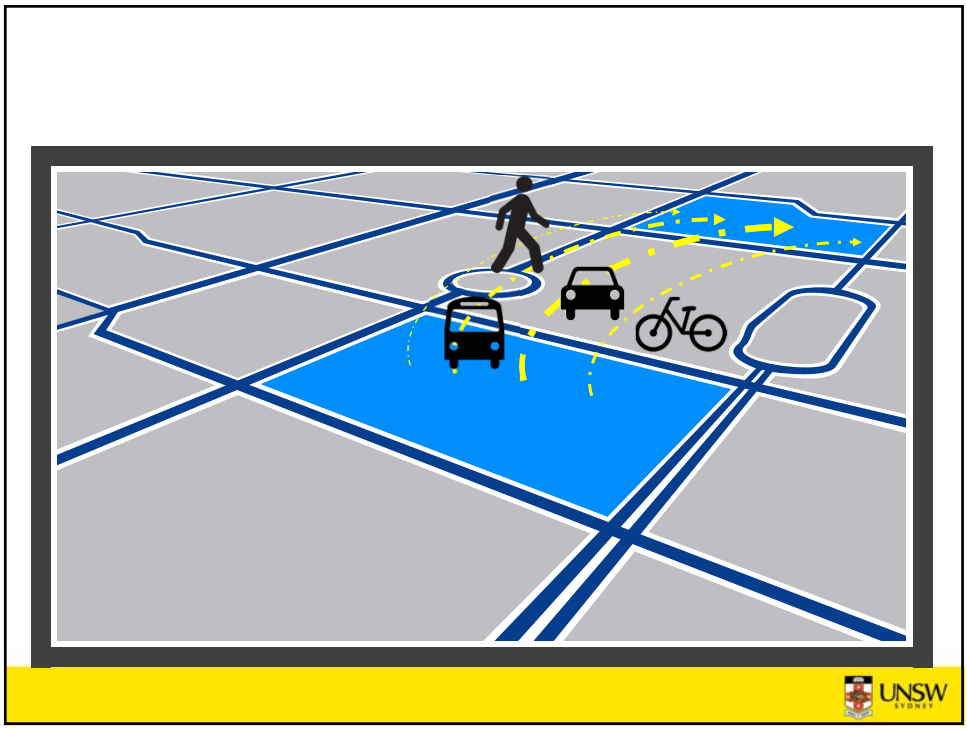
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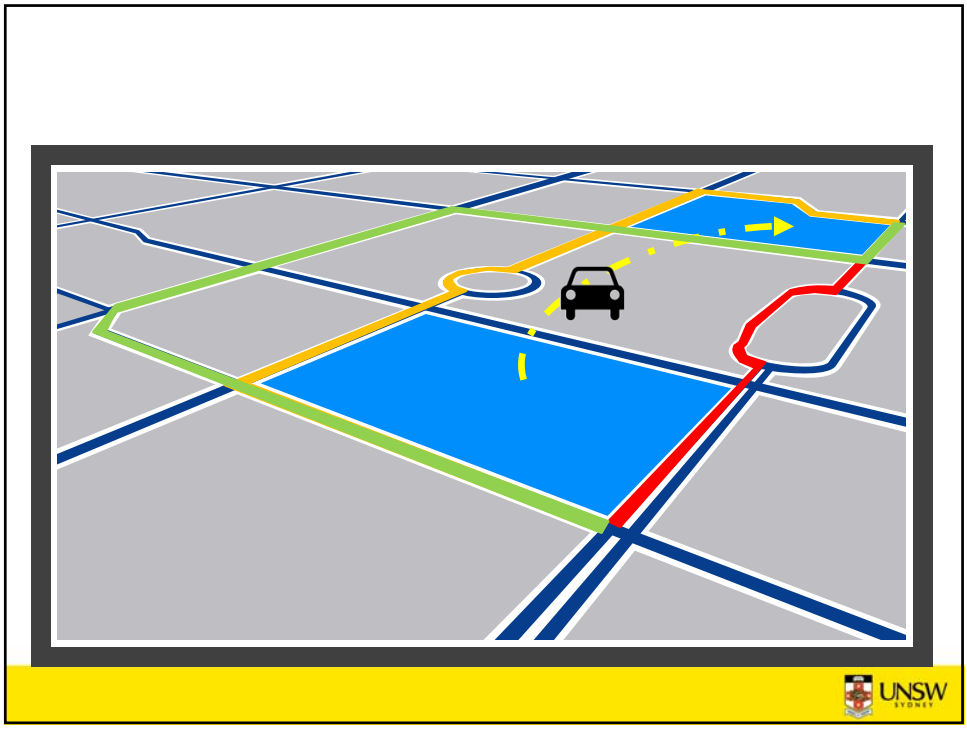
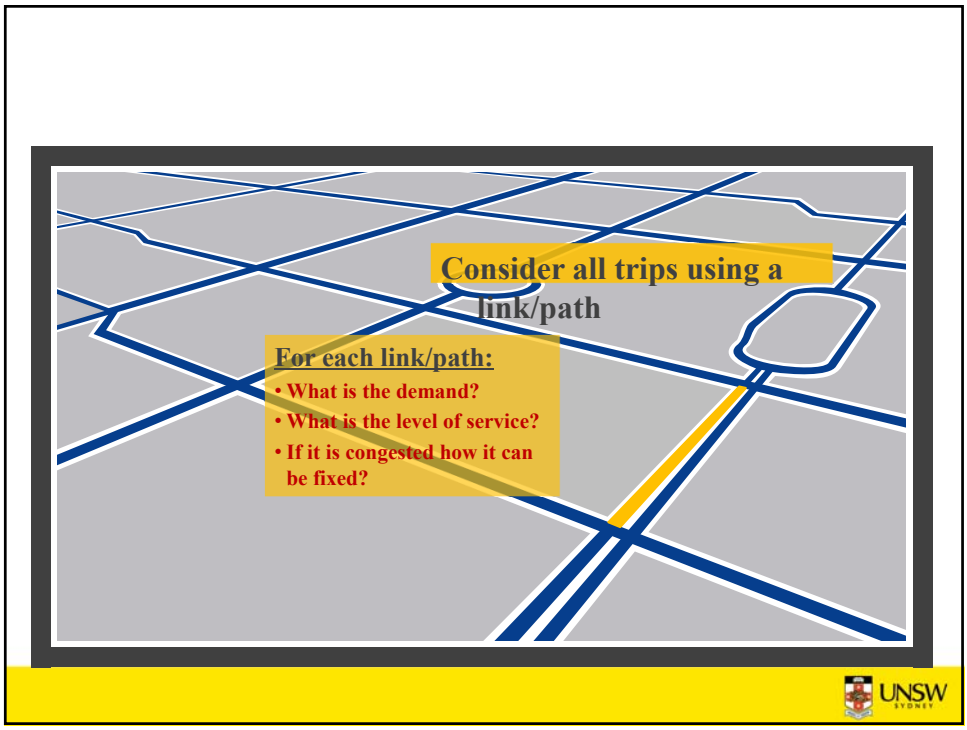
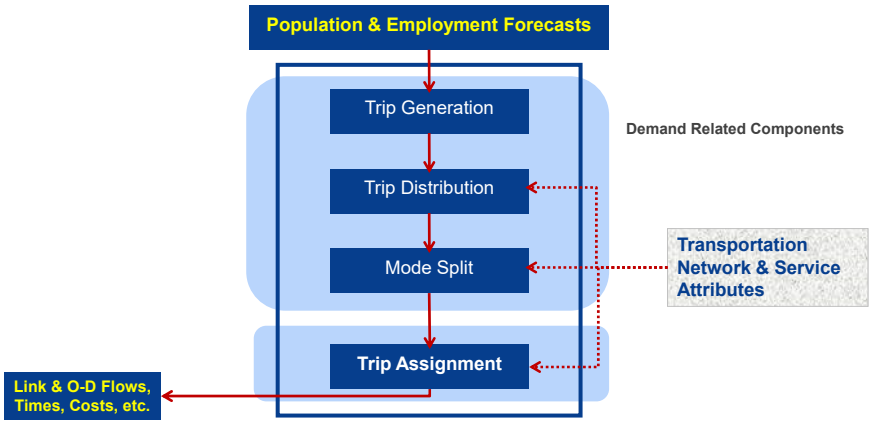
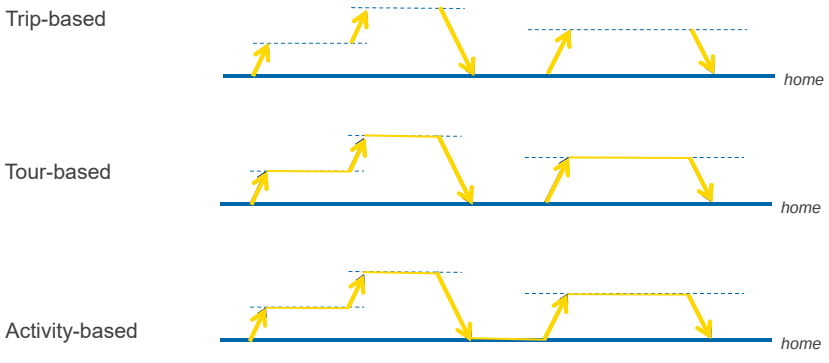



Consider all trips using a link/path
For each link/path:
• What is the demand?
• What is the level of service?
• If it is congested how it can be fixed?

## General Framework of 4-Step Models

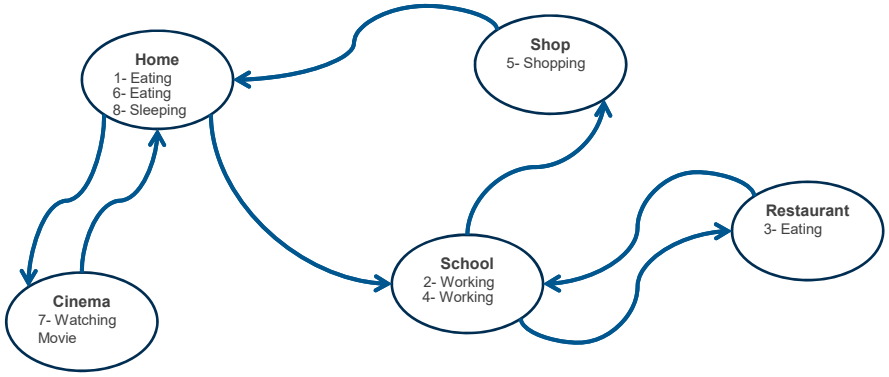



## Visualization



# Activity-based modelling

## Activity Generation Example

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## Focus

| Trip Based Modelling | Activity Based Modelling |
|---|---|
| o Directly focuses on “trips”<br>o Without explicit recognition of the motivation or reason for the trips and travel | o Focuses on “activity participation behavior”<br>o Views travel as a demand derived from the need to pursue activities |

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## Trips vs. Tours

| Trip Based Modelling | Activity Based Modelling |
|---|---|
| o The trip-based approach represents travel as a mere collection of “trips” | o The activity-based approach precludes illogical mode-trip chains by using “tours” |
| o Each trip is considered as independent of other trips | o Tours are chains of trips beginning and ending at a same location, say, home or work. |
| o Such a neglect of the temporal, spatial and modal linkages between the trips can lead to illogical trip chain predictions | o Focuses on sequences or patterns of activity participation and travel behavior |

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## Concept of Time

| Trip Based Modelling | Activity Based Modelling |
|---|---|
| o Time is reduced to being simply a “cost” of making a trip | o Individuals' activity-travel patterns are a result of their time-use decisions within a continuous time domain |
| o A day is viewed as a combination of broadly defined peak and off-peak time periods | |

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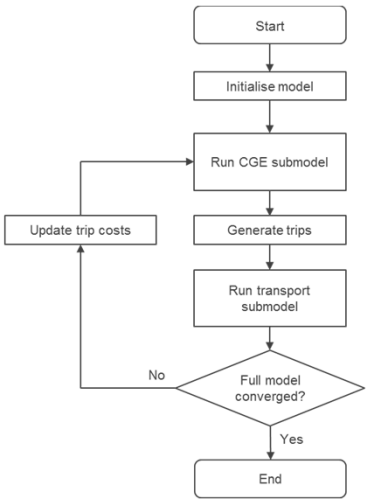
## Level of Aggregation

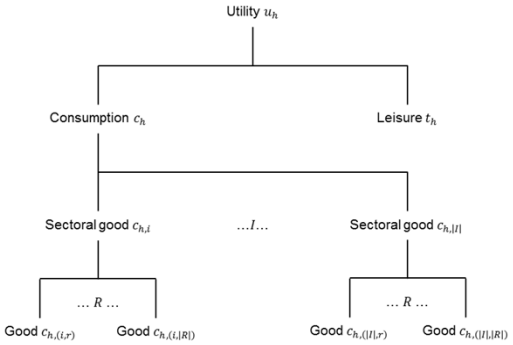
| Trip Based Modelling | Activity Based Modelling |
|---|---|
| o Most aspects of travel (number of trips, modal split, etc) are analyzed at an aggregate level<br>o The study area is divided into Traffic Analysis Zones (TAZ).<br>o Accommodate the effect of socio-demographic attributes of households and individuals in a very limited fashion | o Accommodate several decision factors related to the socio-demographic characteristics of the individuals who make the activity-travel choices, and the travel service characteristics of the surrounding environment |

## Methodology



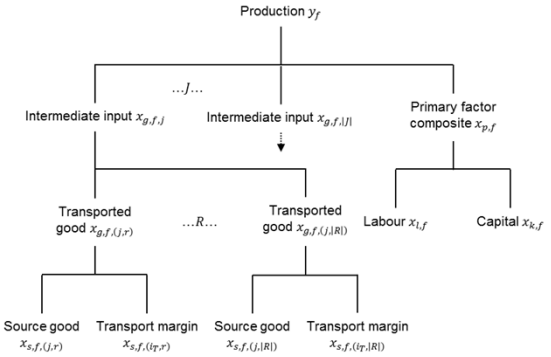

- Integrated CGE and transport model:
  - The CGE submodel simulates households and firms interacting in markets over a set of regions $R$ and industries $I$
  - Household activities generate daily commuting, shopping and leisure vehicle trips between regions $R$, which are then converted into OD demands between travel zones $Z$ for time periods $T$
  - The transport submodel assigns trips for each time period to the road network
  - Time prices for household activities and freight margins are returned to the CGE submodel for further iterations
- Scripted in AMPL, using the PATH solver for the CGE submodel and the AMPL scripting language for the remaining components

# Households



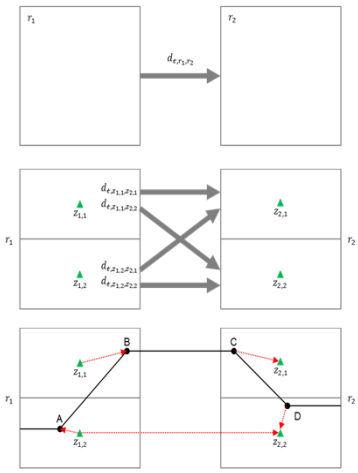

- Set of households $H$, with each household representing the people residing in region $r \in R$ and employed in firm $f \in F$
- Utility maximisation subject to both monetary and time constraints:
  - $p_{c,h}c_h = p_{l,h}l_h + p_k\omega_{k,h}$
  - $l_h + t_h + v_{l,h}l_h + v_{c,h}c_h + v_{t,h}t_h = \omega_{t,h}$
- Cobb–Douglas top and middle nests, with CES lower nests
- Each activity costs travel time, and activities generate commuting, shopping and leisure trips
- Behaviour depends on prices and travel times

# Firms




- Set of firms $F$, with each firm representing the production activity of industry $i \in I$ in region $r \in R$, producing a single output
- Cost minimisation subject to CRS production
- Leontief top nest, and CES nests for regional substitution and primary factor substitution
- Fully specified transport margins, with the margin requirement proportional to the travel time from source to destination

# Trip generation



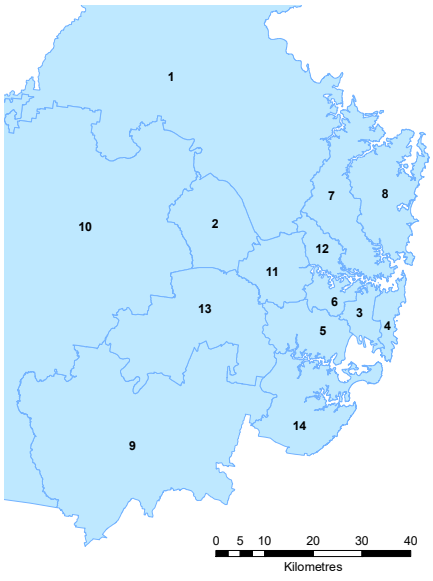

- Labour, consumption and leisure generate commuting, shopping and leisure trips respectively
  - Each trip is a daily return journey from the residential region
  - Inbound and outbound trips are split throughout the day, generating time-dependent regional OD matrices
- Each region is then split into a number of travel zones $Z$ for the transport submodel
  - The regional and travel zone OD datasets are calibrated separately
  - The two sets are connected by assuming that demand in the travel zone OD pairs change in the same proportions as their corresponding regional OD pairs
- Since the full road network may not be simulated, the travel zone OD trips are pre-assigned into:
  - Direct trips that bypass the road network
  - Network trips that are assigned to the road network

# Transport submodel

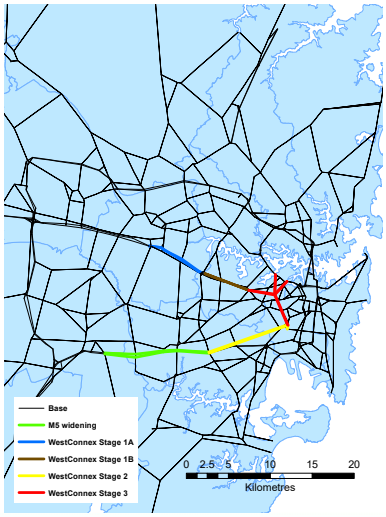
- Network trips are assigned to the given network according to user equilibrium for each time period
- Assignment is based on the Frank–Wolfe algorithm:
  - Calculate the cost of traversing each link based on current link flows using the BPR function $c_{t,\ell}(d_{t,\ell}) = c_{0,\ell}\left(1 + a_\ell\left(\frac{d_{t,\ell}}{d_{CAP,\ell}}\right)^{b_\ell}\right)$
  - Find the shortest path from each origin to each destination using Dijkstra's algorithm and assign volumes to the shortest paths
  - Check whether the termination condition has been met, as measured by the relative gap between the total system travel time and the shortest path travel time
  - If the termination condition has not been met, update flows by solving for the minimum of the Beckmann function using the bisection method and return to the first step.
- Travel time prices and freight margins are then returned to the CGE submodel

## Calibration

- The model was calibrated for testing purposes using data for the Sydney transport network and economy, but data and results should be **treated as synthetic** as it has not undergone thorough validation
- Transport submodel
  - Based on the 2011 Sydney Strategic Travel Model (STM) OD demands and network
  - The road network from the STM was refined to 1,898 links and 791 nodes representing all of Sydney's arterials and freeways
  - BPR parameters were adjusted such that the transport model closely matched Google Maps observations
- CGE submodel
  - Regions: 14 Statistical Areas Level 4 (SA4) covering Sydney
  - Industries: transport, and all others
  - Multipliers for linking trips and trip costs were first derived using data from the 2011 Household Travel Survey, with a script developed to allocate trips and trip costs
  - The remainder of the CGE calibration followed standard procedures, based on an IO table generated in IELab

## Application




- Simulation of the M5 widening and WestConnex:
  - Scenario 1: 2011 base.
  - Scenario 2: 2011 base plus M5 widening.
  - Scenario 3: 2011 base plus M5 widening and WestConnex Stage 1A.
  - Scenario 4: 2011 base plus M5 widening and WestConnex Stages 1A and 1B.
  - Scenario 5: 2011 base plus M5 widening and WestConnex Stages 1A, 1B and 2.
  - Scenario 6: 2011 base plus M5 widening and WestConnex Stages 1A, 1B, 2 and 3.

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## Results

- Iterations:
  - Scenario 1: single iteration to replicate base data
  - Scenarios 2 to 6: 25 iterations each, although the results largely converged to a band around 5% to 10% above and below the mean results within three iterations
  - Each iteration took around 2 hours to solve, almost entirely from the transport submodel
- Reductions in travel costs manifested in both increases in household leisure time and increases in labour hours.
- Widening of the M5 Motorway resulted in a total increase in welfare of $A188.51 million per year, with the largest beneficiaries being residents and producers in south west Sydney.
- The M4 Motorway widening led to more evenly spread but marginal gains in welfare across the metropolitan area
- WestConnex led to significant welfare gains of A$499.16 million, A$749.97 million and A$1,333.88 million per year for Scenarios 4, 5 and 6 respectively, with every region experiencing improvements. Inner regions fared best, with outlying regions experiencing the fewest benefits and production reducing slightly due to crowding of demand

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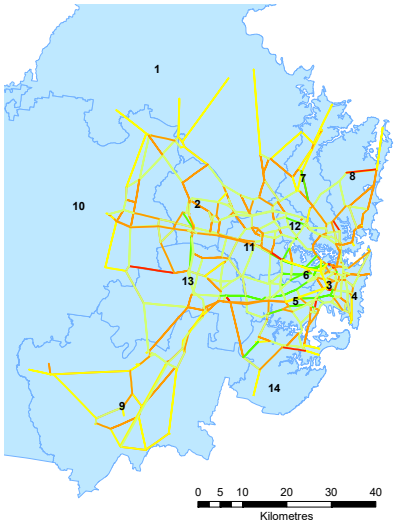
## Change in link volumes from Scenario 1 to 6




- Traffic was diverted from parallel arterial routes onto WestConnex and the widened M5
- Overall, there was a 0.1632% increase in traffic (induced demand) across the whole metropolitan area

Decrease > 20%
Decrease between 0 and 20%
No change
Increase between 0 and 20%
Increase > 20%

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## Conclusion

- Existing models can simulate travel demands and interactions in transport networks to a high degree of detail, but many rely on fixed economic parameters
- The contributions of this model are both conceptual and technical:
  - In applying the CGE submodel as a trip generator and distributor in the four-step framework
  - In developing the linkages between the submodels that enable them to be calibrated as full CGE and transport models
- Extensions:
  - Mode choice and the generation of freight trips
  - Land markets, to replicate the behaviours of a LUTI model

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# Assessing and Anticipating Changing Skill Needs: A CGE Perspective

by

Tony Meagher
Centre of Policy Studies, Victoria University

CGE Workshop, Sydney, August 13 2018

1

Getting Skills Right

## Assessing and Anticipating Changing Skill Needs

OECD

2

## Skill Needs

- In most countries, large shares of employers complain that they cannot find workers with the skills that their businesses require.
- At the same time, in many countries, a number of college graduates face difficulties in finding job opportunities matching their qualifications

OECD

3

## **Skills Assessment and Anticipation Exercises**

- Labour market forecasting
- Skill shortages
- Skill mismatches
- Foresight

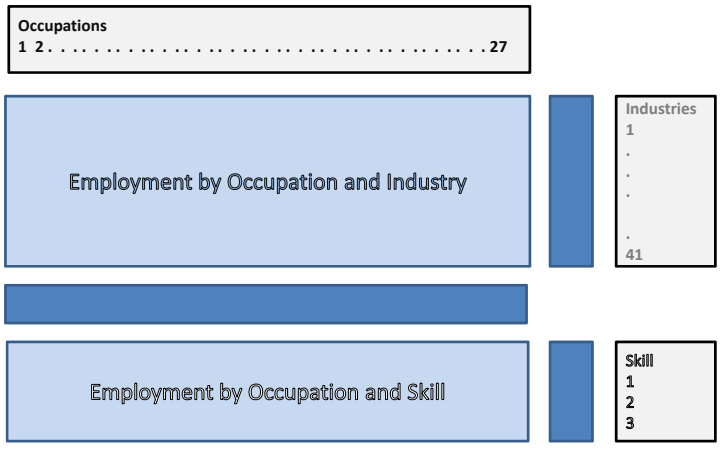
4

## E3ME-WLME Forecasting System

- Cedefop: European Centre for the Development of Vocational Training
- Demand for labour by industry
  - E3ME model - Cambridge Econometrics
- Supply of labour by skill
  - IER, University of Warwick
- "Balance" in markets for labour by occupation
  - WLME – Warwick Labour Market Extension

5

## Employment Technology

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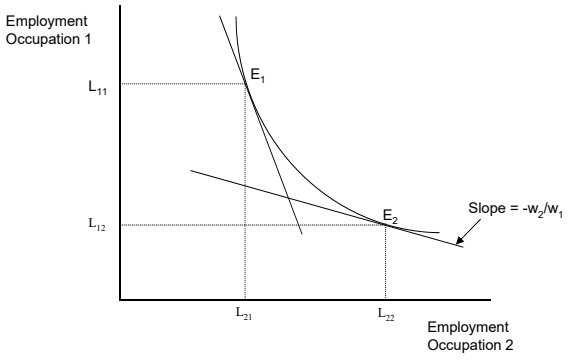
## E3ME-MLME Forecasting System

- Demand for labour by industry
  - E3ME model - Cambridge Econometrics
- Supply of labour by skill
  - IER, University of Warwick
- Equilibrium in markets for labour by occupation
  - MLME – Melbourne Labour Market Extension

7

## Substitution between Occupations in Industries

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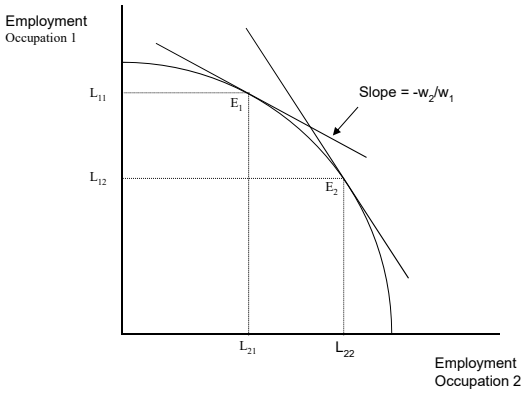
## Skill Transformations between Occupations

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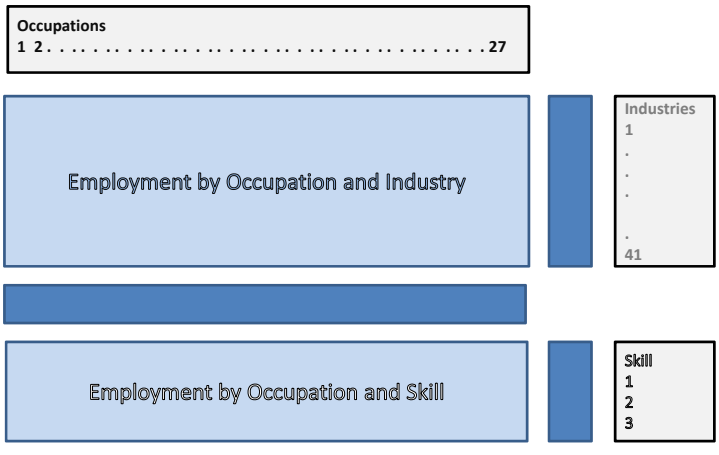
## Employment Technology




10

## E3ME-MLME Forecasting System II

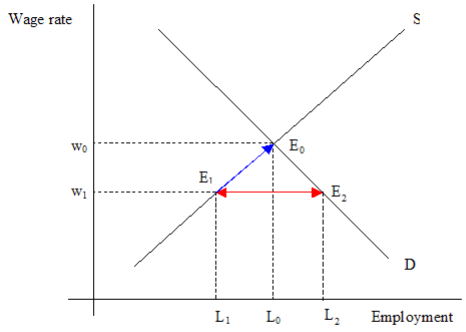
- Shocks
  - Demand for labour by industry
  - Supply of labour by skill
  - Technical change in production
  - Preference change in labour supply
- Shocks induce excess demands and supplies in markets for labour by occupation
- Imbalances induce changes in occupational wage rates and/or policy intervention (training, migration)

11

## Skills Assessment and Anticipation Exercises

- Labour market forecasting
- Skill shortages
- Skill mismatches
- Foresight

12




*Excess Demand for Labor (Skills Shortage)*

13

# Measuring skills shortages

- Analysis of market indicators
  - skilled vacancies
  - wages
  - employment and unemployment
  - participation and hours worked
- Employer based surveys

14

## Survey Definition

Skills shortages exist when employers are unable to fill, or have considerable difficulty filling, vacancies for an occupation at current levels of remuneration and conditions of employment, and reasonably accessible location

(Australian Bureau of Statistics)

15

## Skills Mismatch

- Overskilling describes the situation whereby the worker believes that they possess more skills than their current job requires
- Underskilling describes the situation whereby the worker believes that their current skills do not meet the demands of the job.
- Productivity will increase if skill mismatches are eliminated
  - Labour force vs employed labour force

16

## Some Limitations of Surveys

- Surveys require judgements by employers and/or workers, introducing subjective errors.
- Surveys relate to historical periods rather than future periods, and there is no accepted methodology for converting from one to the other
- Respondents have no economy-wide perspective. Policies based on collective opinions of respondents may result in excess demands or supplies. Policy responses are uncoordinated.

17

## Why are survey methods so dominant?

- Labour market economists tend to be specialised in survey techniques and associated computer packages.
  - Excellence vs policy
- There are substantial barriers to entry associated with CGE analysis.
  - Black boxes
- CGE economists have concentrated on commodity markets and shown limited interest in labour markets.

18

## Forecast and Foresight Exercises

- Forecast exercises provide information about future labour market scenarios
- Foresight exercises provide a framework for stakeholders to assess available information, and determine policies to achieve desirable scenarios
  - Skills councils
  - Skilled Occupations List for immigrants

19

# Economic Consequences of Population Ageing and Policy Reponses in China

13 August 2018

**Xuejin Zuo, Xiujian Peng, Xin Yang and Meifeng Wang**

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## Outline of the presentation

1. Introduction
2. CHINAGEM model and pension module
3. Baseline development
4. Policy simulations
5. Conclusions

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# Introduction

- Sustained low fertility rates since the 1990s in China
- Dramatic age structure change and population ageing
- China's pension system and its challenge to sustained economic growth
- Policies for dealing with ageing problem in China

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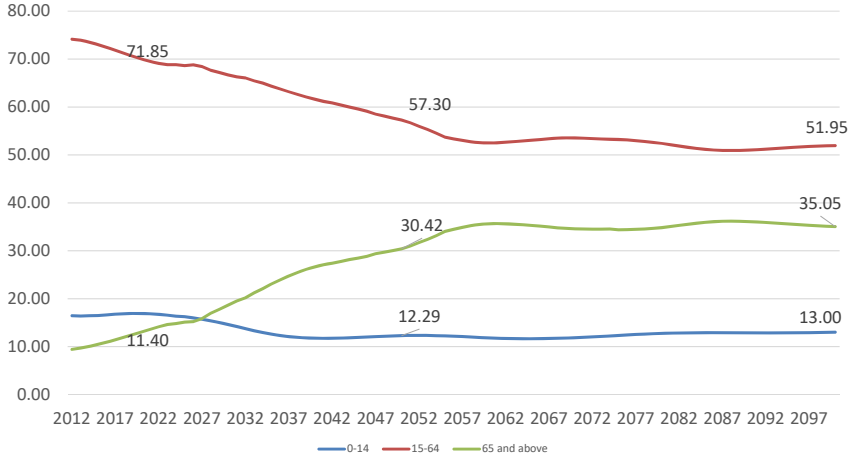
# Rapid age structure change in China

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## Aim of the research

- the economic consequences of population ageing and
- the economic implications of policies dealing with population ageing problem



## Modelling framework

- A dynamic computable general equilibrium (CGE) modelling approach
- CHINAGEM model – A dynamic CGE model of the Chinese economy with 2012 database
  - ❖ Dynamic mechanism
    three types of inter-temporal links:
    --- physical capital accumulation;
    --- financial asset/liability accumulation and
    --- lagged wage adjustment processes.
- Labour market module
- Pension module
- Government account

# Labour market module

- Demand for and employment of labour by activity;
- Supply of labour by category;
- Wage adjustment reflecting the gap between demand and supply;
- The determination of everyone's activity in year t; and
- Linking the number of people in activity o in year t to the number of people in category c in year t+1.

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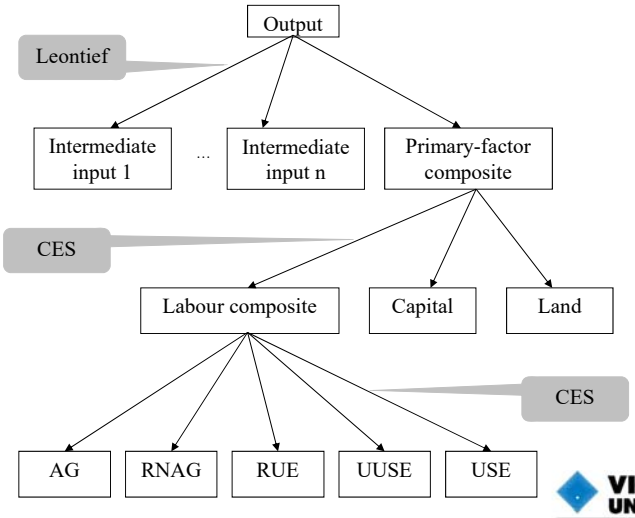
# Framework of CHINAGEM model -- Production

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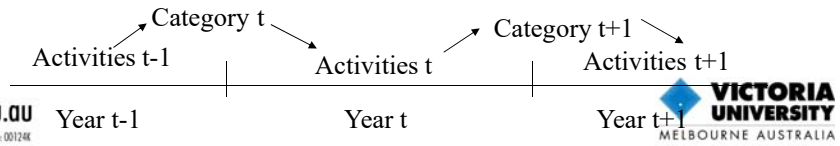
| Labour Categories | Labour Activities |
|---|---|
| Agriculture (AG) | Agriculture |
| Rural Non-Agriculture (RNAG) | Rural Non-Agriculture |
| Rural-Urban (RUE) | Rural-Urban |
| Urban Unskilled (UU) | Urban Unskilled |
| Urban Skilled (US) | Urban Skilled |
| Rural Unemployment | Rural Unemployment |
| Rural-Urban Unemployment | Rural-Urban Unemployment |
| Urban Unemployment | Urban Unemployment |
| Rural New Entrants | |
| Urban New Entrants | |

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## Offers to labour market by categories of Labour Supply

| | AG | RNAG | RUE | UUSE | USE | RAGU | RUU | UU |
|---|---|---|---|---|---|---|---|---|
| AG | * | * | * | | | | | |
| RNAG | * | * | * | | | | | |
| RUE | * | * | * | | | | | |
| UUSE | | | | * | * | | | |
| USE | | | | * | * | | | |
| RAGU | * | * | * | | | | | |
| RUU | * | * | * | | | | | |
| UU | | | | * | * | | | |
| NRUR | * | * | * | * | * | | | |
| NURB | | | | * | * | | | |

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## Pension module

- China's pension insurance system
  -- Urban employees' basic pension insurance scheme
  -- Urban and rural residents' basic pension insurance scheme

## China's current pension insurance system

| Urban employees basic pension insurance scheme | | Urban and rural residents' basic pension insurance scheme | |
|---|---|---|---|
| Pillar 1 | Pillar 2 | Pillar 1 | Pillar 2 |
| 20% of wage paid by employers | 8% of wage paid by employees | Mainly subsidized by central and local government Rates varies But low | Paid by residents Contribution is voluntary |

## China's current pension insurance system
### -- coverage of each pension scheme

| Labour category | Urban employees basic pension insurance scheme | Urban and rural residents' basic pension insurance scheme |
|---|---|---|
| USE | 100% | --- |
| UUSE | 80% | 20% |
| RUE | 25% | 75% |
| AG | --- | 100% |
| RNAG | --- | 100% |
| UU | --- | 100% |
| RAGU | --- | 100% |
| RUU | --- | 100% |
| REST | --- | 100% |



## China's pension system –
### contribution to pension fund

- Urban employees' basic pension insurance scheme

*Pillar 1:*

Contribution1_1(o)
= CRATE1*WAGELEVEL(o)*EMPERSON(o)*COVERAGE(o)*
*P_ACON_P1_O1;

Stock1_1at t
= Stock1_1 at t-1 +Interest at t-1 + (Contribution1_1 at t +
Government1_1 at t -Befefit1_1 at t );

## China's pension system – contribution to pension fund

- Urban employees' basic pension insurance scheme

  *Pillar 2:*
  *Contribution per person by age and occupation:*
  CON_PP_P2(a,o) = CRATE2*WAGELEVEL(o)

## China's pension system – contribution to pension fund

- Urban employees' basic pension insurance scheme

  Pillar 2: *Stock per person*

  Stock2_1 (a,o) per person before age 58
  = STK_PP_P2@1(W_LASTAGE(a),o) + CON_PP_P2@1(W_LASTAGE(a),o) + STK_PP_P2@1(W_LASTAGE(a),o)*RINT

  Stock2_1 (a,o) per person at age 58
  STK_PP_P2_58(*"AGE58"*,o) =
  STK_PP_P2@1(*"AGE57"*,o) + CON_PP_P2@1(*"AGE57"*,o) + STK_PP_P2@1(*"AGE57"*,o)*RINT

  Stock2_1 (a,o) per person after age 58
  STK_PP_P2(a,o) =
  STK_PP_P2@1(LASTAGE(a),o) - BEN_PP_P2@1(R_LASTAGE(a),o)
  + STK_PP_P2@1(LASTAGE(a),o) *RINT

## China's current pension insurance system – contribution to pension fund

- Urban employees' basic pension insurance scheme

Pillar 2: *Stock aggregate*

For working age workers (age 20-57):

(all,a,W_AGE)(all,o,OCC1) STK_AG_P2A(a,o)
= STK_PP_P2(a,o) * EMPERSON(a,o)*COVERAGE(o)*P_STP2_O1;

For retired wokers (58 and above)

(all,a,R_AGE)(all,o,OCC1) STK_AG_P2B(a,o) = STK_PP_P2(a,o) * POPRETAGE(a,o)*COVERAGE(o)*P_STP2_O1;

## China's pension insurance system – contribution to pension fund

- Urban and rural residents' basic pension insurance scheme

*Pillar 1*

(All, o,OCC) CON_P1_T2A(o) = CON_PP_P1_O2 * PCO_P1_T2A(o);

(All, o,OCC) PCO_P1_T2A(o)
= (1-COVERAGE(o) * [Sum(a,W_AGE,EMPERSON(a,o))];

(All, o, UNEMP) CON_P1_T2B(o)
= CON_PP_P1_O2 * COVERAGE(o)*PERSONS_UNEM(o);

CON_P1_T2C = CON_PP_P1_O2 * RESTCONBT;

## China's pension insurance system – payment to pensioners

Urban employees' basic pension insurance scheme

- "Old pensioners" - Workers who retired before 1996

$$\mathbf{Payment}O_t = W_t * 40\%$$

- "New pensioners" -Workers who started to work in and after 1996

Pillar 1: $\mathbf{Payment}N1_t = W_{\tau_r - 1} \times (\tau_r - \tau_s) \times 1\%$

Pillar 2: $\mathbf{Payment}N2_t = \mathbf{PenAss2}(a_r)/15$



## China's pension insurance system – payment to pensioners

- Workers who started to work before 1996 and not retired before 1996

Pillar 1

$$\mathbf{Payment}M1_t = \mathbf{W}_{\tau_r - 1}(\tau_r - \tau_s) \times 1.0\% + \mathbf{W}_{\tau_r - 1}(1996 - \tau_s) \times 0.3\%$$

Pillar 2

$$\mathbf{Payment}M2_t = \mathbf{PenAss2}(a_r)/15$$


## China's pension insurance system – payment to pensioners

- Urban and rural residents' basic pension insurance scheme

  Pillar 1

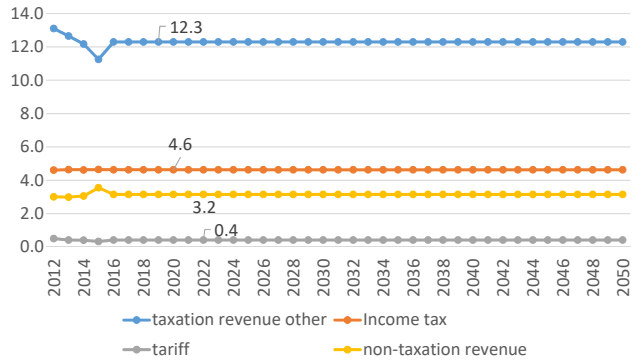
  PPAY_P1_T2 = {POPRETIR_T - sum(o,OCC1,POPRETIR(o))}*TYPE2INDEX;

  BEN_AG_P1_T2 = BEN_PP_P1_T2 * PPAY_P1_T2

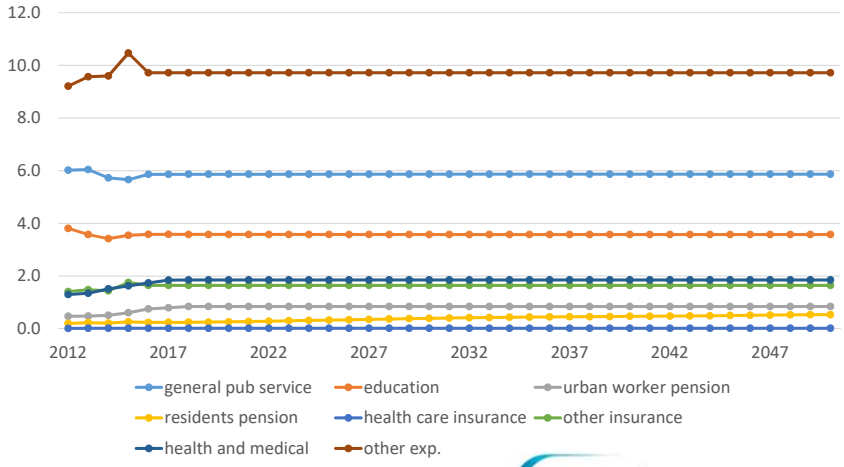
## Government account

- Government general budget balance
  = government general budget revenue
  – government general budget expenditure

# Government account –
## Government general budget revenue

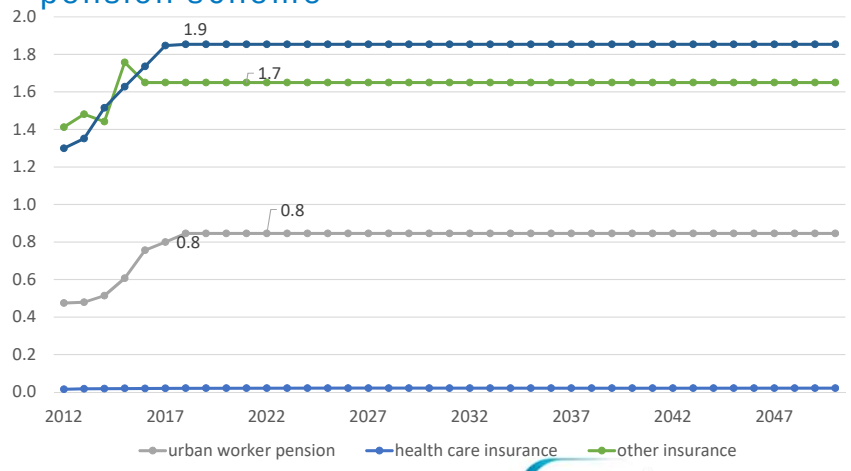



# Government account –
## Government general budget expenditure



## Government account –

### Government general budget expenditure on pension scheme

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## Baseline simulation

- 2013 to 2016 -- historical simulation: we tell the model what actually happened to China's economy.
- 2017 to 2050 -- forecast simulation
  - -- annual growth rate of labour force based on 2015 LFPR and working age population projection from medium variant population projection
  - -- GDP will follow historical trend and keep growing but at a lower rate

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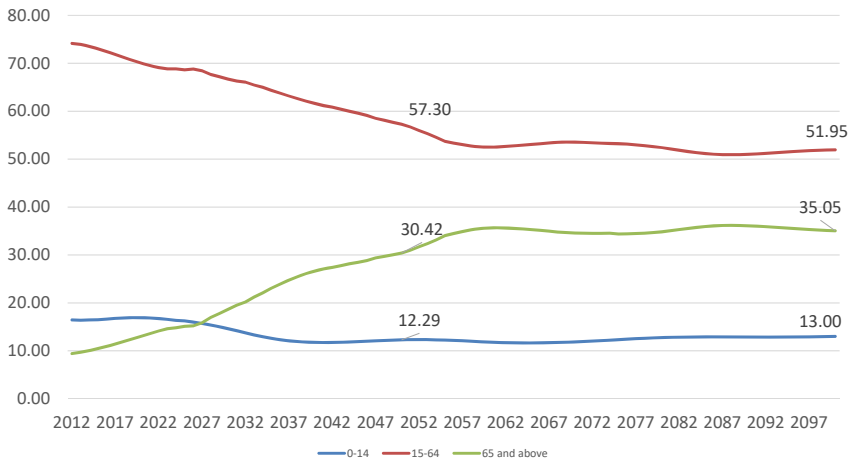
## Rapid age structure change in China

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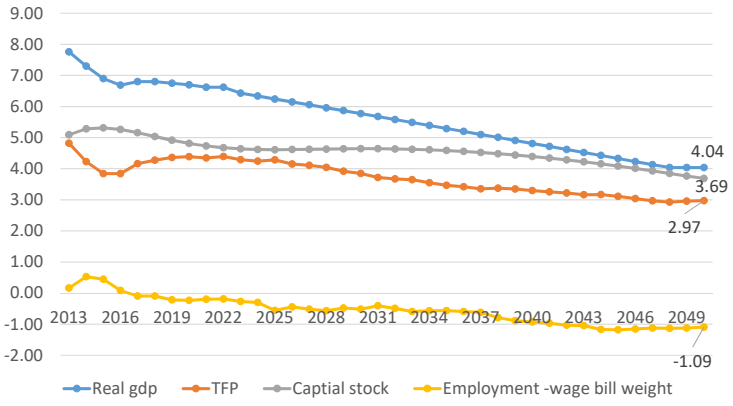
## China's economic performance

### 2017 to 2050 – Baseline simulation

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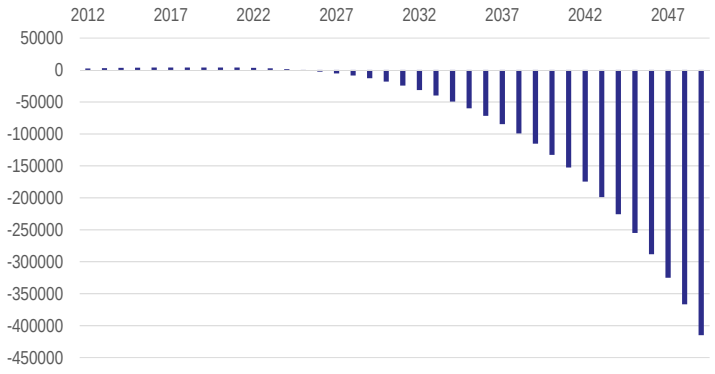
# Change of pension stock (billion)–

## Urban employees' basic pension insurance scheme (baseline simulation)

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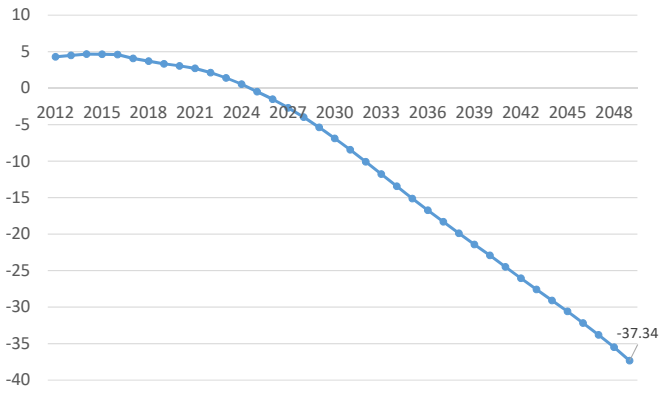
# Pension stock as share of GDP(%)

## Urban employees' basic pension insurance scheme (baseline simulation)

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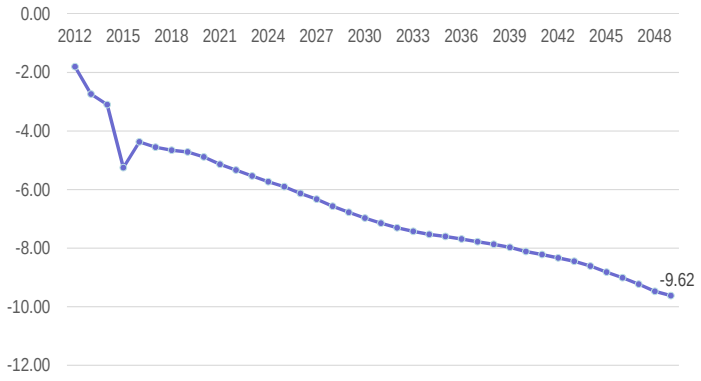
## Government budget balance as share of GDP (%)
### (baseline simulation)



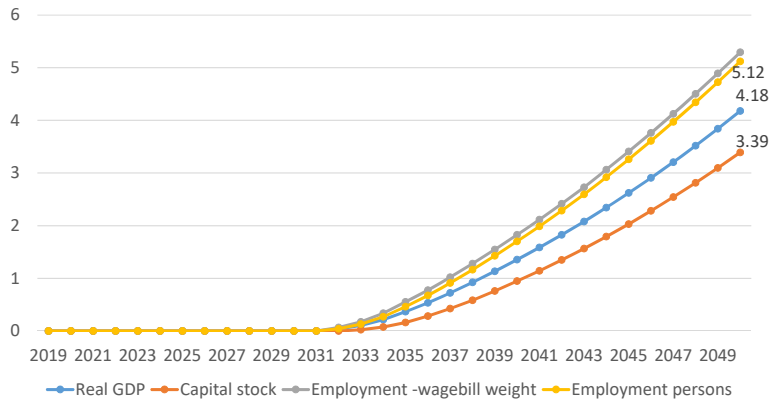



## Policy responses

How to sustain China's economic growth against the backdrop of the rapid ageing?

- New population policy which may bring more labour force growth and more contribution to pension fund;
- Retirement age extension policy which will not only bring more labour to contribute to both macro economy and the pension fund but also delay people withdraw from pension fund;
- Reduce the contribution rate and increase workers' participation in the pension scheme;
- Reduce the pensioners' payment rate
- Increase tax rate to reduce government budget deficit
- -----
- Combine all of these together

## Economic effects of policies dealing with rapid ageing problem – new population policy
- accumulated deviation from baseline scenario (%)

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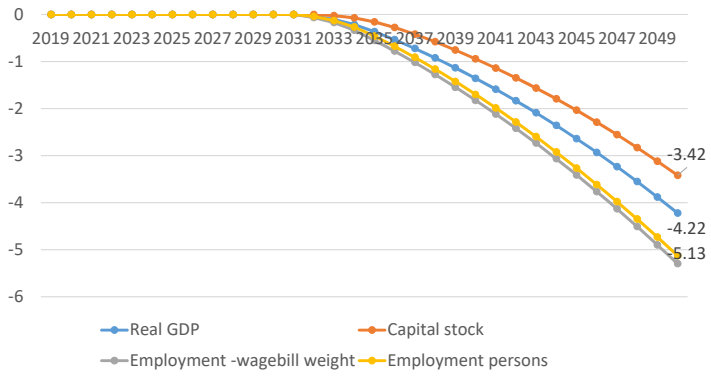
## Economic effects of policies dealing with rapid ageing problem – new population policy
- accumulated deviation from baseline scenario (%)

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## Economic effects of policies dealing with rapid ageing problem

- accumulated deviation from baseline scenario

| Policies | Employment | Real GDP |
|---|---|---|
| New population policy if it is successful | 5.11% | 4.18% |
| New population policy if it does not work | -5.13% | -4.22% |

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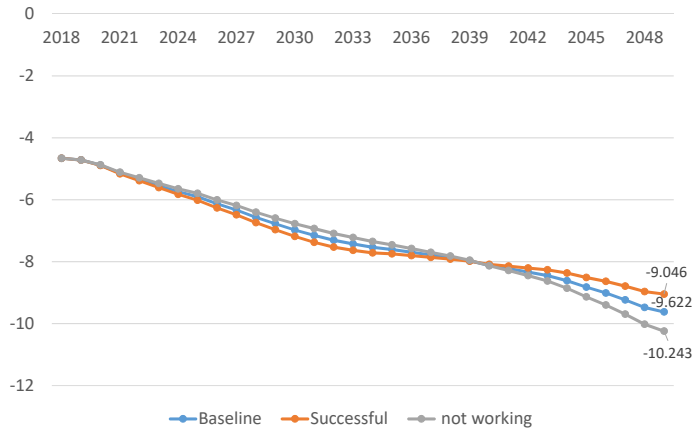
## Economic effects of policies dealing with rapid ageing

–Government budget balance as share of GDP (%)

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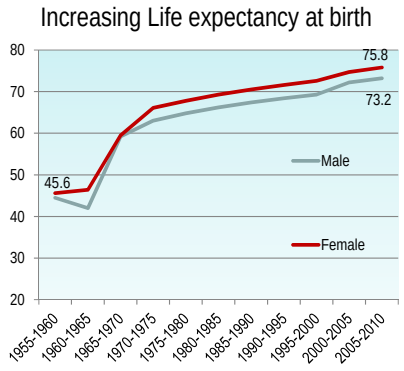
# Economic effects of policies dealing with rapid ageing

## -- retirement age extension

China's low retirement age compounding the ageing problem

Current official retirement age in China

- -- 50 for female workers
- -- 55 for female officials
- -- 60 for male employees

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# Economic effects of policies dealing with rapid ageing

## -- retirement age extension

Gradually increases the retirement age to 65 starting from 2020

The economic effects will be released soon

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## What we learnt from this CGE analysis so far

- Baseline forecast of
  -- employment in different activities which help to calculate the contribution to the pension fund and also the payment to the pensioners;
  -- wage rate by different activities which affect the contribution to the pension fund and also the payment to the pensioners;
- -- growth path of TFP to maintain the economic growth with the declining labour force;

And also

- Tax rate change in order to pay for the pension scheme ;
  ---



## Thanks you and questions?

# Indonesia's moratorium on palm oil expansion from natural forest

14 August 2018

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CoPS

## Team….

- A result of years of collaboration among these institutions:

Australian Government AusAID

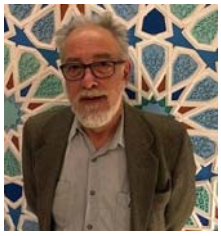
CoPS VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

CEDS Center for Economics and Development Studies

Kementerian PPN/ Bappenas

ADB Asian Development Bank

- Most recent project was funded by Aus-AID (2013- 2014)
- Developed IndoTERM
- Article available in the ADR



Indonesia's Moratorium on Palm Oil Expansion from Natural Forests: Economy-Wide Impacts and the Role of International Transfers

ARIEF A. YUSUF, ELIZABETH L. ROOS, AND JONATHAN M. HORRIDGE*

Indonesia has introduced a moratorium on the conversion of natural forests to land used for palm oil production. Using a dynamic, bottom-up, interregional computable general equilibrium model of the Indonesian economy, we assess several scenarios of the moratorium and discuss its impacts on the domestic economy as well as on regional economies within Indonesia. We find the moratorium reduces Indonesian economic growth and other macroeconomic indicators, but international transfers can more than compensate the welfare losses. The impacts also vary across regions. Sumatra, which is highly dependent on palm oil and is home to forests that no longer have a high carbon stock, receives fewer transfers and suffers the greatest economic loss. Kalimantan, which is relatively less dependent on palm oil and has forests with a relatively high carbon stock, receives more transfers and gets greater benefit. This implies that additional policy measures anticipating the unbalanced impacts of the moratorium are required if the trade-off between conservation and reducing interregional economic disparity is to be reconciled.

*Keywords:* carbon emissions, computable general equilibrium, Indonesia, palm oil
*JEL codes:* R10, R11, R13

P.2

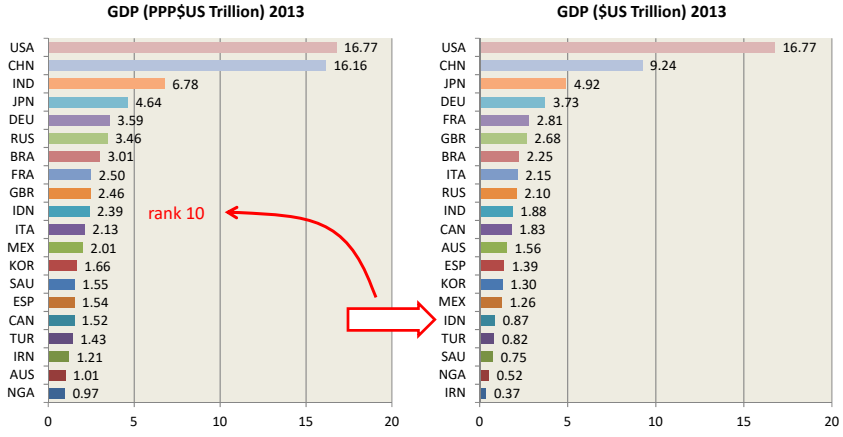
## Introduction

- UN **R**eduction of **E**missions from **D**eforestation and forest **D**egradation (REDD) programmes seeks to reduce forest emissions and enhance carbon stocks in forests while contributing to national sustainable development. Eg. establish financial mechanism.
- Deforestation contribute about 20% of global CO2 emissions.
- The main reason for deforestation is the conversion of forest to agricultural land for commercial or subsistence farming. Global phenomenon.
- Several studies have been conducted to evaluate the economic viability of incentive payment to reduce deforestation and CO2 emissions.
- In general, it seems difficult to provide a framework, which is based on long-term contracts, given fluctuations in agricultural commodity prices in the short-run.
- In this paper, we run 2 simulations to investigate the moratorium placed on the conversion of forests in Indonesia.

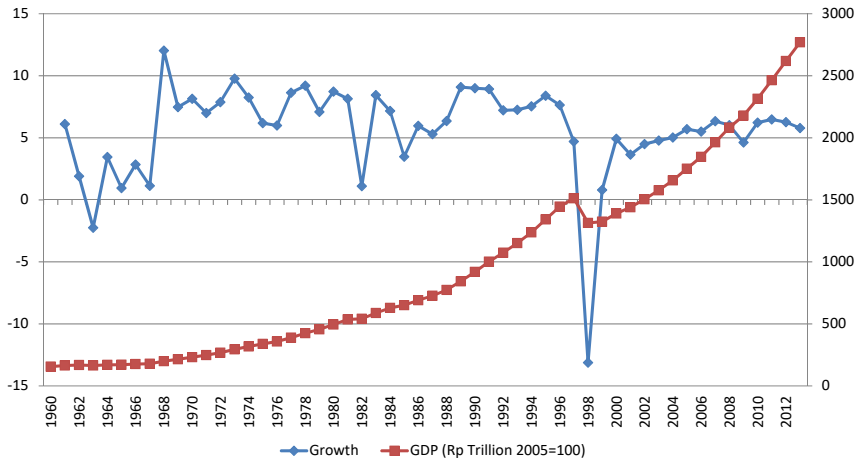


## Indonesia is now among the world's 10 biggest economies

- Indonesia's economy is highly dependent on it resource-based sectors.
- Recent years, the palm oil sector has become an important economic and export-oriented industry.



## which experienced remarkably high growth in the 70s-90s, ...



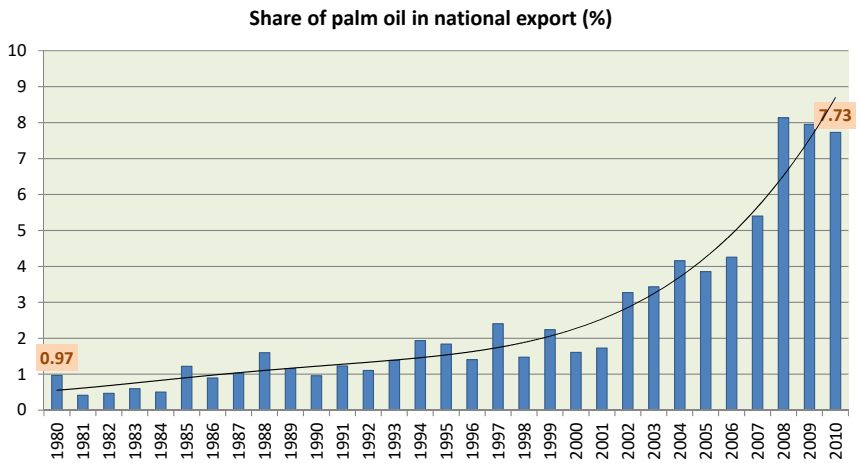



## Indonesia's recent development challenges

1. A slowing-down in economic growth, ..
2. ... and the rate of poverty reduction
3. Income inequality is rising including no improvement in the inter-regional economic disparity.
   and ....
4. Global contributor of carbon emissions

This paper is a "story" of where strategies to anticipate the 4 challenges can be conflicting and how to work around it.

## The importance of oil palm in national export has been steadily increasing

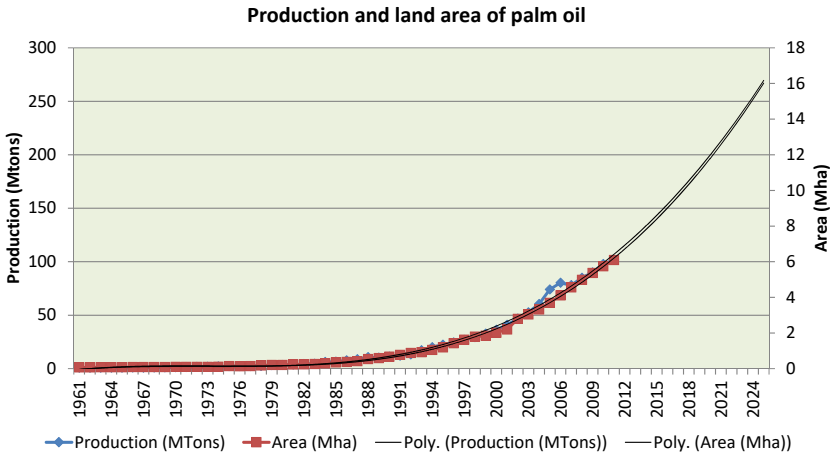



P.7

## In most provinces, palm oil land has doubled in size over the last decade. In Kalimantan (among the most pristine forest), more than tripled.


P.8

## If the trend continues, more pressure on natural forest, and more carbon emissions




Source: FAO Database

P.9

## Introduction of moratorium

- In May 2010, GoI announced a moratorium prohibiting district governments from granting new concession licenses for activities that convert primary forests and peat lands to oil palm plantations (oil palm concessions); to fast-growing tree plantations for pulp and paper (timber concessions)
- The moratorium came into force in May 2011 and was extended in May 2013 and May 2017.

P.10

## Paper's objectives

- This objectives of this paper is (1) to see the macroeconomic effect of the moratorium on the Indonesian economy including how the effect is distributed across different regions in the country and
- (2) to see to what extent international transfers, which is a payment for ecosystem services (PES) where international community pays the avoided deforestation or the additional carbon storage services, can mitigate the effect of the moratorium.

P.11

## IndoTerm…

- A family of Australian TERM The Enermous Regional Model Developed by CoPS (Centre of Policy Studies), Victoria University (formerly: Monash University)
- Applied in:

  Australia, Brazil, Finland, China, South Africa, Indonesia
- In Indonesia

  Emerald (Pambudi)

  IndoTERM v.1 (CEDS UNPAD, CoPS, 2006)

  IndoTERM v.2 (ADB, CoPS, CEDS UNPAD, 2012)

  IndoTERM v.3 - Dynamic (CoPS, CEDS UNPAD, BAPPENAS, AusAID, 2013-2014)
- A result of years of collaboration among these institutions:

## IndoTERM model

IndoTERM consists of two inter-dependent modules.

- The first module describes the core model equations related to region-specific behaviour of producers, investors, households, government and exporters at a regional level. It also describes the dynamic mechanism in the model, namely, capital accumulation and labour market adjustment. (See Horridge 2011 for details)
- The second module describes the treatment of land-use change, emissions and REDD payment.



## IndoTERM model specifications (LAND & EMISSIONS)

- IndoTERM identifies 5 land uses, namely, Crops, Estate Crops, Oil Palm plantation, Managed Forest and Natural Forest.
- It specifically model (i) the conversion of natural forest to palm oil plantation and (ii) the REDD payment, which is a once-off payment for the promise of not converting natural forest to palm oil plantations.

- First equation determines the change in land area

$$\triangle AREA_{(i,d)} = \left[ LNDAREA_{(i,d)} / 100 \right] * xlnd_{(i,d)} \quad \text{for REG d, land using IND i} \qquad \text{(E.1)}$$

$\triangle \mathrm{AREA}_{(i,d)}$ is the change in the amount of land available by industry i, region d

$\mathrm{LNDAREA}_{(i,d)}$ is the initial amount of the land available by industry i, region d.

$\mathrm{xlnd}_{(i,d)}$ is the percentage change in the land rental value by ind i ,region r

## IndoTERM model specifications (LAND & EMISSIONS)

(E.2) determines the change in CO2 emissions due to land-use change (LUC) by region

$$\triangle CO2_{(d)} = \sum_{i \in IND} CO2INT_{(i,d)} * \triangle AREA_{(i,d)} + CO2INTNF_{(d)} * \triangle NFAREA_{(d)} \quad \text{(E.2)}$$

for REG d, land using IND i

$\triangle CO2_{(d)}$ is the total change in CO2 emissions by region,

$CO2INT_{(i,d)}$ is the total CO2 intensity measured tonnes of emission per hectare for all industries using land,

$CO2INTNF_{(d)}$ is the CO2 intensity measured as tonnes of emissions per hectare of Natural Forest, and

$\triangle NFAREA_{(d)}$ is the ordinary change in the natural forest area by region r.



## IndoTERM model specifications (LAND & EMISSIONS)

Equations (E.3) and (E.4) allows us to impose two rules to simulate the different land conversion scenarios.

$$\triangle AREA_{("Forestry",d)} = -0.5 * \triangle AREA_{("OilPalm",d)} + f\_rule1_{(d)} \quad \text{for REG d} \quad \text{(E.3)}$$

$$\triangle AREA_{("Forestry",d)} = -\triangle AREA_{("OilPalm",d)} + f\_rule2_{(d)} \quad \text{for REG d} \quad \text{(E.4)}$$

where

$\triangle AREA$ is the change in the land area allocated to Managed Forestry and Oil Palm plantations by region, and

$f\_rule1$ and $f\_rule2$ are shift variables, used to activate or deactivate the respective equations

## IndoTERM model specifications (LAND & EMISSIONS)

(E.5) calculates the change in the REDD payment by region as the difference between the REDD payment between two consecutive years.

$$\Delta REDD_{(d)} = REDD^{t}_{(d)} - REDD^{t-1}_{(d)} \quad \text{for REG d} \quad \text{(E.5)}$$

$$REDD^{t}_{(d)} = CO2PRICE * \left[ -\Delta CO2_{(d)} + BaseEmit_{(d)} \right] \quad \text{for REG d} \quad \text{(E.6)}$$

CO2PRICE is the carbon price per tonne of CO2 emission,

$\Delta$CO2 is the change in CO2 emission from changing the use of land and is determined in (E.2), and

BaseEmit is the level of CO2 emissions in the baseline simulation and determined via (E.7).





f_HOU

## IndoTERM model specifications (LAND & EMISSIONS)

Equation (E.7) determines the base level of CO2 emissions.

$$BaseEmit_{(d)} = \Delta CO2_{(d)} + f\_BaseEmit_{(d)} \quad \text{for REG d} \quad \text{(E.7)}$$

BaseEmit is the base level of CO2 emissions by region,

f_BaseEmit is a shift variable used to activate or deactivate the equation

In our theory, the REDD payment is directly paid to households in each region

$$HOUTOT_{(d)} = WAGE_{(d)} + \Delta REDD_{(d)} \quad \text{(E.8)}$$

Wage is the wage income by region,

$\Delta$REDD is the ordinary change in the REDD payment by regions as determined in Equation (5),

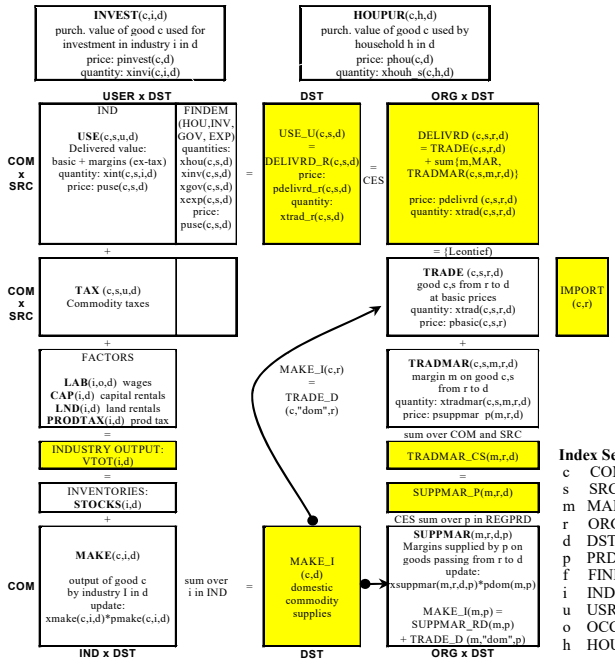
## IndoTERM model specifications (LAND & EMISSIONS)

The REDD payment is a payment to Indonesian households from a foreign donor. We add the payment with other net transfers from the ROW. The final equation shows that the share of the BOT and REDD payment to GDP.

$$SHRBOTGDP = \frac{[\Delta BOT + \Delta NTROW]}{GDP} \qquad \text{(E.7)}$$



## IndoTERM Database structure

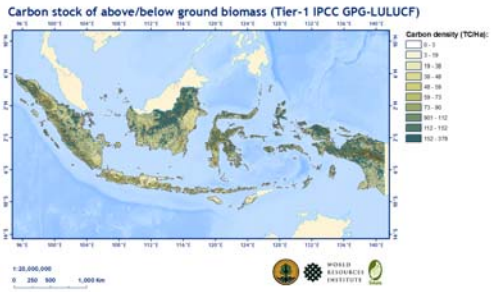



Source:
Input-Output Table, Inter-regional input-output table, regional data of production, Social Accounting Matrix, Spatial data

Base year: 2005

| Index Set | Description |
|---|---|
| c | COM Commodities |
| s | SRC Domestic or imported (ROW) sources |
| m | MAR Margin commodities |
| r | ORG Regions of origin |
| d | DST Regions of use (destination) |
| p | PRD Regions of margin production |
| f | FINDEM Final demanders(HOU, INV,GOV, EXP) |
| i | IND Industries |
| u | USR Users = IND + FINDEM |
| o | OCC Skills |
| h | HOU Households |

# Emissions database




In parameterizing the land-use module, we require data on:

- land area, measured in hectares, used for commercial purposes by region;
- land area, measured in hectares, identified as natural forest by region; and
- the $CO_2$ intensities per hectare by land use and region.


# IndoTERM model specifications (3)

- ***SIM0 – the baseline simulation***
  *The absence of the moratorium and REDD scheme. Oil palm land grow between 3-8 percent per annum depending on the regions toward 2030. Higher growth regions are provinces in Kalimantan and rather low growth regions are in Sumatera. We assume that half the oil palm land is originated from natural forest and the other half from production forest. This is roughly based on Carlson et al (2013).*
- ***SIM1 – Moratorium without international transfers***
  *Reproduces the growth paths of (i) but without further conversion of natural forest to palm oil. We assume that oil palm land still grows but from the conversion from managed forest.*
- ***SIM2 – Moratorium with international transfers***
  *Reproduces the growth paths of (ii) but with a REDD payment proportional to the emissions saved by (ii). We convert the avoided deforestation into avoided carbon emissions and translate it into international transfers by multiplying the avoided emissions with the price of carbon ($10/tCO2e). We distribute the transfers to the regions according to their magnitude of emissions reduction. The transfers is given directly to representative households who will spend the money received as consumption spending.*

## Baseline simulation assumptions

- Forecast is driven by projected changes in population, labor force, productivity, and foreign demand that are roughly consistent with Indonesia's recent GDP growth rates of 6% per annum.
- Land productivity rises by 3% per annum in all agricultural sectors, including crops, estate crops, oil palm, and managed forests.
- Land productivity in all extractive sectors, except for oil and gas, rises by 2% per annum. The assumption reflects our view that Indonesian oil reserves offer little scope for an output increase.
- For all land-using sectors, except the palm oil sector, we assume that the land area under cultivation is fixed. We assume that the land area for palm oil increases by 8% in Kalimantan and Papua, 4% in East Sumatra and Sulawesi, and 3% in West Sumatra

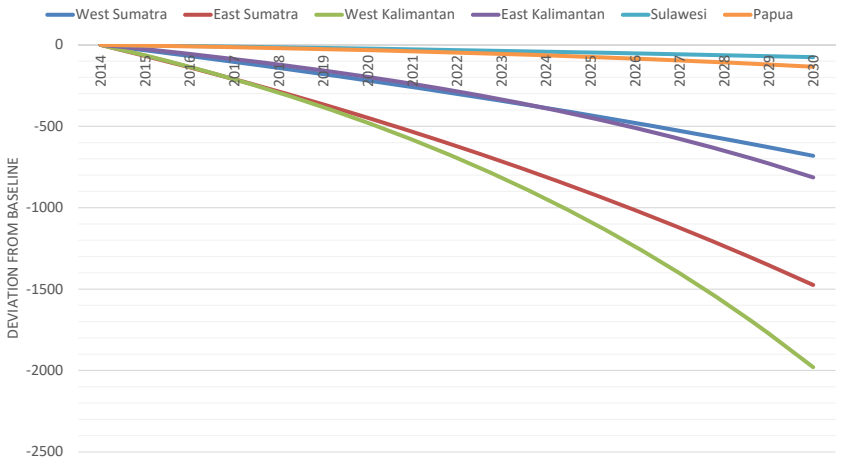
## Baseline simulation results

- All regions expand during the simulation period but at different growth rates.
- Regional performance depends on the type of economic activity that is dominant in that specific region(eg palm oil production on Sumatra and Kalimantan).
- Kalimantan and Sumatra show the highest levels of land-use conversion from forest to palm oil plantation.
- Another regional difference is the tons of CO2 that is stored in their respective forests.

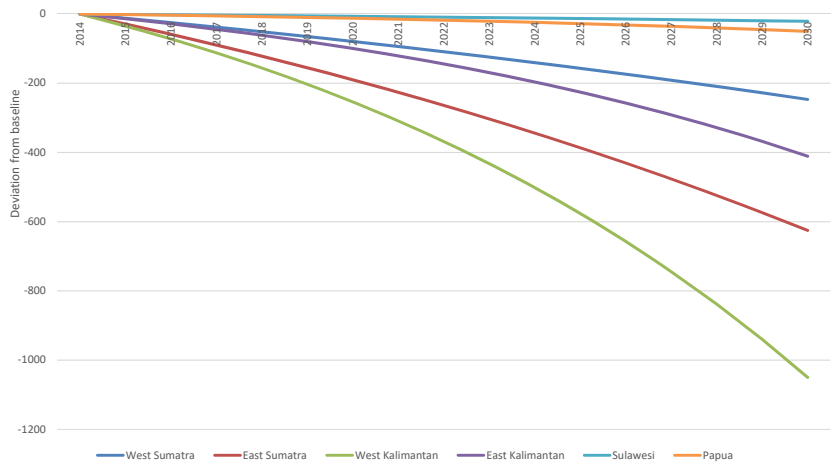
## Policy simulations

- ***SIM1 – Moratorium without international transfers***
  *Reproduces the growth paths of (i) but without further conversion of natural forest to palm oil. We assume that oil palm land still grows but from the conversion from managed forest.*
- ***SIM2 – Moratorium with international transfers***
  *Reproduces the growth paths of (ii) but with a REDD payment proportional to the emissions saved by (ii). We convert the avoided deforestation into avoided carbon emissions and translate it into international transfers by multiplying the avoided emissions with the price of carbon ($10/tCO2e). We distribute the transfers to the regions according to their magnitude of emissions reduction. The transfers is given directly to representative households who will spend the money received as consumption spending.*

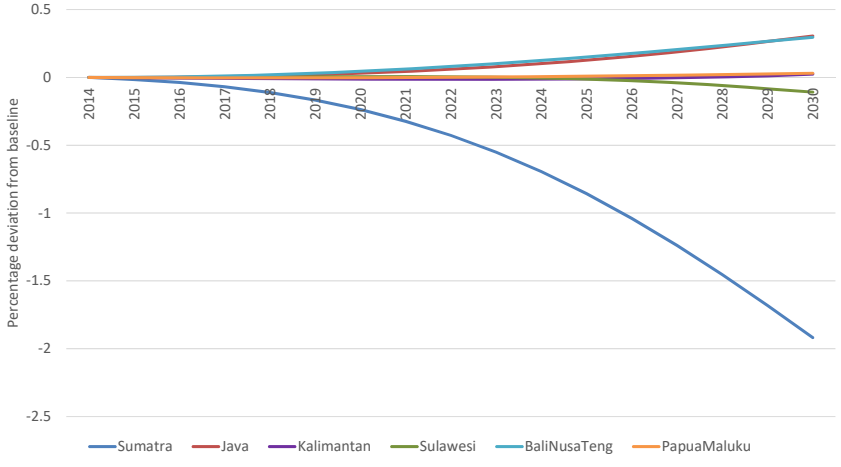
## Palm Oil land area by region (000 ha) (ordinary cumulative deviation from baseline) – SIM1



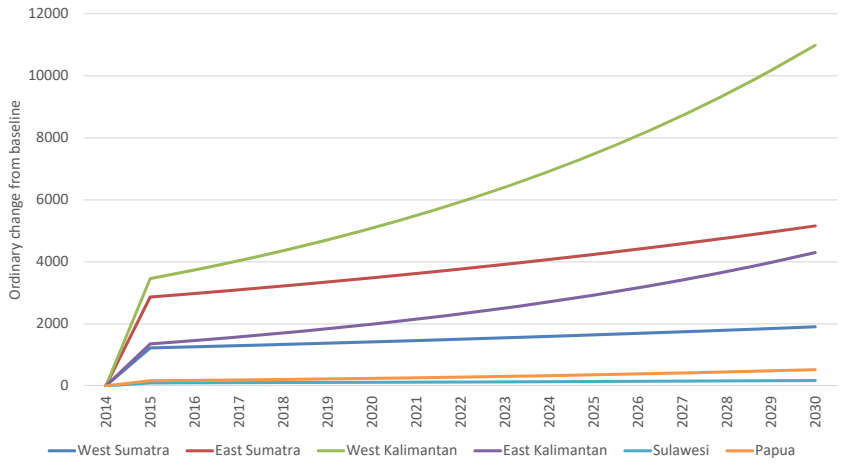
## $CO_2$ Emissions by Region (ordinary cumulative deviation from baseline) – SIM1



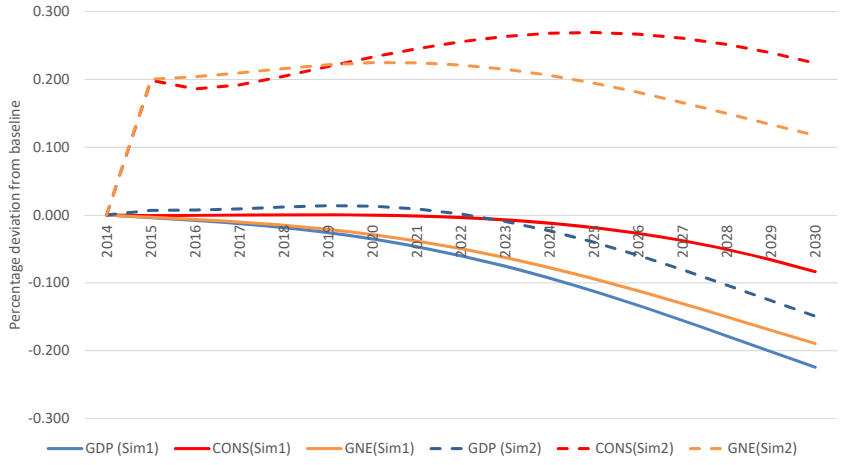

## GDP by region (percentage deviation from baseline) – SIM1



## REDD payment by region (ordinary change from baseline) – SIM2




## GDP, GNE and consumption (percentage deviation from baseline) – SIM1 & SIM2



## Conclusion

- Our simulation suggest that moratorium reduces Indonesian economic growth, and other macroeconomic indicators, but international transfers ($10/tCO2 emissions avoided) can more than compensate the welfare loss.
- However, the impact varies across regions.
  - Sumatra which is highly-dependent on oil palm; of which its economy is less broad-based and its carbon stock of its forest is no longer high, receive less transfers and suffer a great economic loss.
  - In the meantime, Kalimantan which is relatively less dependent on oil palm than Sumatra, and its forest's carbon stock is still high, receive more transfers and get greater benefit.
- This result suggest that additional policy measures anticipating the imbalanced impact of the transfers is required if the trade-off between conservation and reducing inter-regional economic disparity needs to be reconciled.

# The economy-wide implications of GSC trade: integrating GSC and CGE models


**Presentation by**

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**of joint work with Peter B. Dixon**

**At the National CGE Workshop, Sydney**

**August 13, 2018**



# The challenge

**Economists have provided excellent analytical descriptions of GSC trade, see for example:**
Koopman, R., Z. Wang and S-J. Wei (2014), "Tracing value added and double counting in gross exports", *American Economic Review*, 104(2), 459-94.

**The next challenge is to develop CGE models to help us understand how GSC trade affects welfare and its distributions between and within nations.**

**The new CGE model must recognize:**
- **fragmentation of production processes;**
- **economies of scale within each process, and**
- **decision making by global actors**

**Our approach: integrate GSC sectoral models with a CGE model**

# GSC sectoral model (e.g. Vehicles)

**The global agent chooses outputs of Design, Components, Assembly and Sales & distribution and trade flows**
***to***
**minimize production and trade costs**
***subject to***
**satisfying final demands in each region**

**This can be set up as a linear or integer programming problem.**

**It produces solutions for regional outputs and trade flows that are highly sensitive to wage rates and trade costs (footloose activities).**

**Regions exhibit specialization in activities within the sector (fragmentation within the sector)**



# Building GSC models

**As a preliminary step we have created a prototype GSC model and an associated CGE model.**

**The GSC model is for the Widget sector. It has 4 activities (Design, Components, Assembly and SalesDistribution) and 2 regions**

# World Widget sector (C1) in 1990

CoPS

*Technology assumptions and data for 1990*

| | Design | Components | Assembly | SalesDist |
|---|---|---|---|---|
| ***(a) Intermediate inputs for producing 1 unit of output of each commodity in both regions*** | | | | |
| Design | 0 | 1 | 0 | 0 |
| Components | 0 | 0 | 1 | 0 |
| Assembly | 0 | 0 | 0 | 1 |
| SalesDist | 0 | 0 | 0 | 0 |
| ***(b) Output per unit of labour input, standard scale (Productivity, PR)*** | | | | |
| Country 1 (US) | 1 | 1 | 1 | 1 |
| Country 2 (Asia) | 0.0833 | 0.1667 | 0.125 | 0.25 |
| ***(c) Powers of transport costs & tariffs (T)on imports by importing region*** | | | | |
| Country 1 (US) | 1.1 | 1.2 | 1.2 | 1 |
| Country 2 (Asia) | 1.1 | 1.2 | 1.2 | 1 |
| ***(d) Demand for final product:*** | | | | |
| Country 1 (US) | | | | Y(4,1) = 1 |
| Country 2 (Asia) | | | | Y(4,2) = 0.5 |
| ***(e) Wage rates*** | | | | |
| Country 1 (US) = 1.0 | Country 2 (Asia) = 0.25 | | | |

**Country 2 (Asia) has very low productivity in all activities**
**Country 2 has low wages, but not low enough to offset low productivity**
**Trade costs are high**



# Output , employment, trade and prices in 1990: Widget GSC solution

CoPS

| | Price | Output | Employment | Exports, qty | Exports, value |
|---|---|---|---|---|---|
| **Country 1** | | | | | |
| Design | 0.950 | 1.5 | 1.425 | 0.0 | 0.0 |
| Components | 1.900 | 1.5 | 1.425 | 0.0 | 0.0 |
| Assembly | 2.850 | 1.5 | 1.425 | 0.5 | 1.425 |
| SalesDist | 3.850 | 1.0 | 1.000 | 0.0 | 0.0 |
| **Total** | | | 5.275 | | 1.425 |
| | | | Wagebill=5.275 | | |
| **Country 2** | | | | | |
| Design | 3.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| Components | 2.545 | 0.0 | 0.0 | 0.0 | 0.0 |
| Assembly | 4.280 | 0.0 | 0.0 | 0.0 | 0.0 |
| SalesDist | 4.420 | 0.5 | 2.0 | 0.0 | 0.0 |
| **Total** | | | 2.0 | | 0.0 |
| | | | Wagebill=0.5 | | |

**Widget trade surplus for U.S. = 1.425**
**U.S. supplies all of the World's Design, Components & Assembly, and exports just Assembly (finished product)**
**Asia's only Widget activity is SalesDist which is nontraded**

**No GSC trade**

## *World input-output table for 1990 ($): CGE database*

CoPS

| | | CNT1 Ind1 | CNT1 Ind2 | CNT2 Ind1 | CNT2 Ind2 | CNT1 Consumption | CNT2 Consumption | Totals |
|---|---|---|---|---|---|---|---|---|
| CNT1 | C1 | 7.125 | | 1.425 | | 3.85 | | 12.400 |
| CNT1 | C2 | | | | | 23.525 | 2.85 | 26.375 |
| CNT2 | C1 | | | | | | 2.210 | 2.210 |
| CNT2 | C2 | | | | | 4.275 | 5.725 | 10.000 |
| Labour | C1 | 5.275 | 26.375 | | | | | 31.650 |
| Labour | C2 | | | 0.5 | 10 | | | 10.500 |
| Taxes | C1 | 0 | 0 | 0.285 | 0 | 0 | 0 | |
| Taxes | C2 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Totals | | 12.400 | 26.375 | 2.210 | 10.000 | 31.650 | 10.785 | |

**U.S. (CNT1) has large trade surplus in Widgets (C1)**

**CNT1, C1: exports = 1.425 imports = 0, trade surplus in C1 = 1.425**

**Widgets (C1) account for 16.7% of employment in U.S. (CNT1)**

**Widgets (C1) account for 4.8% of employment in Asia (CNT2)**



## Baseline CGE forecast: shocks 1990 to 2000

CoPS

***Asia (CNT2) has rapid technical progress relative to U.S. (CNT1)***

***Widgets (IND1) has rapid technical progress relative to Other (IND2)***

***Trade costs fall***

**(1) labour-saving technical progress in IND1, CNT1 = 15%**

**(2) labour-saving technical progress in IND2, CNT1 = 0%**

**(3) labour-saving technical progress in IND1, CNT2 = 27.75%**

**(4) labour-saving technical progress in IND2, CNT2 = 15%**

**(5) reduction in the power of the tariff on CNT2's imports of COM1 = 12.5%**

# *Projection from 1990 to 2000 using standard CGE model*

CoPS

| | U.S. | Asia |
|---|---|---|
| Real GDP (% change from 1990 to 2000) | 2.72 | 18.76 |
| Real consumption, welfare (% change) | 2.41 | 19.76 |
| Wage rate (% change) | 0.00 | 13.82 |
| Factory price of Widgets (% change) | -15.01 | -23.85 |
| Factory price of Other (% change) | 0.00 | -3.25 |
| Aggregate employment | 0.00 | 0.00 |

U.S. trade surplus in Widgets increases from 1.425 in 1990 to 1.605 in 2000
Share of U.S. employment in Widgets goes from 16.7% to 16.4%
Share of Asian employment in Widgets goes from 4.8% to 4.5%

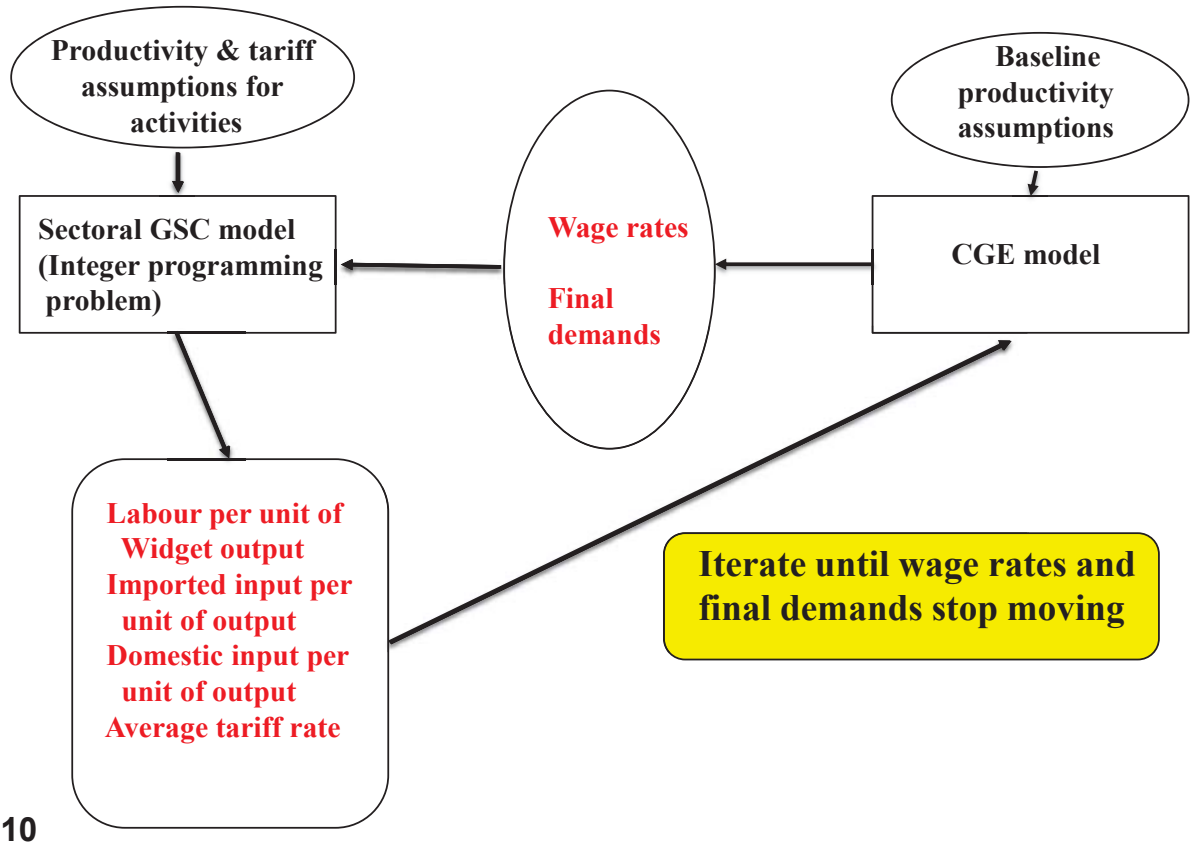
*Asia grows rapidly relatively to U.S.*
*Wage rates in Asia grow rapidly relative to U.S.*
*Widgets get cheap relative to other goods*

*CGE forecasts almost no structural change*



# Integrating GSC and CGE: plan A

CoPS



# World Widget sector (C1) in 2000

CoPS

*Technology assumptions and data for 2000*

| | Design | Components | Assembly | SalesDist |
|---|---|---|---|---|
| *(a) Intermediate inputs for producing 1 unit of output of each commodity in both regions* | | | | |
| Design | 0 | 1 | 0 | 0 |
| Components | 0 | 0 | 1 | 0 |
| Assembly | 0 | 0 | 0 | 1 |
| SalesDist | 0 | 0 | 0 | 0 |
| *(b) Output per unit of labour input, standard scale (Productivity, PR)* | | | | |
| Country 1 (US) | 1.1765 | 1.1765 | 1.1765 | 1.1765 |
| Country 2 (Asia) | 0.1765 | 0.3922 | 0.3069 | 0.3460 |
| *(c) Powers of transport costs & tariffs (T)on imports by importing region* | | | | |
| Country 1 (US) | 1.05 | 1.05 | 1.1 | 1 |
| Country 2 (Asia) | 1.05 | 1.05 | 1.1 | 1 |
| *(d) Demand for final product: initial situation* | | | | |
| Country 1 (US) | | | | Y(4,1) = 1 |
| Country 2 (Asia) | | | | Y(4,2) = 0.75 |

*(e) Wage rate*

Country 1 (US) = 1 Country 2 (Asia) =0.3

***Country 2's is now competitive in Components: productivity is 33% of that in country 1 while wages are 30%***

***Country 2's is almost competitive in Assembly***

***Trade costs have fallen***

***Demand & wages in country 2 have risen***



CoPS

# Output , employment, trade and prices in 2000: Widget GSC solution

| | Price | Output | Employment | Exports, qty | Exports, value |
|---|---|---|---|---|---|
| **Country 1** | | | | | |
| Design | 0.808 | 1.75 | 1.413 | 1.75 | 1.413 |
| Components | 1.657 | 0.00 | 0.000 | 0.00 | 0.000 |
| Assembly | 2.503 | 1.00 | 0.850 | 0.00 | 0.000 |
| SalesDist | 3.353 | 1.00 | 0.850 | 0.00 | 0.000 |
| **Total** | | | 3.113 | | 1.413 |
| | | | Wagebill=3.113 | | |
| **Country 2** | | | | | |
| Design | 1.700 | 0.00 | 0.000 | 0.00 | 0.000 |
| Components | 1.575 | 1.75 | 4.239 | 1.00 | 1.575 |
| Assembly | 2.552 | 0.75 | 2.444 | 0.00 | 0.000 |
| SalesDist | 3.419 | 0.75 | 2.168 | 0.00 | 0.000 |
| **Total** | | | 8.851 | | 1.575 |
| | | | Wagebill=2.655 | | |

**Between 1990 and 2000 GSC model implies that:**

**U.S. Widget trade balance goes from surplus of 1.425 to deficit of 0.162**

**U.S. Widget employment falls from 5.275 to 3.113**

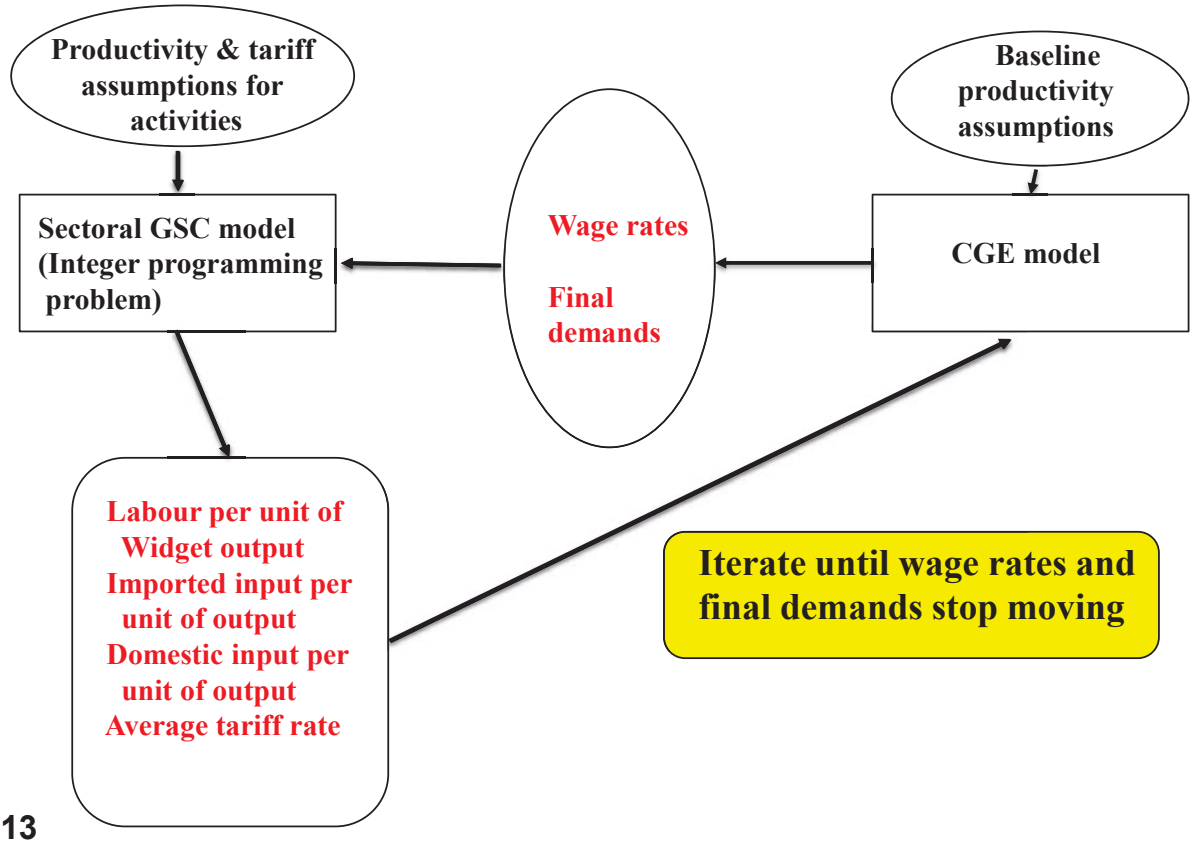
**Asian Widget employment rise from 2 to 8.851**

**U.S. supplies all of the World's Design**

**Asia supplied all of the World's Components**

**Each country does its own Assembly**

# Integrating GSC and CGE: plan A





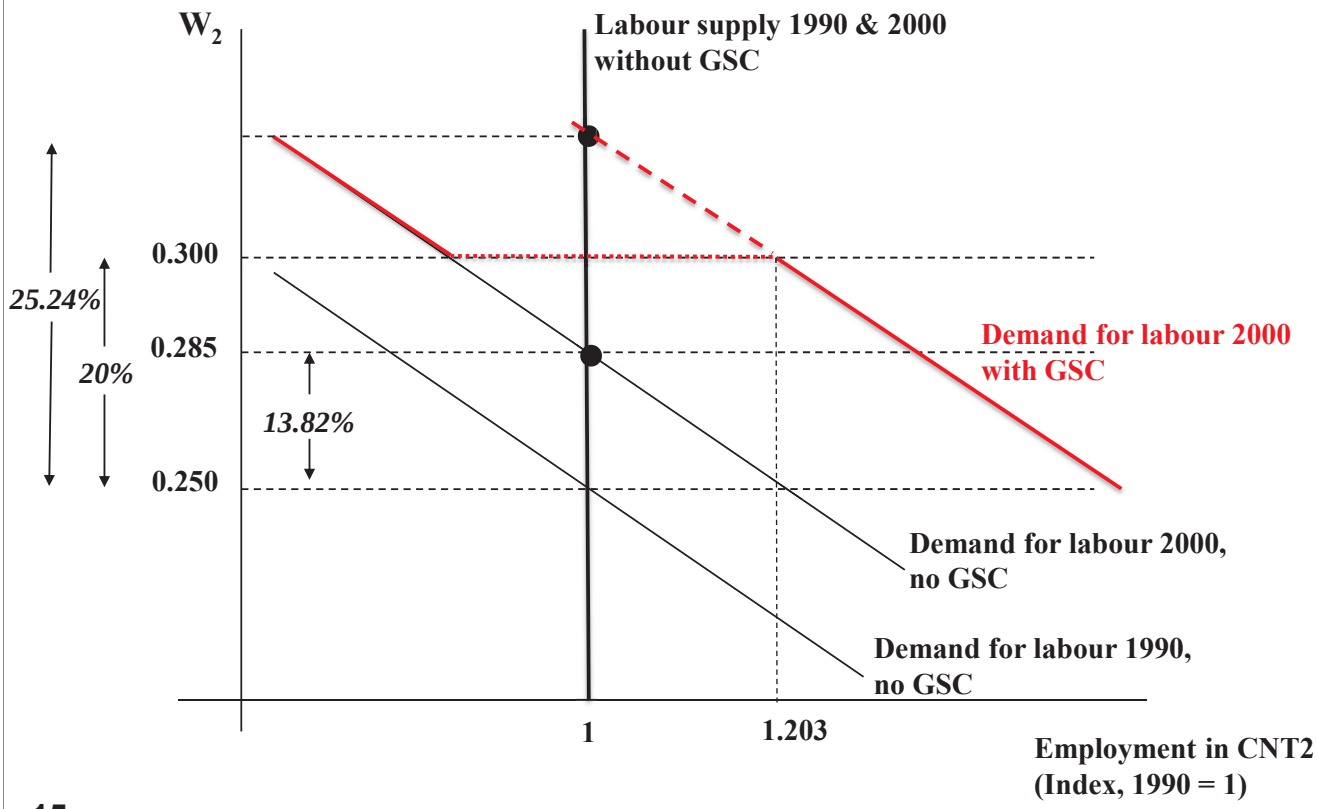

# Integrated GSC-CGE solution for 2000: Plan A, non-converging

| | Standard CGE | GSC iter1 | CGE iter2 | GSC iter2 | CGE iter3 | GSC iter3 | CGE iter4 |
|---|---|---|---|---|---|---|---|
| Baseline shocks (1) to (5) | YES | | | | | | |
| Baseline shocks (2) and (4) (excludes Widget shocks. These come from GSC) | | | YES | | YES | | YES |
| GSC productivity assumptions for Widget activities | | YES | | YES | | YES | |
| **Widget sectors shocks from GSC to CGE** | | | | | | | |
| labour per unit of output, IND1, CNT1 | | *-14.42* | | *-14.08* | | *-14.53* | |
| labour per unit of output, IND1, CNT2 | | *5.45* | | *-27.71* | | *5.55* | |
| C1 from CNT1 per unit output in IND1, CNT1 | | *-39.36* | | *-0.80* | | *-39.30* | |
| C1 from CNT1 per unit output in IND1, CNT2 | | *-70.39* | | *0.04* | | *-70.24* | |
| C1 from CNT2 per unit output in IND1, CNT1 | | *31301.7* | | *8.58* | | *31326.4* | |
| C1 from CNT2 per unit output in IND1, CNT2 | | *8950.6* | | *-10.13* | | *8917.7* | |
| **Economy-wide shocks from CGE to GSC** | | | | | | | |
| quantity of consumption of C1 in CNT1 | *9.77* | | *7.01* | | *9.76* | | *7.02* |
| quantity of consumption of C1 in CNT2 | *32.46* | | *37.83* | | *30.595* | | *37.83* |
| wage rate in CNT2 | *13.82* | | *25.24* | | *13.89* | | *25.24* |

**Increase in wage rate in country 2 oscillates between 13.8% and 25.2%**

# Non-convergence: GSC opportunity puts hole in country 2's demand curve for labour

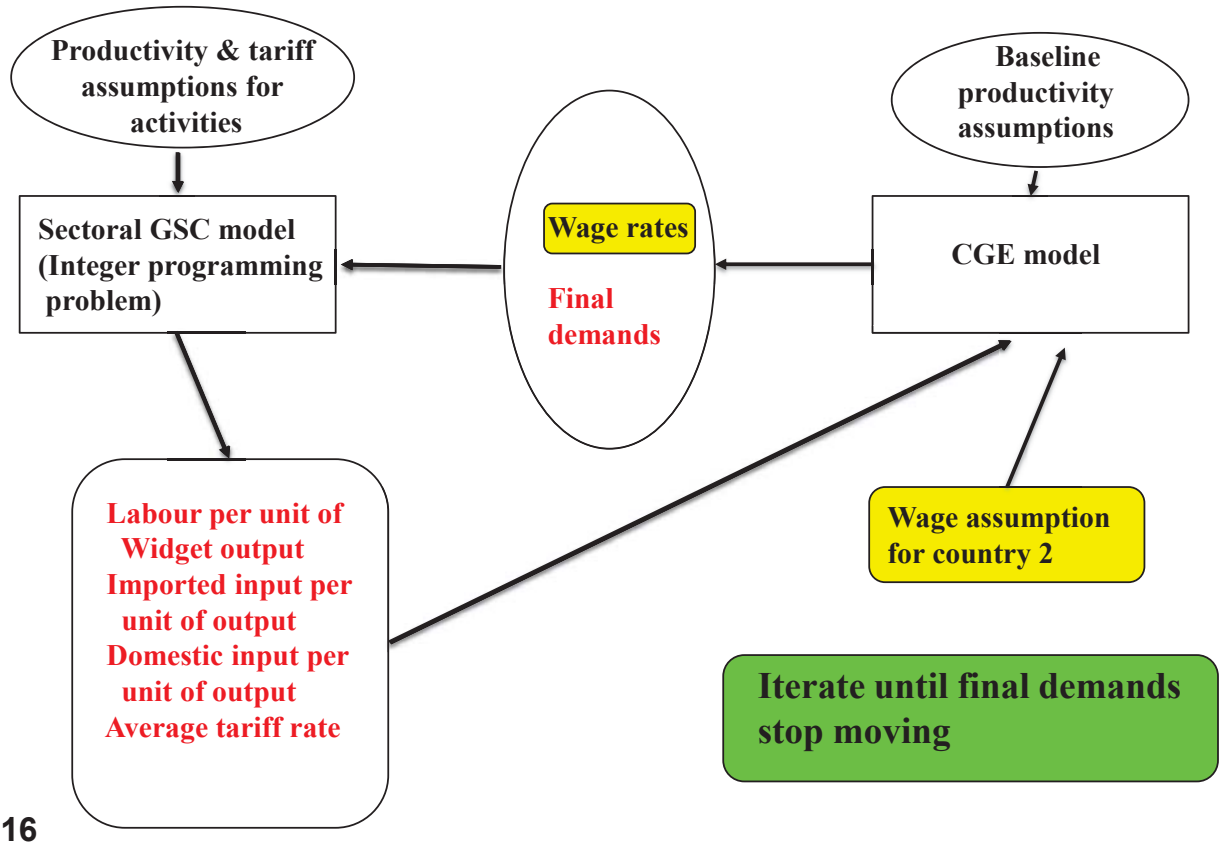
CoPS






# Integrating GSC and CGE: plan B

CoPS



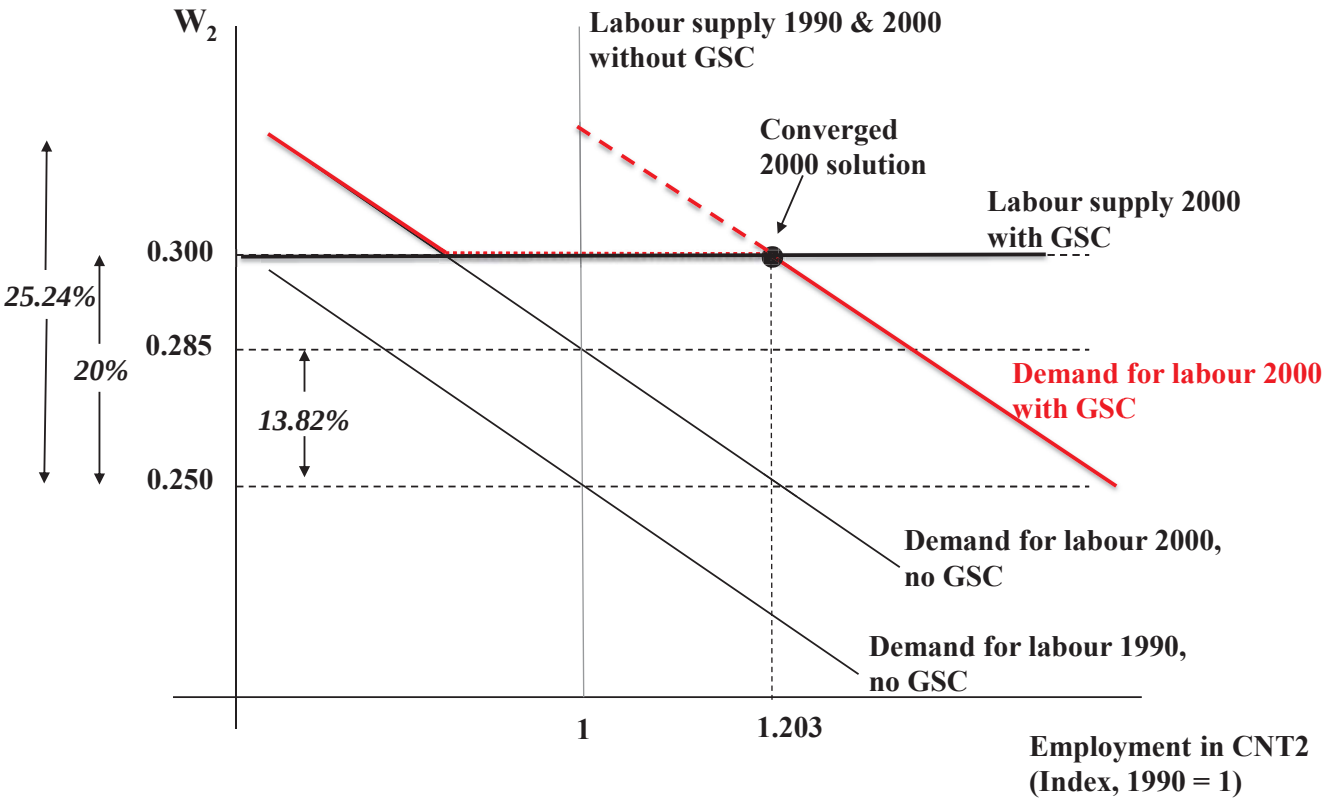
# Integrated GSC-CGE solution for 2000: converging

| | CGE iter2 | CGE Iter2b | GSC Iter2b | CGE Iter3b | GSC Iter3b | CGE Iter4b |
|---|---|---|---|---|---|---|
| Baseline shocks (2) and (4) (excludes Widget shocks. These come from GSC) | YES | YES | | YES | | YES |
| GSC productivity assumptions for Widget activities | | | YES | | YES | |
| **Widget sectors shocks from GSC to CGE** | | | | | | |
| labour per unit of output, IND1, CNT1 | -14.42 | | *-12.35* | | *-12.34* | |
| labour per unit of output, IND1, CNT2 | 5.45 | | *4.88* | | *4.88* | |
| C1 from CNT1 per unit output in IND1, CNT1 | -39.36 | | *-40.11* | | *-40.11* | |
| C1 from CNT1 per unit output in IND1, CNT2 | -70.39 | | *-72.78* | | *-72.79* | |
| C1 from CNT2 per unit output in IND1, CNT1 | 31301.7 | | *30320.10* | | *30317.30* | |
| C1 from CNT2 per unit output in IND1, CNT2 | 8950.6 | | *9427.60* | | *9429.80* | |
| **Economy-wide shocks from CGE to GSC** | | | | | | |
| quantity of consumption of C1 in CNT1 | *7.01* | *7.98* | | *8.07* | | *8.07* |
| quantity of consumption of C1 in CNT2 | *37.83* | *63.10* | | *63.41* | | *63.41* |
| wage rate in CNT2 | *25.24* | 20 | | 20 | | 20 |

**Increase in wage rate in country 2 is assumed to be 20%.**
**Convergence in final demands is rapid**



# Convergence: GSC opportunity puts hole in country 2'd demand curve for labour



# *Projection from 1990 to 2000 using integrated GSC-CGE model*

CoPS

| | U.S. | Asia |
|---|---|---|
| Real GDP (% change from 1990 to 2000) | 1.83 | 45.93 |
| Real consumption, welfare (% change) | 1.63 | 46.82 |
| Wage rate (% change) | 0.00 | 20.00 |
| Factory price of Widgets (% change) | -12.74 | -23.30 |
| Factory price of Other (% change) | 0.00 | 2.00 |
| Aggregate employment | 0.00 | 20.34 |

**U.S. Widget trade balance goes from surplus of 1.425 to deficit of 0.173**
**Share of U.S. employment in Widgets goes from 16.7% to 10.9%**
**Share of Asian employment in Widgets goes from 4.8% to 19.1%**

***GSC opportunity allows effective employment in Asia to grow strongly underpinning very rapid GDP growth in Asia relative to U.S.***

***Integrated GCS-CGE model projects profound structural change***



# Concluding remarks

CoPS

- **Integrating GSC and CGE modelling has the potential to show how open trade policies can transform the economies of developing countries that have a pool of low-productivity labour**
- **Armington and Melitz models alone can't do this. They produce conservative structural outcomes.**
- **We now need to build a small number of GSC models using real data and integrate these models with a standard CGE model such as GTAP.**

# THE IMPACT OF LNG EXPORT EXPANSION IN QUEENSLAND

## WITH SPECIAL EMPHASIS ON THE EFFECTS OF INCREASED GAS PRICES

Philip Adams
Centre of Policy Studies
19 November 2014 (Revised 8 August 2018)



# Question

What is the net impact on Australia, its industries and regions of the LNG export expansion in Queensland?

# Method

Using the Victoria University Regional Model (VURM) project a number of trajectories for the Australian economy:

(1) Base case – without the LNG expansion

(2) Full-price (Baseline) – deviates from (1) in response to the construction and production of QLD LNG at full international price parity. [Relevent, August 2018]

(3) Low-price (Baseline) – same as (2) but with less than full international price parity. [Not relevent, August 2018, and hence ignored]



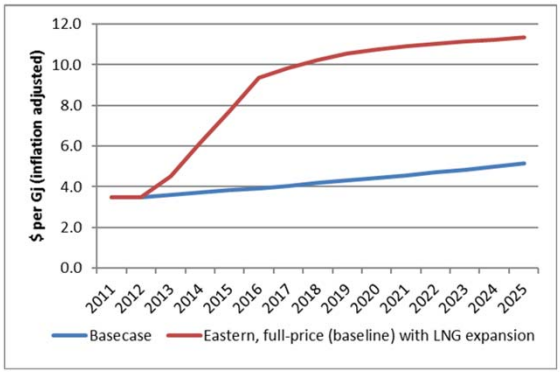
# LNG Projects

| LNG Project | Average gas consumption (Pj per annum) | Start-up-Full production | Number of LNG trains | Total construction spend ($m, 2013 prices) |
|---|---|---|---|---|
| QLD Curtis LNG | 486 | 2016 | 2 | 19,800 |
| Gladstone LNG | 446 | 2018 | 2 | 18,000 |
| Australia-Pacific LNG | 514 | 2017 | 2 | 24,700 |

# Price Assumptions

(relative to the national CPI)

*Figure 1: Wholesale price of Gas (Eastern states)*





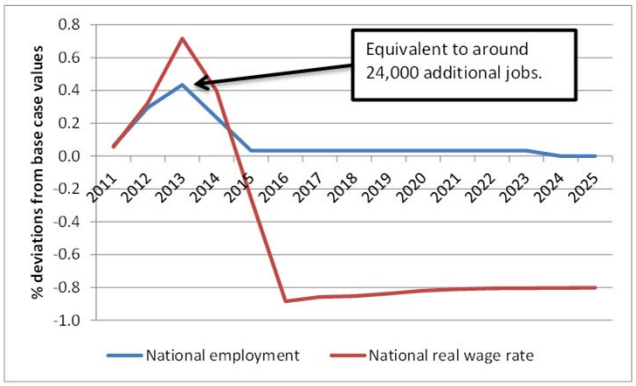

# Price Assumptions

(relative to the national CPI) (in 2025 relative to 2015)

- NSW – Industrial 32%
- NSW – Residential 26%
- VIC – Industrial 108%
- VIC – Industrial 28%
- QLD – Industrial 24%
- QLD – Industrial 8%
- TAS – Industrial 106%
- TAS – Industrial 31%

# Effects – National labour Market

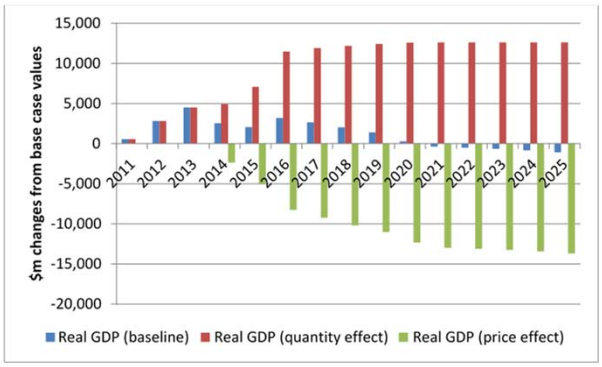
***Figure 2: Effects on the national labour market***





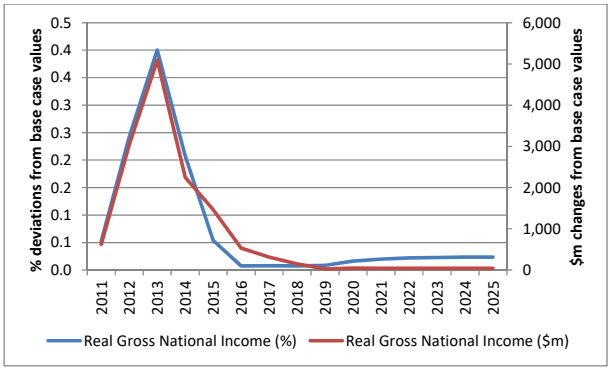

# Effects – National Real GDP

***Figure 3b: Effects on real GDP ($m changes)***



# Effects on National Real GNI

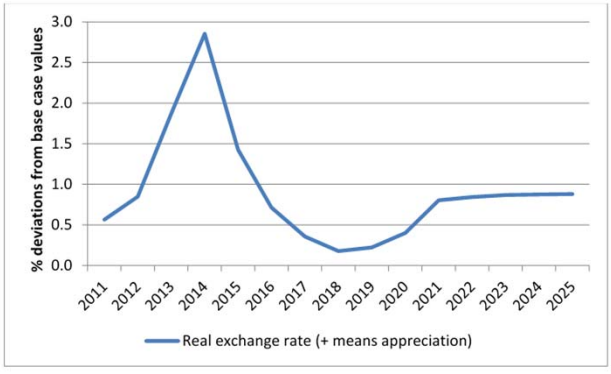
***Figure 4: Effects on real Gross National Income (% and $m changes)***





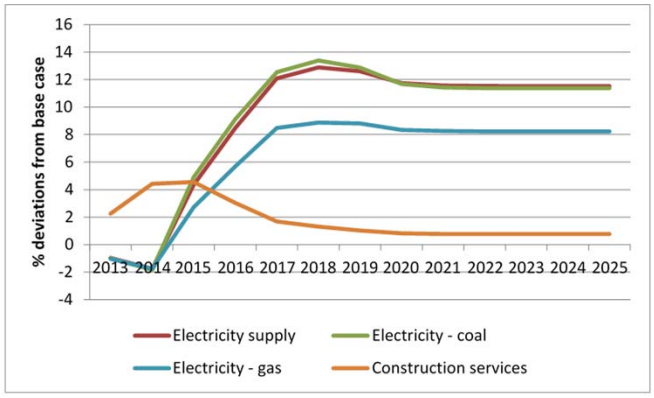

# Effects on the Real Exchange Rate

***Figure 5: Effects on the real exchange rate***



# Industry Winners

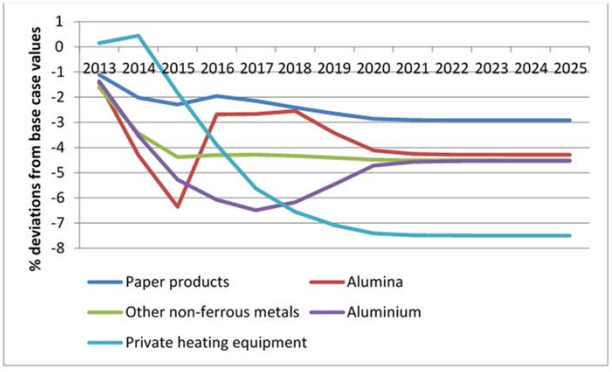
*Figure 6a: Sample of industries that gain production at the national level*





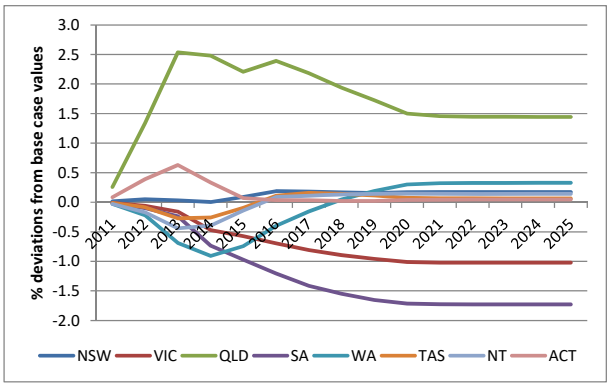

# Industry Losers

*Figure 6b: Sample of industries that lose production at the national level*



# Effects on Real GSP

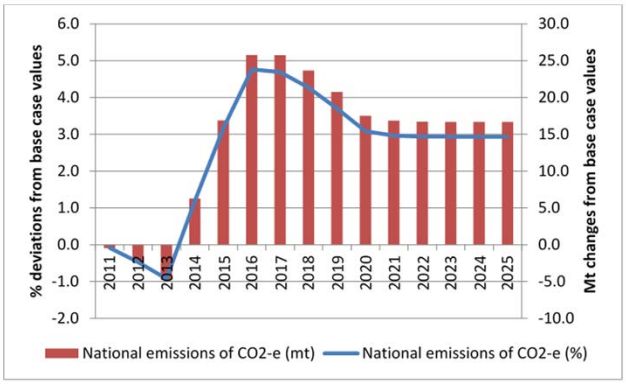
***Figure 7: Effects on real Gross State Product (GSP)***






# Greenhouse Gas Emissions (?)

***Figure 8: Effects on Australia's greenhouse gas emissions***



# Take home messages

1. During construction, the projects boost real GDP and national welfare, and have a generally positive impact.
2. During the production phase, national impacts are marginal. Real GDP and welfare increase slightly.
3. Some industries gain, particularly electricity sectors. Other industries lose due to the adverse cost impacts.
4. Because some industries gain and others lose, so some regions gain (QLD), and others lose (notably Vic and SA).
5. The projects will lead to higher CO2-e emissions, due to stimulus to coal-fired electricity generation.

# For when things pan out differently: Using economy-wide models to inform budget sensitivity

Anthony Rossiter (Department of Treasury and Finance, Victoria and Monash University)
Janine Dixon (Victoria University)
Grace Gao (Department of Treasury and Finance, Victoria)

The views expressed in this presentation reflect the views of the authors only and do not necessarily reflect those of the Victorian Government or the Department of Treasury and Finance, Victoria.

## Outline

- Why do budget sensitivity analysis?
- Three approaches to sensitivity analysis
- Illustrative scenarios for Victoria using economy-wide models
  - Higher participation rate
  - Consumption and dwelling investment negative shock
- Caveats and future work

## Why budget sensitivity analysis?

- Budget estimates predicated on assumptions of future economic, operating and financial conditions
- Sensitivity analysis enables the effect of variations in the macroeconomic/financial outlook on the budget position to be quantified
- Budget papers must include "discussion of the sensitivity of […] fiscal estimates to changes in […] economic and other assumptions" underpinning the estimates (Charter of Budget Honesty Act *(Cth)* 1998, S12(1)(c))

## 1. Static, independent variations in single indicators

- Approach adopted by all state and territory governments to varying degrees
- Quantifies the effect of a change in an indicator (or tax base) on government revenue, expenses and/or the budget, holding all else constant
- Easy to compute (especially tax-base variations)
- May be useful for understanding the effect of a forecast error in a single indicator
- … But these types of variations rarely occur in isolation

## 2. Partial equilibrium analysis

- Approach used by the Australian Government since the 2008-09 Budget
- Construct illustrative scenarios involving simultaneous variations in several economic indicators, tracing the impact through the budget
- Impacts highly stylised and may not capture all relevant economic feedback (or policy) responses to changed conditions
- May not have a consistent theoretical foundation

## 3. General equilibrium analysis

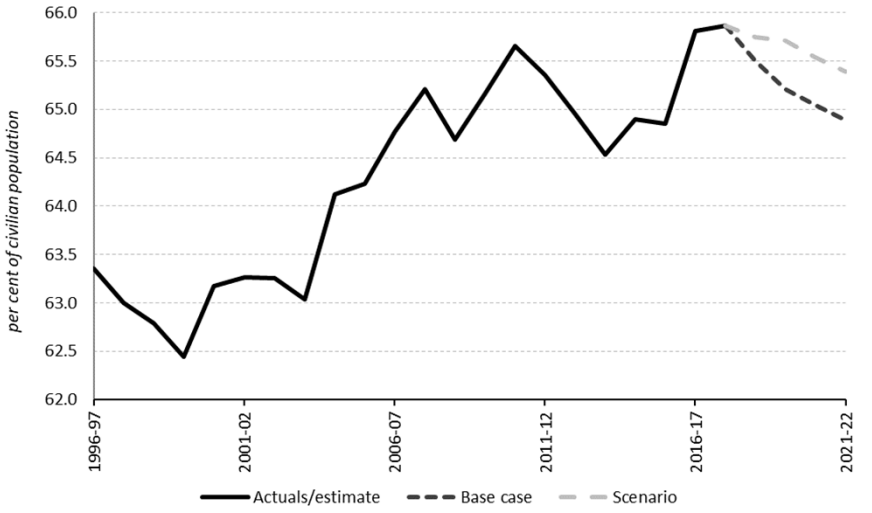
- Approach used by the Victorian Government since the 2017-18 Budget
- Similar aims to the partial analysis, but
  - Captures relevant economic feedback mechanisms
  - Adopts a consistent theoretical framework (VURM)
  - Provides richer detail, including industry-specific consequences
- Assumes no discretionary policy change
- At present, revenue and spending impacts from economic parameter changes flowed through using elasticities or other modelling frameworks

## Operationalising sensitivity analysis in VURM

- Base case adopts budget economic forecasts
  - Back out deep parameters (e.g. total factor productivity growth) within VURM that are consistent with the forecast profile
- Scenarios achieved by adjusting endogenised variables or deep parameters (e.g. household saving rate) to achieve desired impacts
- Equilibrium adjustment mechanisms then help map out the transition path back to the steady state
- Use a simplified two-region aggregation to expedite computation

## Higher participation rate scenario

Victoria's labour force participation rate under the base case and scenario




*Sources: Australian Bureau of Statistics; Department of Treasury and Finance, Victoria*

## Higher participation rate: VURM considerations

- Need to take care given the way the full-employment closure operates
  - Just boosting the employment-population ratio would depress wage rates and boost unemployment
  - Need to augment with demand (household consumption) shock to mop up extra labour supply

## Higher participation rate: Economic impact

Effect on major economic parameters
(percentage deviation from base case)

| | 2018-19 estimate | 2019-20 estimate | 2020-21 estimate | 2021-22 estimate |
|---|---|---|---|---|
| **Real GSP** | 0.16 | 0.37 | 0.47 | 0.54 |
| **Employment** | 0.22 | 0.51 | 0.63 | 0.70 |
| **Consumer price index** | 0.11 | 0.13 | (0.01) | (0.09) |
| **Wage price index** | (0.04) | (0.25) | (0.50) | (0.65) |

*Source: Centre of Policy Studies, Victoria University*

# Higher participation rate: Projected fiscal impact

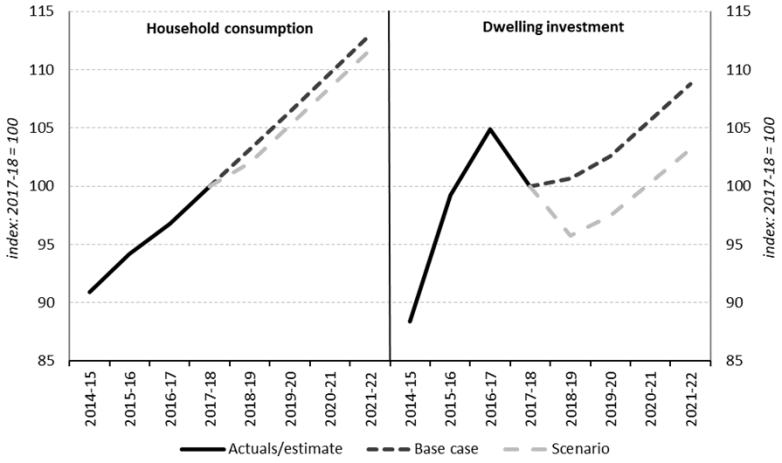
($ million)

| | 2018-19 estimate | 2019-20 estimate | 2020-21 estimate | 2021-22 estimate |
|---|---|---|---|---|
| Income from transactions | 210.1 | 338.8 | 297.1 | 286.9 |
| Expenses from transactions | 76.2 | 121.3 | 35.7 | (24.6) |
| **Net result from transactions** | **133.9** | **217.6** | **261.4** | **311.5** |
| Other economic flows | 2.2 | 5.6 | 3.7 | 3.7 |
| **Net result** | **136.1** | **223.2** | **265.1** | **315.2** |
| **Net debt (cumulative)** | **(136.1)** | **(361.6)** | **(628.9)** | **(946.4)** |
| **Net debt to GSP ratio (percentage point difference)** | **(0.04)** | **(0.10)** | **(0.15)** | **(0.21)** |

*Source: Department of Treasury and Finance, Victoria*

# Consumption and dwelling investment downturn

Household consumption and dwelling investment under the base case and scenario




*Sources: Australian Bureau of Statistics; Centre of Policy Studies, Victoria University; and Department of Treasury and Finance, Victoria*



VICTORIA State Government | Treasury and Finance

## Consumption and dwelling investment downturn: VURM considerations

- Implemented as a national shock, given impetus would reflect national drivers
  - Size (broadly) calibrated to 2008-09 magnitude
- Indirect implementation of shock
  - Household consumption – higher national household saving rate
  - Dwelling investment – threshold rate of return required to purchase newly constructed property

## Consumption and dwelling investment downturn: VURM considerations

- Specific caveats around property-market impacts
  - Real-side modelling framework does not readily capture land ownership transfer
  - No active monetary policy accommodation
- Unlike partial analysis, captures exchange rate movements $\Rightarrow$ some insulation from impacts

# Consumption and dwelling investment downturn: Economic impact

Effect on major economic parameters
(percentage deviation from base case)

| | 2018-19 estimate | 2019-20 estimate | 2020-21 estimate | 2021-22 estimate |
|---|---|---|---|---|
| **Real GSP** | (0.28) | (0.28) | (0.29) | (0.30) |
| **Employment** | (0.32) | (0.22) | (0.16) | (0.12) |
| **Consumer price index** | 0.26 | 0.11 | (0.01) | (0.12) |
| **Wage price index** | (0.02) | (0.37) | (0.64) | (0.85) |

*Source: Centre of Policy Studies, Victoria University*

# Consumption and dwelling investment downturn: Projected fiscal impact

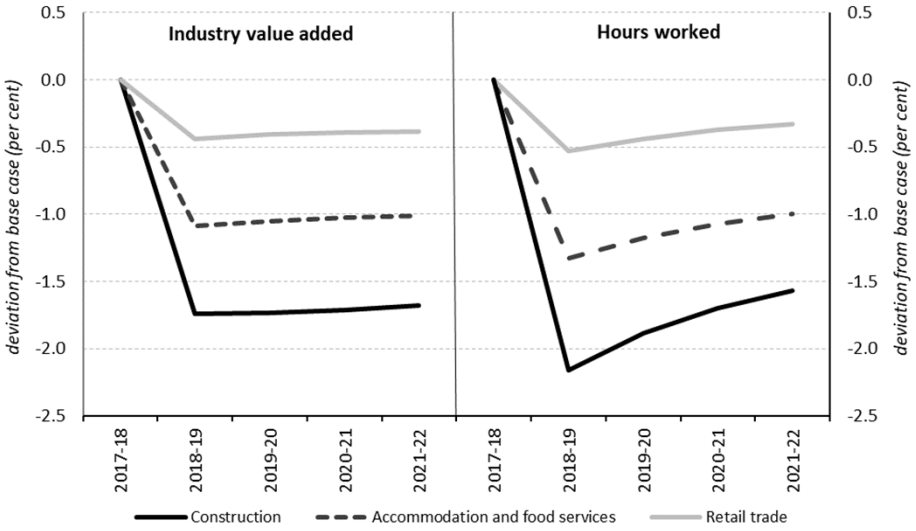
($ million)

| | 2018-19 estimate | 2019-20 estimate | 2020-21 estimate | 2021-22 estimate |
|---|---|---|---|---|
| Income from transactions | *(291.2)* | *(326.6)* | *(355.5)* | *(361.1)* |
| Expenses from transactions | (18.9) | (55.7) | (159.6) | (248.7) |
| **Net result from transactions** | **(272.3)** | **(270.8)** | **(195.9)** | **(112.5)** |
| Other economic flows | (4.4) | (5.4) | (3.8) | (3.7) |
| **Net result** | **(276.7)** | **(276.3)** | **(199.7)** | **(116.2)** |
| **Net debt (cumulative)** | **276.7** | **545.8** | **738.1** | **846.7** |
| **Net debt to GSP ratio (percentage point difference)** | **0.08** | **0.13** | **0.17** | **0.18** |

*Source: Department of Treasury and Finance, Victoria*

## GE modelling enables industry focus

Weaker conditions in the Victorian construction and discretionary spending sectors




*Source: Centre of Policy Studies, Victoria University*

## Caveats and challenges

- Economy-wide modelling offers an opportunity to relay the impact of credible alternative economic environments, but
  - Mechanics of shock implementation through "deep" parameters may not be fully intuitive
  - Model closure matters for interpretation and implementation
  - As real-side models, CGE models may have more difficulty assessing nominal shocks
  - Lack of policy accommodation ⇒ potential to significantly overstate economic and fiscal impacts

## Future work

- Extension of fiscal module (VURMTAX) within VURM to internalise more of the revenue and expenditure impacts

# Studying landowner taxation in NSW

## *Dynamic tax modelling using VURMTAX*

National CGE Workshop, Sydney, August 2018

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CoPS

## Tax policy analysis according to Harberger (2008)

*"…The alternative sensible way to go is to try to construct a computable general equilibrium model that takes into account the precise conditions, economic structure and tax laws prevailing in a particular country at a given moment in time.*

*One can then simulate the results of an increase or decrease in the corporate tax rate, given all the bells and whistles that characterize that country's tax system…*

*…To my knowledge, nobody has yet tried to do this, but it is an inviting topic for new research…"*

· Harberger, A. C. (2008) *The Incidence of Corporation Income Tax revisited*.

## Todays outline

**Multi-regional dynamic CGE modelling of Australia's tax system**.

- What taxes have we studied in VURMTAX and how have they been modelled?

**Henry Review (2009): Improve tax system resilience, efficiency via landowner taxation.**

- What levers exist to achieve this in todays tax policy arsenal?
  - **Local council rates on unimproved value (UIV):** Broad based, few exemptions;
  - **State land tax on aggregate landholdings:** Multiple exemptions.
    - How do these impact efficiency relative to council rates?
    - Is the impact large?

**OUR AIM**

**(1)** Determine the dominant source of state land tax allocative efficiency distortions.

**(2)** Quantify the degree to which it impacts relative efficiency of this policy tool.

**Our Yardstick:** The excess burden of local council rates (UIV).



## National excess burden according to Harberger (1962)

*"…The counterbalancing is not precise owing to the fact that the corporation income tax carries an "excess burden"…*

*…The result of this twofold inefficiency is that the same resources, even though fully employed, produce less* ***national income*** *in the presence of the tax than in its absence…"*

- Harberger, A. C. (1962) *The Incidence of Corporate Income Taxation*.

## VURMTAX
## Calculating National Excess Burdens

Deviation in real (domestic GNE-price deflated) **gross national income** from baseline forecast in year *t*

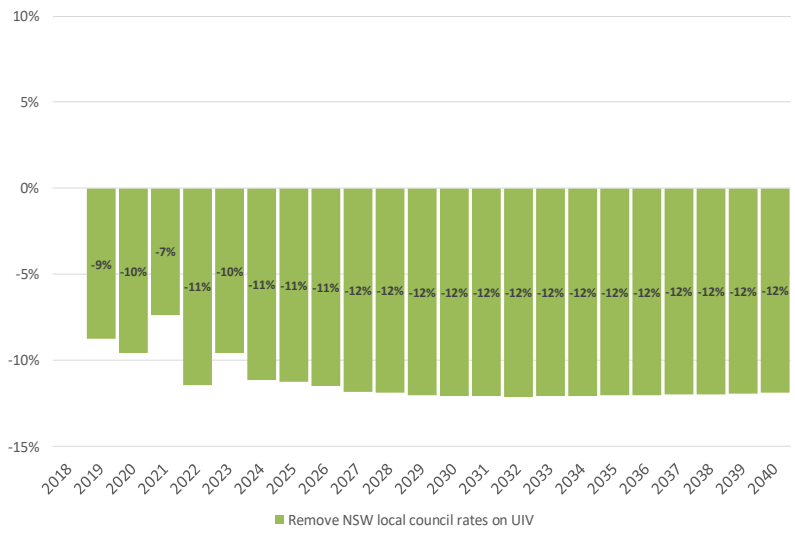
Deviation in the real **value of household leisure** in year *t*

$$EXBUR(t) = -\frac{d\_GNI(t) - d\_vleis(t)}{d\_LST(t)}$$

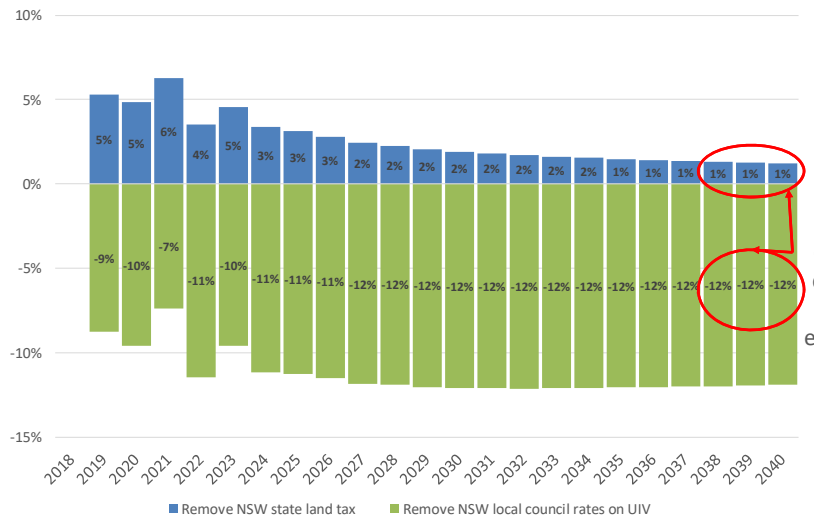
Real value of lump sum transfers to households required to balance government operating budgets at all levels of government



## Our Yardstick
## The national average excess burden for council rates (UIV) in NSW



## State land tax in NSW
## Relative efficiency falls short of local council rates




**TODAY**
Is there a dominant factor that explains this difference in average excess burden estimates?



## What is VURMTAX?

Based on the VURM (MMRF) CGE model of Australia's states and territories.

- **Recursive-dynamic:** What are the short- and long-run impacts of tax policy reform?
- **Bottom-up multi-regional:** Taxes levied by state governments impact state government bottom lines.
- **Multi-production:** 76 industries that produce 84 commodities.
- **2-region NSW / RoA aggregation today.**
  - **Why?** NSW are one of only a couple of states that levy local council rates on UIV.

# Indirect taxes in VURMTAX
# Production taxes

Absorption Matrix

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| | | PRODUCERS | INVESTORS | HOUSEHOLDS | EXPORT* | STATE/TERRITORY GOV. | FEDERAL GOV. | STOCKS | NEM |
| | | *I*-by-*R* | *I*-by-*R*-by-*F* | *H*-by-*R* | 1 | *R* | *R* | *R* | 1 |
| BASIC FLOWS | *C*-by-*S* | V1BAS | V2BAS | V3BAS | V4BAS | V5BAS | V6BAS | V7BAS | V8BAS |
| NEM | 1 | V1NEM | | | | | | | |
| MARGINS | *C*-by-*S*-by-*M* | V1MAR | V2MAR | V3MAR | V4MAR | V5MAR | V6MAR | | |
| STATE/TERRITORY SALES TAX INCOME | *C*-by-*S* | V1TAXS | V2TAXS | V3TAXS | V4TAXS | | | | |
| FEDERAL SALES TAX INCOME | *C*-by-*S* | V1TAXF | V2TAXF | V3TAXF | V4TAXF | | | | |
| GST | *C*-by-*S* | V1GST | V2GST | V3GST | V4GST | | | | |
| LABOUR | *O* | V1LAB | | | | | | | |
| CAPITAL | *F* | V1CAP | | | | | | | |
| LAND | *F* | V1LND | | | | | | | |
| OTHER COSTS | *F* | V1OCT | | | | | | | |
| PRODUCTION TAX (STATE/TERRITORY) | 1 | VPTXS | | | | | | | |

*C* = Number of commodities
*R* = Number of regions
*I* = Number of industries
*S* = *R* domestic + single imported source
*O* = Number of occupations
*M* = Number of commodities used as margins
*H* = 1: Number of households in each region
*F* = Number of investor types: Local and Foreign
** NOTE: Export column is for domestic goods only*

**Factor-income specific production taxes:** e.g., any land tax is a production tax with post-land tax land income as its tax base.

**Otherwise:** Levied against aggregate costs, e.g., registration duty on the road freight industry.

P.9

# Indirect taxes in VURMTAX
# Sales taxes

Absorption Matrix

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| | | PRODUCERS | INVESTORS | HOUSEHOLDS | EXPORT* | STATE/TERRITORY GOV. | FEDERAL GOV. | STOCKS | NEM |
| | | *I*-by-*R* | *I*-by-*R*-by-*F* | *H*-by-*R* | 1 | *R* | *R* | *R* | 1 |
| BASIC FLOWS | *C*-by-*S* | V1BAS | V2BAS | V3BAS | V4BAS | V5BAS | V6BAS | V7BAS | V8BAS |
| NEM | 1 | V1NEM | | | | | | | |
| MARGINS | *C*-by-*S*-by-*M* | V1MAR | V2MAR | V3MAR | V4MAR | V5MAR | V6MAR | | |
| STATE/TERRITORY SALES TAX INCOME | *C*-by-*S* | V1TAXS | V2TAXS | V3TAXS | V4TAXS | | | | |
| FEDERAL SALES TAX INCOME | *C*-by-*S* | V1TAXF | V2TAXF | V3TAXF | V4TAXF | | | | |
| GST | *C*-by-*S* | V1GST | V2GST | V3GST | V4GST | | | | |
| LABOUR | *O* | V1LAB | | | | | | | |
| CAPITAL | *F* | V1CAP | | | | | | | |
| LAND | *F* | V1LND | | | | | | | |
| OTHER COSTS | *F* | V1OCT | | | | | | | |
| PRODUCTION TAX (STATE/TERRITORY) | 1 | VPTXS | | | | | | | |

*C* = Number of commodities
*R* = Number of regions
*I* = Number of industries
*S* = *R* domestic + single imported source
*O* = Number of occupations
*M* = Number of commodities used as margins
*H* = 1: Number of households in each region
*F* = Number of investor types: Local and Foreign
** NOTE: Export column is for domestic goods only*

**Sales taxes:**
Revenue accrual tracked by jurisdiction [STATE: preceded by an *S;* FEDERAL: *F*], e.g., transfer duty on property/vehicles.

**GST:**
A sales tax, modelled independent of other sales taxes.

P.10

## What taxes do we model? Direct taxes

Direct taxes also studied.

4. **User-specific income taxes:**
   - Personal income tax (PIT)

$$PITTAX = 0.239 \cdot PITBASE \ - FCRED.$$

   - Corporate income tax (CIT)

$$R1CAP_{PT,LOC}(i,q) = (1 - T_{LOC}) \cdot R1CAP_{PRT}(i,q),$$

$$R1CAP_{PT,FOR}(i,q) = (1 - T_{FOR}) \cdot R1CAP_{PRT}(i,q).$$



## What taxes do we model? State land tax vs council rates on UIV

**State land tax**

An imperfect tax on land owners.

- Why? Because it carries exemptions:
  - Primary production land (PPL) is exempt;
  - Principal place of residence (PPR) is also exempt.
- In addition: levied on entity holding basis, not a property-by-property basis.

**Local council rates on UIV**

Not perfect…

- Some distinction between rate-per-dollar-value charge based on land zone type, e.g., primary production, mining, business and residential property charged different rates.

But pretty close…

- Few (mainly public entity) exemptions.

## Land tax in VURMTAX
## How do we model the exemptions?

**State land tax**

An imperfect tax on land owners.

- Why? Because it carries exemptions:
  - Primary production land (PPL) is exempt; **No tax collections**
  - Principal place of residence (PPR) is also exempt. **More challenging**
- In addition: levied on entity holding basis, not a property-by-property basis.

**Local council rates on UIV**

Not perfect…

- Some distinction between rate-per-dollar-value charge based on land zone type, e.g., primary production, mining, business and residential property charged different rates.

but pretty close…

- Few (mainly public entity) exemptions;



## Dwelling services: Supply in VURM

Dwelling service industry in VURMTAX:

- **Two dwelling industries.**
  - *DwellingLow*: Low-density dwelling services;
  - *DwellingHigh*: High-density dwelling services.

- **Two tenure choices.**
  - *DwelLowOwn*: Owner-occupied low density housing;
  - *DwelLowRent*: Low-density tenancy.

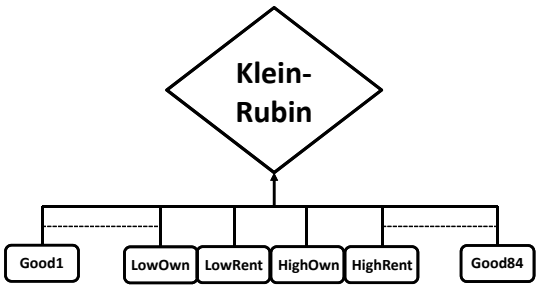
- Each industry makes two commodities.

**QUESTION**

If land tax is paid by industry, how do you ensure consumers of tenancy housing pay the land tax?

$X_1^{market} = X_1^{misallocated} + X_1^{optimal} = 0.81.$

## Dwelling services: Demand in VURM




Using a framework like this does not get you much action when it comes to removing land tax.

- No direct substitution between housing of different tenure, or low versus high density housing.



## Resource misallocation and the PPR exemption

A discrete choice model of housing tenure choice.

- A family unit *j* maximise the utility they derive from consuming:
  1. Tax-free owner occupied housing (which uses $X_1(j)$ units of state land);
  2. Taxed tenancy housing (which uses $X_2(j)$ units of state land); and,
  3. Other goods, $Z(j)$;

$$U(j) = D(j) * U\left(\frac{X_1(j)}{A_1(j)}, Z(j)\right) + (1 - D(j)) * U\left(\frac{X_2(j)}{A_2(j)}, Z(j)\right)$$

- Relative price of owner-occupied land and tenancy land is related to the relative tax rates on the two types of land use:

$$\frac{P_1}{P_2} = \frac{1 + T_1}{1 + T_2}$$

- **State land tax:** The PPR exemption means $T_1$=0, while $T_2$=0.17 (as a rate on income).

$X_1^{market} = X_1^{misallocated} + X_1^{optimal} = 0.81.$

# Land tax in VURMTAX
# Measuring the allocative efficiency distortion

How do we measure the allocative efficiency distortion of the PPR exemption?

- Measure the amount of land use under market conditions $X^{market}$, relative to land use with no PPR exemption $X^{optimal}$ (this is the resource misallocation);
- The tax collected on tenancy land;
- If we eliminate the distortion, we forego the revenue but gain from resource re-allocation. The excess burden is the negative ratio of these quantities:

$$\text{Excess burden (average)} = -\,{}^{0.0135}/_{-0.077} = 18\%.$$

P.17

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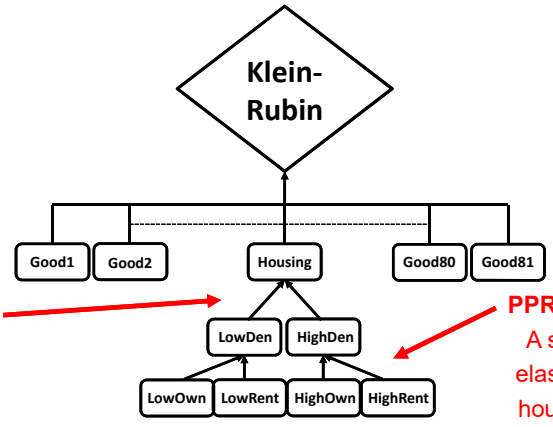
# Modelling the PPR exemption
# POINT 1: Staged decision making by demanders

We alter the usual VURMTAX household consumption theory to accommodate our findings from the discrete choice model of tenure choice.




**Density choice**
Result is not very sensitive to substitution elasticity.

**PPR Exemption**
A substitution elasticity of 4 in housing tenure choice is the key

P.18

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# Modelling the PPR exemption
# POINT 2: Allocating tax loads to tenancy

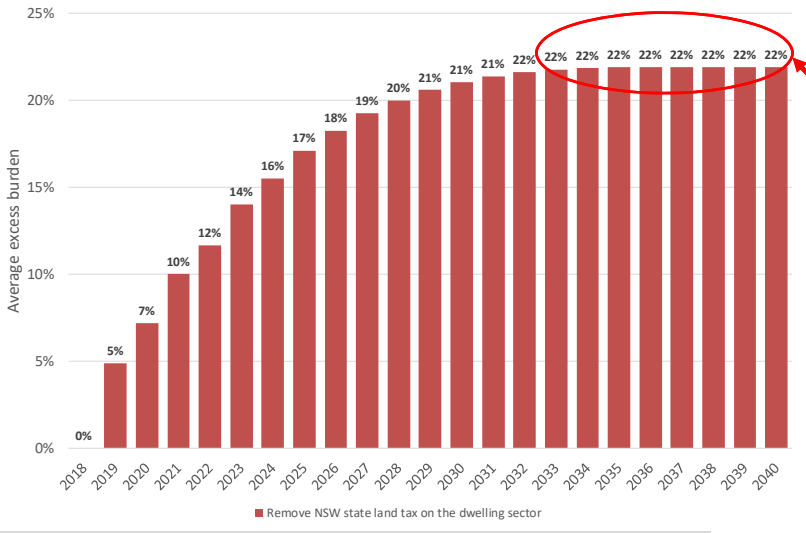
Achieved via revenue-neutral sales tax/subsidies on rental/owner-occupied dwelling services in region $\boldsymbol{q}$, consumed by households in region $\boldsymbol{q}$.

$$V3TAXS(DwellingLowOwn,q,q) = -SHROWN(DwellingLow,q) * V1LNDTXS(DwellingLow,q),$$

$$V3TAXS(DwellingLowRent,q,q) = SHROWN(DwellingLow,q) * V1LNDTXS(DwellingLow,q),$$

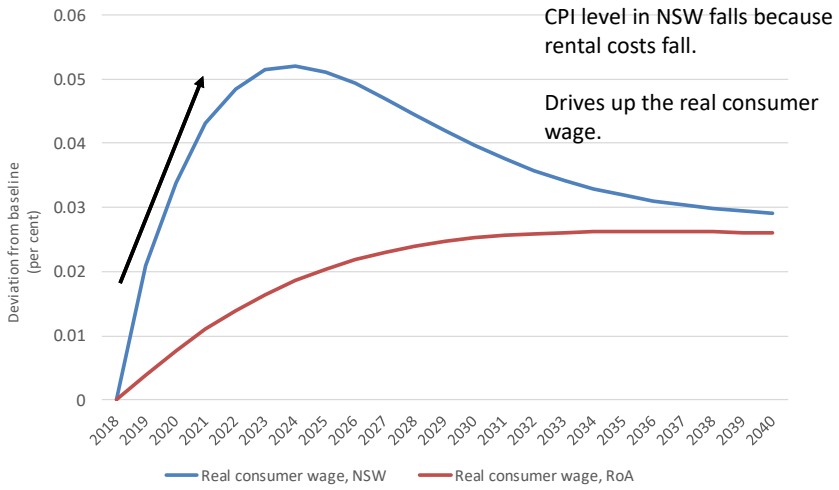


# Eliminating land tax on dwellings in NSW
# The state average excess burden




Broadly in line with our discrete choice model.

# Eliminating land tax on dwelling services
# Impact on the real consumer wage

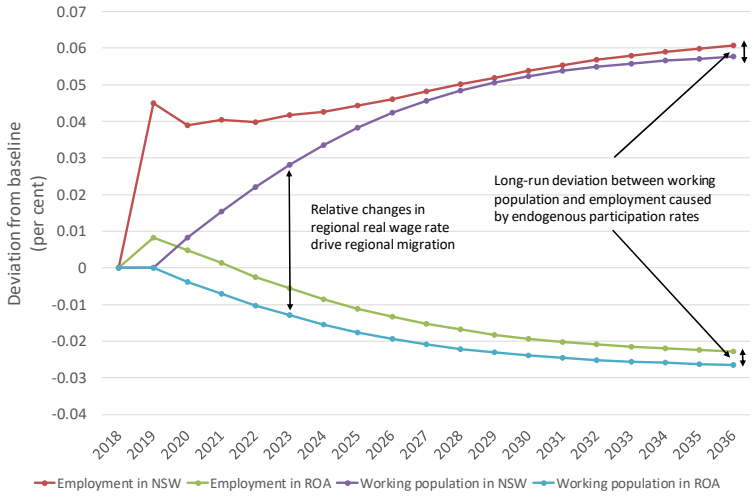



CPI level in NSW falls because rental costs fall.

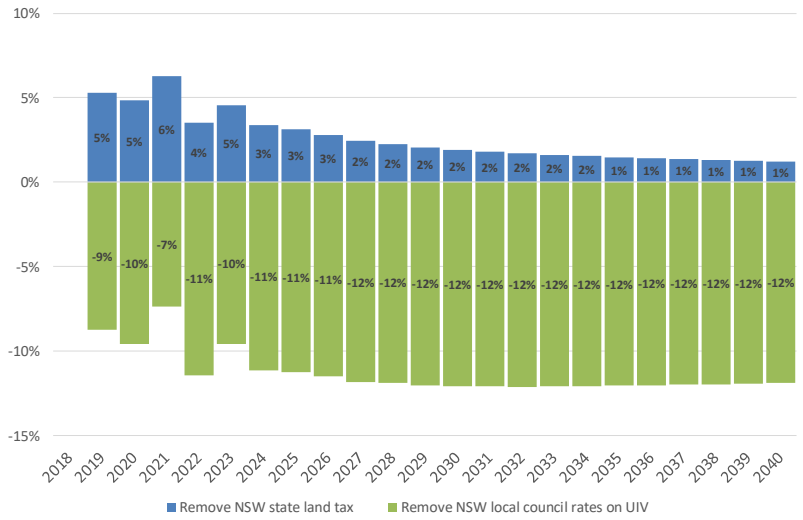
Drives up the real consumer wage.



# Eliminating land tax on dwelling services
# Impact on regional migration

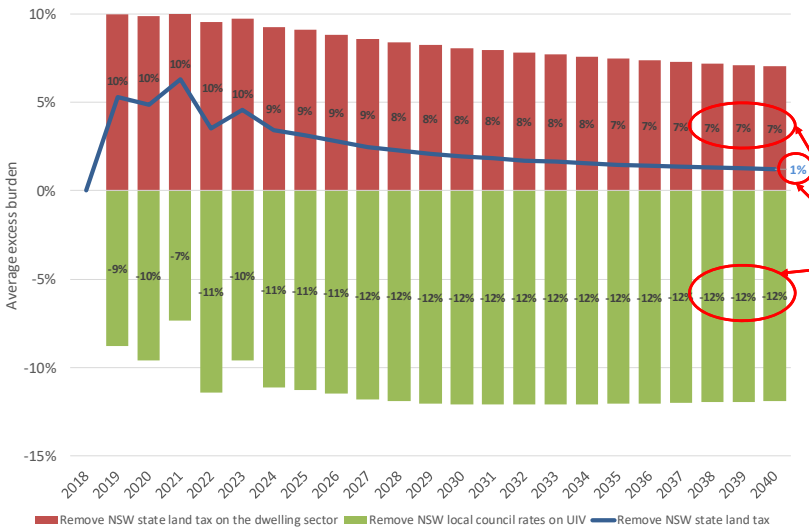


## National average excess burden
## NSW State land tax rate vs. NSW local council rate removal




P.23

## National average excess burden
## The national excess burden of state land tax in NSW with a PPR exemption




The excess burden of NSW state land tax (1%) is a weighted sum of two other excess burdens.

P.24

# Summary

**VURMTAX:** a rigorous framework for us to study the impact of:

- Tax reform:
  - What do tax rate/threshold/coverage changes mean for the real economy?
  - What about tax mix swaps?
    - We are now positioned to study stamp duty/land tax or stamp duty/council rate (UIV) policy swaps in detail.
- Economic shocks:
  - What do economic shocks imply for government budget balances?

**Example:** Landowner taxes in NSW.

- **Local council rates (UIV):**
  - Very efficient - foreign and interstate landowner taxation;
- **State land taxes:**
  - The PPR-induced tenure choice distortion disrupts allocative efficiency;
  - Our work demonstrates how learnings from non-representative agents models can inform CGE analyses.

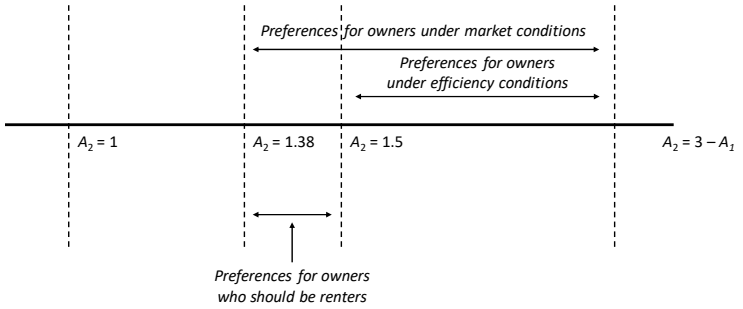


# Land tax in VURMTAX
# Picturing the impact of land tax on land use

Assumptions:

- Optimal land use allocation is a 50/50 split between owner-occupiers/tenants;
- Also:

$$A_1 + A_2 = 3,$$
$$1 \leq \{A_1, A_2\} \leq 2,$$



# Land tax in VURMTAX
# What is the tax base?

Post-land tax land income generated from industry ***i*** operating in region ***q*** ϵ {NSW, RoA}.

*V1LNDINC(i,q)*

**Pre-tax land income** **Council rates (UIV)**

$$V1LNDINC(i,q) = V1LND(i,q) - V1LNDTXL(i,q) - V1LNDTXS(i,q) - V1LNDTXF(i,q) - V1LNDTXSO(i,q)$$

**State land tax**
No collections from primary producers. Takes care of the PPL exemption



$X_i^{market} = X_i^{misallocated} + X_i^{optimal} = 0.81.$

# Land tax in VURMTAX
# Measuring the allocative efficiency distortion

How do we measure the allocative efficiency distortion of the PPR exemption?

- The amount of land use under market conditions $X^{market}$, relative to land use with no PPR exemption $X^{optimal}$ (this is the resource misallocation);

$$X^{market} - X^{optimal} = 0.0135,$$

$$X^{market} = \sum_{i=1}^{2} X_i^{market}, \qquad X^{optimal} = 2 * X_1{}^{optimal},$$

$$X_i^{market} = X_i^{misallocated} + X_i^{optimal}.$$

- The tax collected on tenancy land:

$$\text{Tax collections} = 0.17 * X_2^{market} = 0.077.$$

- If we eliminate the distortion, we forego the revenue but gain from resource re-allocation. The excess burden is the negative ratio of these quantities:

$$\text{Excess burden (average)} = -\,{}^{0.0135}/_{-0.077} = 18\%.$$

# Achieving a stable long-term baseline for the global economy in the dynamic GTAP model

2018 CGE Workshop, Sydney
13 August 2018

Paul Gretton
East Asia Bureau of Economic Research, Crawford School and
Centre of European Studies
The Australian National University
(Draft: Not for quotation or circulation; Comments welcome)

## Abstract

A dynamic version of the GTAP model of the global economy became available in 2012. The dynamic version known as GDyn, introduced partial adjustment mechanisms for capital accumulation and a dynamic accounting of capital-finance and related income flows between regional households and firms, and a global trust. In long-run equilibrium, the model rates of return are to be equal and constant over time. In practice, illustrative results presented with the release of GDyn show the equilibrium conditions are not satisfied. Model stability has been achieved through further development within the GDyn framework to satisfy the stated longer-run neoclassical equilibrium conditions. This development involved setting as exogenous a target national rate of return determined by factors exogenous to the model and a theoretic treatment of the borrowing and lending in global financial markets. The revised model - GDyn-F – is used to project an illustrative baseline of the global economy for six regions comprised of five individual country economies and one multi-country region. Some key issues for further baseline development in GDyn-F are identified together with some matters for further research.

# Some background

- Presentation draws on results presented to 2018 Conference on Global Economic Analysis
- Started with GDyn model – Public domain, general purpose technology
  - Built on the GTAP model – with long tradition of applications and well documented
  - Documented – Ianchovichina and Walmsley (2012); Gdyn tablo file
- Conference paper introduced two innovations to the Gdyn model
  - Exogenous target rate of return on capital to reflect regional differences in institutions and risk
  - CET/CES theory for modelling mobility of saving between regions – replace atheoretic treatment
- Extended capabilities achieved model stability not in original model, more suited to:
  - Trace out the time scale of effects of a policy change, particularly over the long-run
  - Examine the impact of long-run growth assumptions and convergence of economies
- Paper available at: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5484

# Dynamics introduced in Gdyn architecture

- Partial adjustment rules for capital accumulation & rates of return
- Full accounting of capital-finance through Regional household wealth, Firm capital accumulation and Global trust
- Neo-classical stability conditions for longer-run equilibrium (I&W, pp 68,9)

$$RORGEXP(r) = RORGTARG(r) = RORGROSS)(r), \forall r \quad (2.104)$$

$$\dot{RORGEXP}(r) = \dot{RORGTARG}(r) = \dot{RORGROSS}(r) = 0, \forall r \quad (2.105)$$

$$KHAT(r) = 0, DKHAT(r) = 0, \forall r \quad (2.106)$$

- Presentation focuses on baseline in model version that meets these stability conditions - labelled GDyn-F

# Use an aggregated database for test scenario

Database (2011 reference year)

| **6 regions** | **13 industry sectors** | **5 primary factor inputs** |
|---|---|---|
| Australia (AUS) | Grains, Crops, Forestry | Land |
| China (CHN) | Livestock, fishing | Natural resources |
| Japan (JPN) | Mining | Skilled labour |
| United States (USA) | Processed food | Unskilled labour |
| European Union (EU28) | Textiles and clothing | Capital |
| Rest of the World (ROW) | Light manufacturing | |
| | Heavy manufacturing | |
| | Utilities | |
| | Construction | |
| | Transport and communication | |
| | Financial services | |
| | Other services | |
| | Ownership of dwellings | |

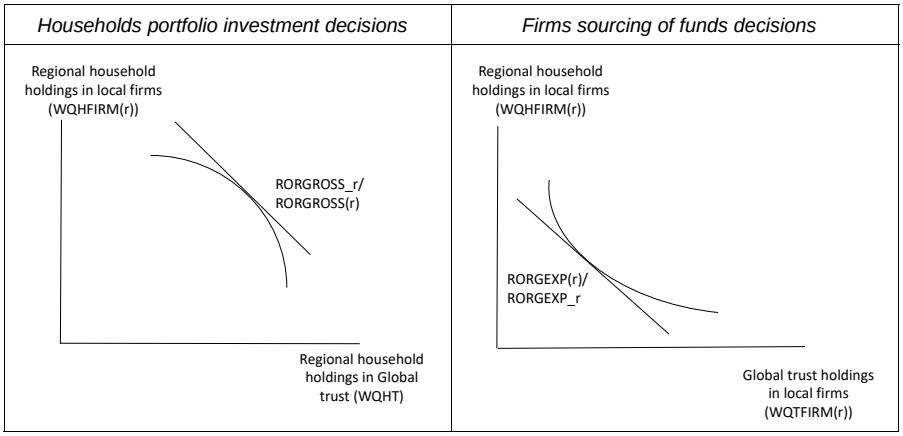
Test scenario: TIME shocked; Std parameters; Simulation period 100 years

- Later extended to a dynamic base line & policy simulation

# An overview of GDyn partial adjustment rules for capital accumulation, rates of return

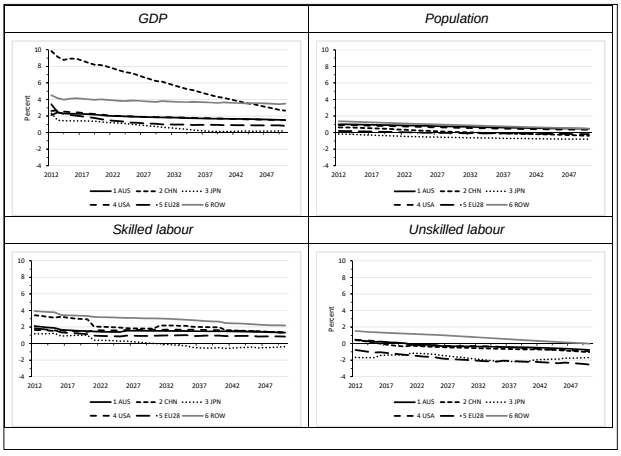
- Financial capital mobile between regions
- Capital adjusts via an investment rule to eliminate difference between expected (RORGEXP) and target (RORGTARG) rates of return
  - Changes to capital simultaneously influence actual returns (RORGROSS)
  - Theory simultaneously coordinates changes in expected and actual returns
- Regional expected rates of return (RORGEXP) gradually adjust towards actual rates (RORGROSS) to eliminate errors in expectations
- The target rate (RORGTARG) exogenous and may be:
  - common – to eliminate all differences in regional institutions and risk
  - region-specific – to allow for differences in regional institutions and risk

# Household and firm optimizing behaviour with a CET|CES approach to modelling capital-finance




Model stable with the CET|CES alternative

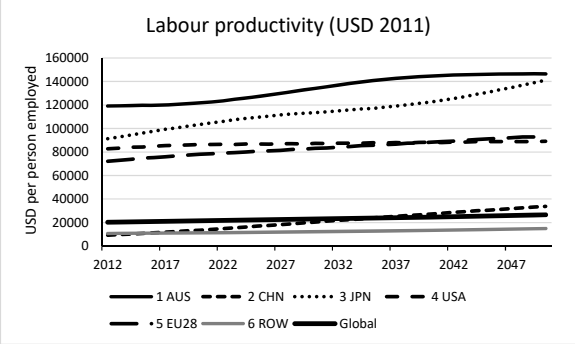
# Baseline projections of GDP, population and labour input growth by region, CEPII, 2012 to 2050




- Key points
  - GDP growth for China high but declining; ROW above average over period
  - Population growth low and declining across regions
  - Skilled-biased labour input growth projected across regions

*Source*: CEPII estimates provided with GDyn_V36, file: Projectionsforthe112_v3.zip downloaded from GTAP webpage 26 June 2016.

# Projected output growth higher than labour input growth implies labour productivity growth




- Key points
  - Substantial variation at commencement of projection period
  - Some convergence evident for CHN, but large gap remains
  - Evidence that implicit LP growth lower than historical averages (see table)

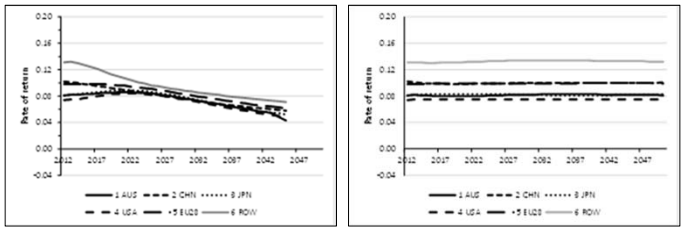
| Average annual growth | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Years | 1 AUS | 2 CHN | 3 JPN | 4 USA | 5 EU28 | 6 ROW | Global |
| CEPII-based projections (USD 2011) | 2012 to 2050 | 0.60 | 6.97 | 1.44 | 0.20 | 0.77 | 1.04 | 0.84 |
| Conference Board Projection (2011 PPP) | 2000 to 2018 | 1.01 | 19.48 | 0.70 | 1.29 | | | |

Sources: Conference Board accessed 31/7/2018; Author estimates based on CEPII projections.

# Baseline projections of gross rate of return stable in GDyn-F as expected

***GDyn-2012*** ***GDyn-F***

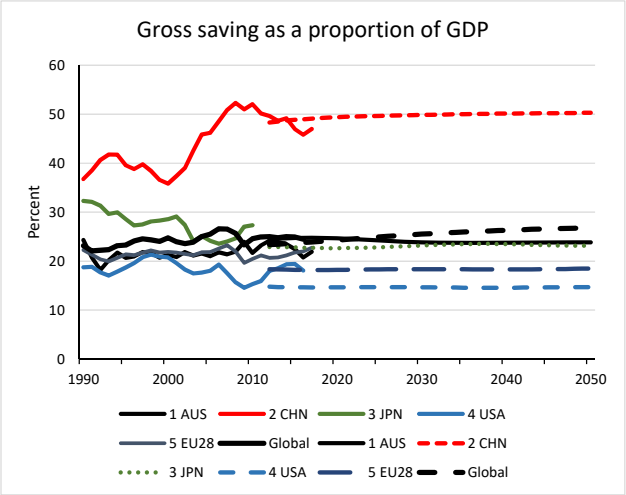
*Gross rate of return*



- Key points
  - Regional differences maintained by assumption
  - Gross rates of return stable in GDYN-F
  - Declining trend projected in GDyn-2012 (to recap: source of eventual model failure)

Source: Author estimates based on GDyn-2012 and GDyn-F.

# Domestic gross saving important - determines funds available for domestic capital accumulation or lending



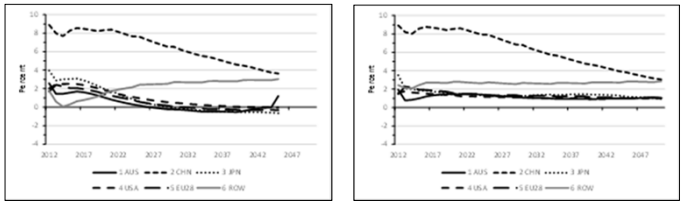

- Key points
  - Closure rule: Saving rate Exog.; BoT End.
  - Stable over projection period, maintaining initial relation
  - CHN high on scale; USA low – historically and in the projection period
  - Contrast: in 1990's early 2000s, saving rate in CHN increased, JPN rate declined

Sources: World Development Indicators accessed 30/7/2018; Author estimates based on GDyn-F.

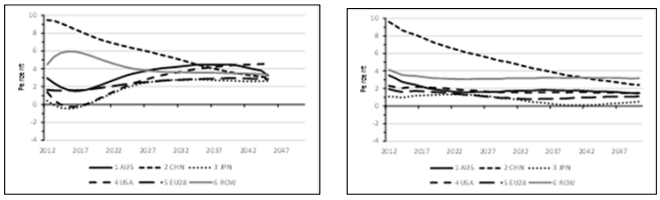
# Model baseline projections of primary factor technical change & fixed capital

***GDyn-2012*** ***GDyn-F***

*Primary factor technical change in non-accumulable endowments (% change)*



*Growth in fixed capital (% change)*



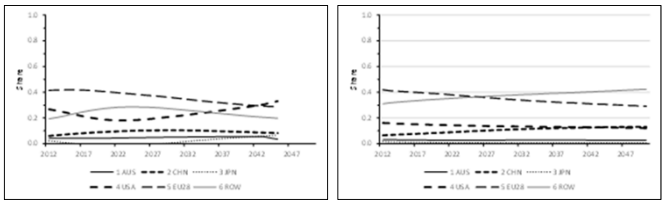
- Key points GDyn-F
  - Tech. change and K growth trace GDP growth across regions
  - Effects complementary to skill-biased labour input growth
  - Jointly satisfy assumed growth in labour productivity

Source: Author estimates based on GDyn-2012 and GDyn-F.

# Base-line projections of share of global trust in regional firms react to growth assumptions

***GDyn-2012*** ***GDyn-F***

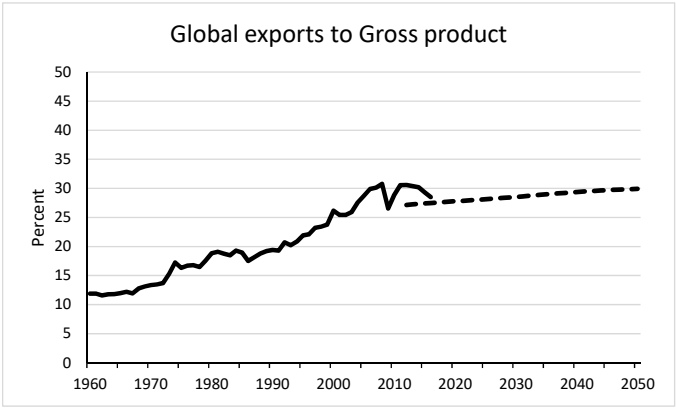
Share of the global trust in regional firms (Regional shares add to 1)



Source: Author estimates based on GDyn-2012 and GDyn-F.

- Key points
  - Share of Global trust in regional firms influenced by matching of investment funding requirements to domestic & foreign saving
  - Shares projected to: increase China & ROW; decrease in EU & USA; stable/low for AUS, JPN
  - Greater variability projected in GDyn-2012

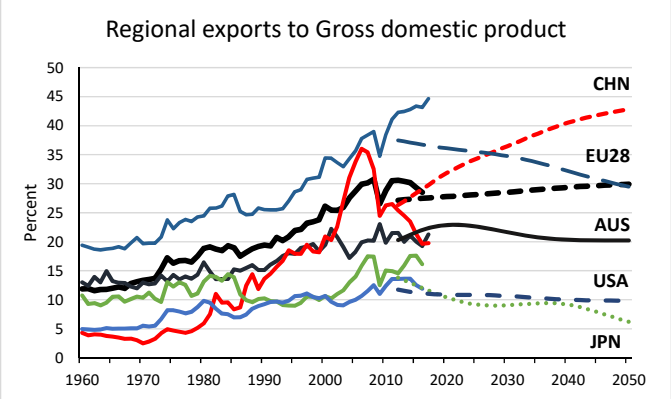
# Global export trade as a share of Gross Global Product projected to rise, but more gradually




Sources: WB Development Indicators accessed 30/7/2018; Author projections.

- Key point GDyn-F
  - Increase reflects high weight in global economies of regions with high trade shares
  - Some reshuffling of regional contributions (see next slide)

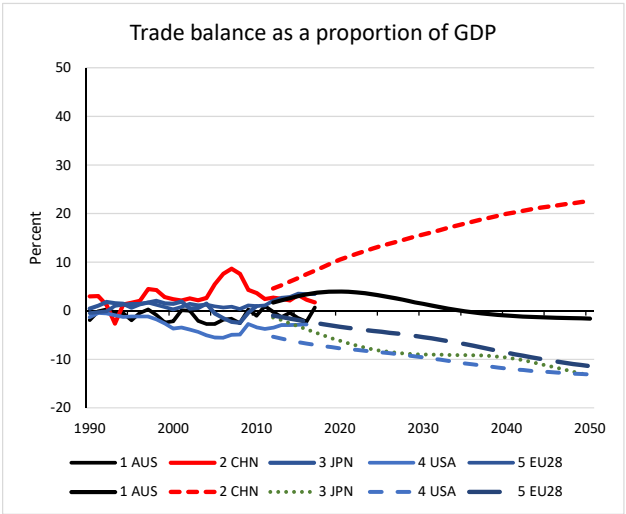
# Past changes and projected trends though differ between regions (with saving rate exogenous)




Sources: WB Development Indicators accessed 30/7/2018; Author projections.

- Key points GDyn-F
  - Outward focus of CHN projected to continue to increase, given domestic saving and propensity to Net Lending
  - EU & JPN projected to become more inward focused
  - Focus of AUS & US similar over projection period

# Trends in net trade positions projected to vary between regions – an alert

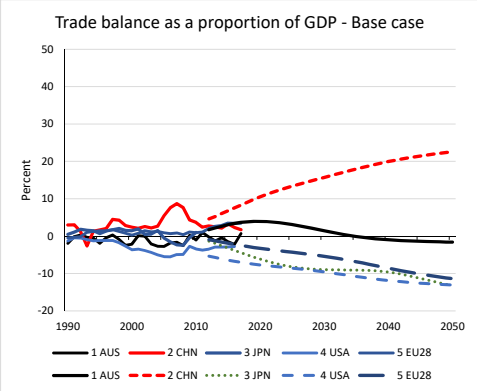


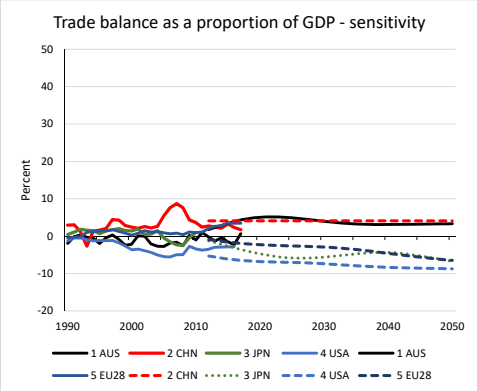

- Key points
  - Model projections commence in region of historical data; stable
  - CHN's output growth absorbed by increase in Net trade relative to GDP, given assumptions about saving & propensity to invest & consume locally
  - **Consider alternative closure (see next slide)**

# An alternative closure: the case of balance of trade exogenous & saving rate endogenous for CHN

Base closure
dpsave("*CHN*") Exog.
DTBALR("*CHN*") Endog.

Alternative closure
**Swap** dpsave("*CHN*") = DTBALR("*CHN*"); En = Ex



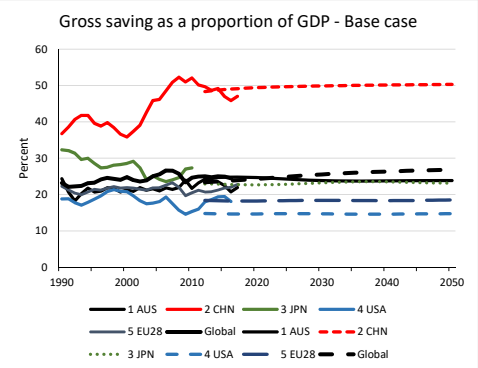



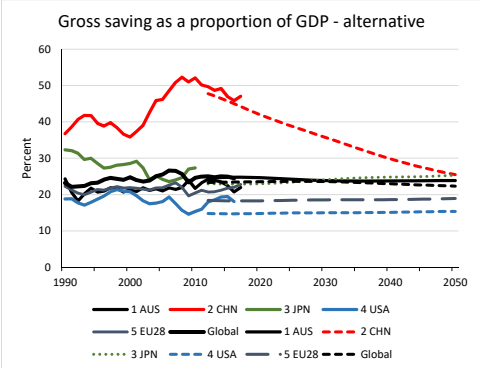

Source: Author estimates based on GDyn-F.

# Sensitivity test: implications of alternative closure change for gross saving share of GDP

Base run:
dpsave("*CHN*") Exog.
DTBALR("*CHN*") Endog.

Alternative closure:
**Swap** dpsave("*CHN*") = DTBALR("*CHN*"); En = Ex




Source: Author estimates based on GDyn-F.

## What achieved and possible base-line developments

- Demonstrated that can deploy published information to project a baseline with GDyn-F, that is stable over
  - Full time horizon of published benchmark data, ie to 2050
  - Over much longer periods, eg out 200 years, as indicated by comparative dynamic testing - see paper
- Suggests framework is suitable platform for further baseline development & policy analysis
- Scope for analysis/improvement of base-line by varying assumptions
  - Labour productivity and modelling of productivity growth
  - Trade balance & national saving behaviour
  - Country risk and long-run required returns to capital
  - Adjustment costs

WARNING: GTAP models do not handle negative saving

## With model that satisfies equilibrium conditions and stable, some other possibilities

- Model theory
  - Handling of negative savings
  - Endogenising regional household saving behaviour
  - Modelling of adjustment costs
  - Modelling of labour supply and demand by occupation
- Appropriateness of parameter values
- An **historical validation** with GDyn would be valuable:
  - Would help inform productivity/trade scenarios, key macro and adjustment assumptions

# GEMPACK 12
# latest developments

Mark Horridge, Michael Jerie, Dean Mustakinov and Florian Schiffmann
13 August 2018

Mark Horridge
Michael Jerie
Dean Mustakinov
Florian Schiffmann

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Level 14, 300 Flinders St
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VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

CoPS

## History of GEMPACK

- The Impact Project started in 1975 as part of the Industries Assistance Commission (now Productivity Commission).
- The aim of the Impact Project was to produce general tools of use to all economists. These include the ORANI model and GEMPACK software.
- In 1982 Ken Pearson got interested in solving the ORANI model using sparse methods
- First GEMPACK training course given in 1984
- In the early 90's the GEMPACK team moved to CoPS at Monash University with many from the Impact Project
- Since 2014 GEMPACK is developed within CoPS at Victoria University

## GEMPACK is now a suite of programs

- GEMPACK (General Equilibrium Modelling PACKage)
  - solves large systems of non-linear equations
  - equations are expressed in algebra-like notation
  - viewer programs help view code and data and analyse results
  - recursive dynamic and intertemporal models can be solved
  - extensive documentation
  - GP is used around the world for CGE modelling

Countries with GEMPACK licences (dark colour)



## The GEMPACK Team

… 35 years later

Michael Jerie

Dean Mustakinov

Florian Schiffmann

Mark Horridge

Louise Pinchen
(GP business manager)

## Set mappings on the LHS of formulas

From GEMPACK 12 set mappings are allowed on the LHS of formulas

```
! map data row to industry !
Mapping ROW2IND from ROW to IND;
! map data row to occupation !
Mapping ROW2OCC from ROW to OCC;

! Define employment by industry and occupation, mapping on LHS !
Formula (all,r,DATAROW)
    EMPLOY(ROW2IND(r),ROW2OCC(r)) = RAWDATA(r,"employment");
```

Restriction: GEMPACK checks the resulting formula is unambiguous. Must not have multiple rows which map to the same thing, say (Education, Cleaner).

```
EMPLOY("Education", "Cleaner") = RAWDATA("r293","employment");
EMPLOY("Education", "Cleaner") = RAWDATA("r547","employment");
```

Ambiguous value for EMPLOY("Education", "Cleaner")! Not allowed.

LHS mapping can be useful inside loops where ambiguity can be avoided.



## Loops in TAB files

From GEMPACK Release 12, loops in TAB files are allowed.

***Syntax:***

```
LOOP (BEGIN [,name=loop_name]) (All,<index_name>,<set_name>);
...
LOOP (END [,name=loop_name]);
```

***Example:***

```
Formula INDSIZE=0;
LOOP (BEGIN) (ALL,i,IND);
  FORMULA INDSIZE=INDSIZE+1;
LOOP (END);
! same as !
Formula INDSIZE=SUM(i,IND, 1);
```

***Example:***

```
LOOP (BEGIN) (ALL,y,YEARS);
  FORMULA YEARCOUNT(y)=$Pos(y,YEARS);
LOOP (END);
! same as !
Formula (all,y,YEARS)
          YEARCOUNT(y)=$Pos(y);
```

# Loops: BREAK

Loop control statements BREAK and CYCLE are allowed within a loop.

***Syntax:***

```
BREAK ([EVERY], [name=loop_name]) [(all, index_name, set_name)...]
                                                        <condition>;
BREAK (ANY, [name=loop_name]) [(all, index_name, set_name)...]
                                                        <condition>;
```

Example

```
Loop (begin) (all,I,IND);
  ...
  BREAK (ANY) (all,c,COM) V2BAS(c,"dom",i) < 0.0; ! break if ith column<0 anywhere !
Loop (end);
```

- terminates the current loop immediately when the given condition is true
- execution continues with the statement immediately following loop(end)
- if loop_name is not given the BREAK applies to the innermost loop
- if loop_name is given the terminated loop may be an outer loop (nested loops)
- if EVERY is given the BREAK is executed if condition is true for **all** values of the given indices (EVERY is default)
- if the qualifier ANY is given the BREAK is executed if condition is true **at least once**



# Loops: CYCLE

Loop control statements BREAK and CYCLE are allowed within a loop.

***Syntax:***

```
CYCLE ([EVERY], [name=loop_name]) [(all, index_name, set_name)...] <condition>;

CYCLE (ANY, [name=loop_name]) [(all, index_name, set_name)...] <condition>;
```

- terminates the **current iteration** of the loop when the given *condition* is true
- execution continues with the next iteration of the loop
- if loop_name, EVERY or ANY qualifiers are used the same rules apply as for the BREAK statement

# Loops: RAS example using BREAK

```
45
46  Loop (BEGIN) (all,k,ITER);
47  Formula
48  ! scale A to add to Control total 1 !
49  (all,c,COM)(all,i,IND)    TmpTot1(c,i) = sum{r,REG, A(c,i,r)};
50  (all,c,COM)(all,i,IND:TmpTot1(c,i)>0)(all,r,REG)
51     A(c,i,r) = A(c,i,r)*Control1(c,i)/TmpTot1(c,i);
52  ! scale A to add to Control total 2 !
53  (all,i,IND)(all,r,REG)    TmpTot2(i,r) = sum{c,COM, A(c,i,r)};
54  (all,c,COM)(all,i,IND)(all,r,REG:TmpTot2(i,r)>0)
55     A(c,i,r) = A(c,i,r)*Control2(i,r)/TmpTot2(i,r);
56  ! scale A to add to Control total 3 !
57  (all,c,COM)(all,r,REG)    TmpTot3(c,r) = sum{i,IND, A(c,i,r)};
58  (all,c,COM)(all,i,IND)(all,r,REG:TmpTot3(c,r)>0)
59     A(c,i,r) = A(c,i,r)*Control3(c,r)/TmpTot3(c,r);
60
61  ! Calculate errors !
62  (all,c,COM)(all,i,IND)    TmpTot1(c,i) = Control1(c,i) - sum{r,REG, A(c,i,r)};
63  (all,i,IND)(all,r,REG)    TmpTot2(i,r) = Control2(i,r) - sum{c,COM, A(c,i,r)};
64  (all,c,COM)(all,r,REG)    TmpTot3(c,r) = Control3(c,r) - sum{i,IND, A(c,i,r)};
65  SumAbsErr(k) = sum{c,COM,sum{i,IND,ABS[TmpTot1(c,i)]}}
66               + sum{i,IND,sum{r,REG,ABS[TmpTot2(i,r)]}}
67               + sum{c,COM,sum{r,REG,ABS[TmpTot3(c,r)]}};
68  BREAK SumAbsErr(k)< 2.42;
69  Loop (END);
```



# Loops: RAS example using BREAK

Can save time on unnecessary iterations (only 24 required!)
Log file tells you when break was triggered

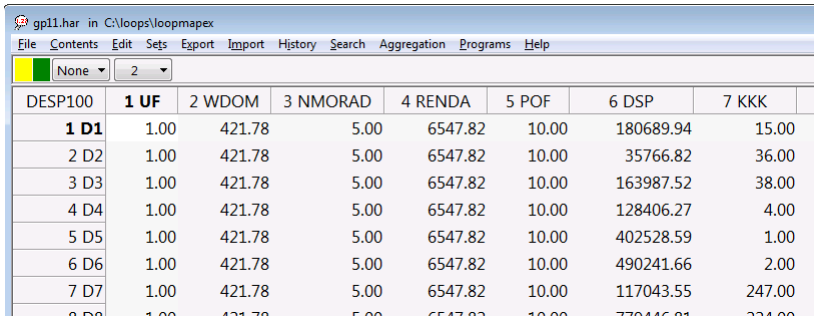
```
201  Starting Loop:"LOOP32"
202   Formula for 'TmpTot1'
203   Formula for 'A'
204   Formula for 'TmpTot2'
205   Formula for 'A'
206   Formula for 'TmpTot3'
207   Formula for 'A'
208   Formula for 'TmpTot1'
209   Formula for 'TmpTot2'
210   Formula for 'TmpTot3'
211   Formula for 'SumAbsErr'
212   Break at line number 68
213  BREAK triggered for Loop "LOOP32" at index "K24"
214
215  [CPU for reads, formulas etc is 2.04 seconds.]
```

# Loops & formula with LHS mapping

Tiago's problem: aggregate 2.8 million rows of "database" data.
The data:

```
Set DSP # Expenses# !(D1-D2875730)! size 2875731;
    VAR # Variables# (UF,WDOM,NMORAD,RENDA,POF,DSP,KKK);

!Database like storage format!
Coefficient (all,d,DSP)(all,v,VAR) DESP(d,v) # Expense Characteristics #;
Read DESP from file INFILE header "POFD";
```


gp11.har in C:\loops\loopmapex

File Contents Edit Sets Export Import History Search Aggregation Programs Help

None 2

| DESP100 | 1 UF | 2 WDOM | 3 NMORAD | 4 RENDA | 5 POF | 6 DSP | 7 KKK |
|---|---|---|---|---|---|---|---|
| 1 D1 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 180689.94 | 15.00 |
| 2 D2 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 35766.82 | 36.00 |
| 3 D3 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 163987.52 | 38.00 |
| 4 D4 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 128406.27 | 4.00 |
| 5 D5 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 402528.59 | 1.00 |
| 6 D6 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 490241.66 | 2.00 |
| 7 D7 | 1.00 | 421.78 | 5.00 | 6547.82 | 10.00 | 117043.55 | 247.00 |



# Loops & formula with LHS mapping

Columns 1, 5 and 7 define mappings to sets REG, POF and KKK respectively.

```
!Map regions!
Mapping DSP2REG FROM DSP TO REG;
Formula (all,d,DSP) DSP2REG(d) = Round(DESP(d,"UF"));

!Map categorias of POF!
Mapping DSP2POF FROM DSP TO POF;
Formula (all,d,DSP) DSP2POF(d) = Round(DESP(d,"POF"));

!Map POF products!
Mapping DSP2KKK FROM DSP TO KKK;
Formula    (all,d,DSP) DSP2KKK(d) = Round(DESP(d,"KKK"));
```

## Loops & formula with LHS mapping

GEMPACK 12 solution with loops (21 seconds) processes 2.8m rows 1 time

```
!Generate Matrix representation!
Coefficient (all,r,REG)(all,p,POF)(all,k,KKK) DESPPOF(r,p,k)
#DespesasPOF#;
! initialise to 0 !
FORMULA (all,r,REG)(all,p,POF)(all,k,KKK) DESPPOF(r,p,k) = 0;

LOOP(BEGIN) (ALL,d,DSP);
   Formula DESPPOF(DSP2REG(d),DSP2POF(d),DSP2KKK(d))
           = DESPPOF(DSP2REG(d),DSP2POF(d),DSP2KKK(d)) + DESP(d,"dsp");
LOOP(END);
Write DESPPOF to file OUTFILE header "POF1";
```

GEMPACK 11 solution (46 minutes) processes 2.8m rows 27x10x3572 times

```
!Generate Matrix representation!
Coefficient (all,r,REG)(all,p,POF)(all,k,KKK) DESPPOF(r,p,k) #DespesasPOF#;
Formula (all,r,REG)(all,p,POF)(all,k,KKK)
DESPPOF(r,p,k)
   = sum{d,DSP:[DSP2REG(d)=r] and [DSP2POF(d)=p] and [DSP2KKK(d)=k], DESP(d,"dsp")};
Write DESPPOF to file OUTFILE header "POF1";
```



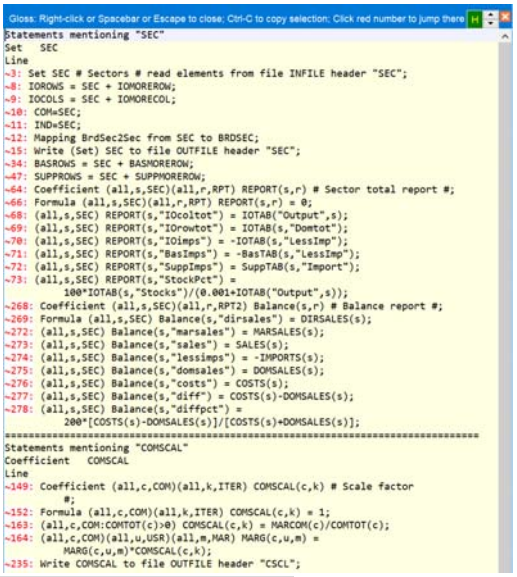
## GEMPACK Delphi (GUI) program changes

- All programs have been made available in 32 and 64 bit versions.
- Programs with GUI now all support high resolution and high dots per inch interfaces.
- Most programs support some of the touch screen capabilities such as scrolling and zooming using touch gestures.
- Majority of visible changes are noticeable in Tabmate.

# Tabmate

## Enhanced gloss feature

- Gloss feature now has a history option which keeps previously glossed items visible below the currently displayed gloss item.
- Previously closed gloss window can be shown again without requiring new gloss.
- History option can be disabled using the “H” button in the title bar.
- All gloss features can be accessed from the Gloss menu or via keyboard shortcuts

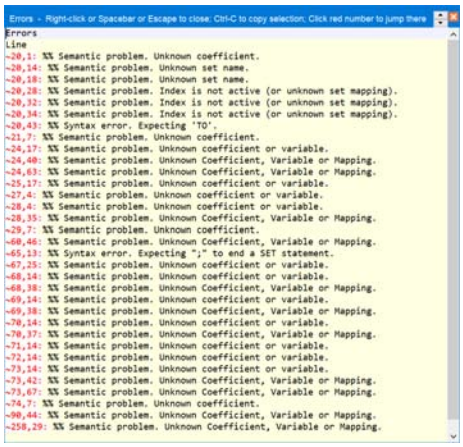





# Tabmate

## Enhanced Error dialog

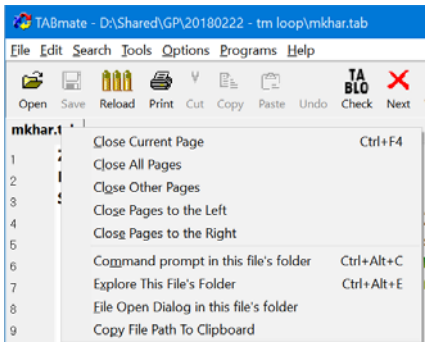
Error dialog has been enhanced to display all errors and allow easy movement between next and previous error location.

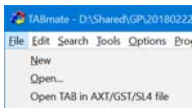


# Tabmate

## File tab options

- Each file tab now has several options to help manage open files.
- There are options that make browsing to file's location faster.
- Open TAB in AXT/GST/SL4 file allows Tabmate to examine TAB files embedded in solution files.



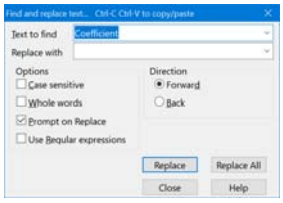



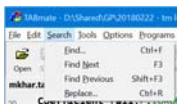



# Tabmate

## Search enhancements

- Search and replace dialogs have been enhanced to allow search using regular expressions.
- Search function has shortcuts for forward and backward searching.
- Search direction is shown by an arrow in the Tabmate notification bar.
- Search can be easily configured to re-start at the top of the file or to stop once file end has been found.
- If search shortcut is invoked while "not found" message is being shown then search will start from the top of the file.



# Tabmate

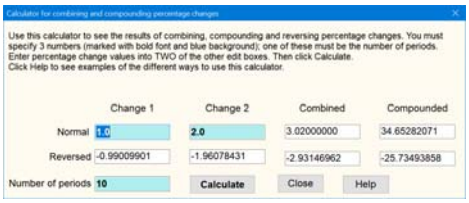
## Editor enhancements

- Line with cursor is highlighted with darker background colour.
- Matching brackets are highlighted with brighter background colour.
- Cursor can move between matching brackets using CTRL+LEFT or CTRL+RIGHT.
- Sections where Zero by Zero and Nonzero by Zero are in effect are highlighted by light green coloured lines in the gutter.
- Sections between loop start and end are highlighted with blue (L1), red (L2) and green (L3+) coloured lines in the gutter.
- Column block selection and replace mode has been introduced.
- Code completion is now available for all known file types with TAB files showing short gloss in description.
- Tab key can be used to indent and SHIFT+Tab can unindent selected lines.
- Block comment option can be used to mark selected section of file as comment.
- Keyboard shortcuts for many common tasks have been added.



# RunDynam 3.80

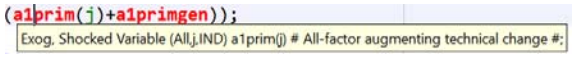
- RunDynam has received a lot of internal enhancements that are invisible to the user but increase usability and reliability at runtime.
- Dialogs for partial runs now remember last selection to make repeated execution easier.
- RunDyam will alert user at the end of the simulation if there were any warnings and allow for quick inspection.
- % change calculator has been added.



## AnalyseGE, ViewHAR, ViewSOL

In addition to inheriting all the Tabmate enhancements, AnalyseGE, ViewHAR and ViewSOL received some additional usability improvements.

- Reload button allows for quick solution reloading
- Brief gloss (middle mouse click or CTRL+SHIFT+SPACE) now shows type of variable (endo/exog, shocked, not shocked, substituted, mixed).




- Increased solution size limits
- 64bit versions available that can handle much larger HAR and SL4 files limited only by available computer memory
- Set library management has been optimised to allow faster editing of larger sets
- Automatic aggregation on 3+ dim headers to make quick viewing of different dimensions easier
- Solution results in ViewHAR can be converted to show annual average



## Licence activation

From release 12 some GEMPACK and RunDynam licences will require activation.

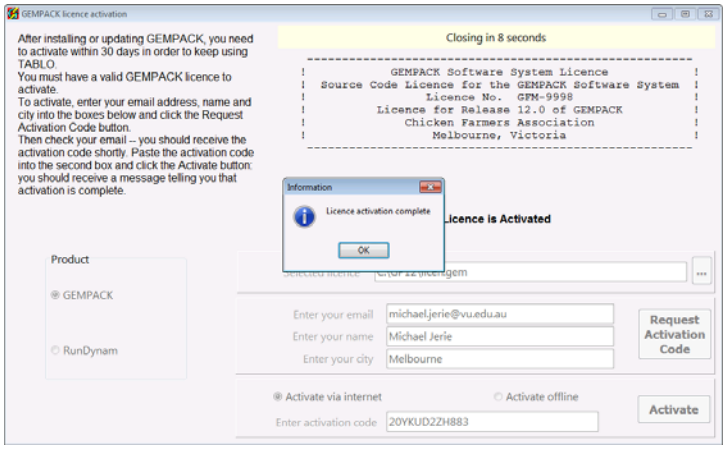
Activation steps:

- at installation time user contacts the GEMPACK licence server
- a code is sent back to the user by email
- the code is used to activate the licence
- the activation must be completed within 30 days otherwise TABLO & GEMSIM or RunDynam stop working

Activation is not transferable between computers; activation must be done for each installation of GEMPACK or RunDynam (with a licence which requires activation)

# Licence activation

What does activation look like?
Complete activation:






# GEMPACK 12 LU factorization

- For GEMPACK 12 a new LU analysis algorithm has been developed
- ideas follow the old Harwell Subroutine Libraries' (HSL) strategies
- Gempack 12 links against optimized math libraries

| | MA48 | GEMPACK LU | Speedup |
|---|---|---|---|
| term 47x31 | 34 | 4 | 850% |
| gtap 40x40 | 23 | 3 | 770% |
| gtap 113x57 | 3062 | 31 | 9877% |

**New CMF options**

```
GempackLU = YES | no;     ! YES is the default
GPLUSearchDepth = 256;    ! default
GPLUEpsColFilter = 0.01;  ! default
GPLUOptimize = no;        ! default
```

## GPLUOpimtize

Reference time with Gempack 11.4 512 seconds

| SerachDepth | 64 | 128 | 256 | 512 | 1024 | 2048 |
|---|---|---|---|---|---|---|
| Sim time [s] | 170 | 99 | 76 | 60 | 76 | 72 |

| EpsColFilter | 0.01 | 0.05 | 0.1 | 0.5 |
|---|---|---|---|---|
| Sim time [s] | 55 | 60 | 69 | 1440 |



## GEMPACK 12+ … features still to come

- GEMPACK 12.0 release date August 2018
- For GEMPACK 12.1 …
  - Higher dimensional coefficients (max dimension 12)
  - Double precision coefficients
  - Allow for very large systems – number of NZ > 2.1 x 10^9

# Capital Income Taxation in a Lifecycle Economy with Firm Heterogeneity

Chung Tran
Australian National University

Sebastian Wende
Australian National University

National CGE Workshop
Sydney, August 2018

## Capital income taxation

1. Firm: Corporate income tax
   - Corporate income: total revenue - expenses and operating costs
2. Household: Personal income tax
   - Personal income: labor, **capital** and other incomes
     - Capital incomes: dividends, capital gains and interests

## Tax reforms in the US

- Before 2003
  - Corporate tax: 35%
  - Capital gains and dividend tax rates: 25%
- 2003: Job and Growth Tax Relief Reconciliation Act 2003: Bush's tax cuts
  - Corporate tax: Kept at 35%
  - Capital gains and dividend tax rates: Down to 15% (temporary)
- 2018: The US Tax Cuts and Jobs Act 2017: Trump's tax cuts
  - Corporate tax: Down to 21%
  - Capital gains and dividend tax rates: 15%

## Questions

- The efficiency and distributive effects of capital taxes
  - Corporate tax
  - Dividend tax
  - Capital gains tax
- Shifting the tax burden from firm to household side
  - Efficiency vs. equity

## This paper

- Address these questions through the lens of a new model
- key features:
  - Household: Life cycle structure and productivity differences
  - Firm: Differences in real and financial positions
  - Dynamic general equilibrium

## Main findings

- The distortions of capital taxes are large and different.
  - The marginal excess burden (MEB)
- Cutting corporate tax results in efficiency gains,
  - but opposing welfare effects across generations and skills
- The effects of capital taxes strongly affected by model features
  - Firm heterogeneity
  - Life-cycle structure
  - Market incompleteness

## Excess burden or deadweight loss of taxation (DWL)

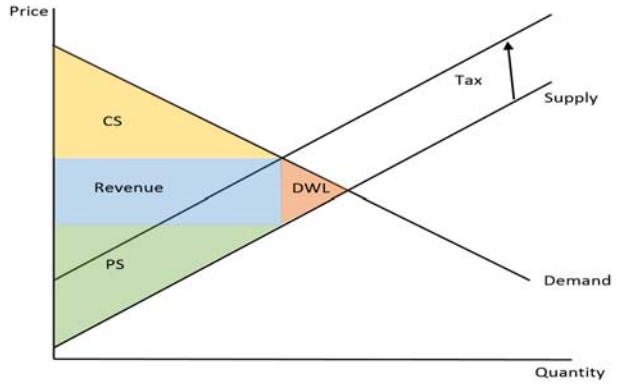



Figure: Measuring excess burden: Harberger's triangle

## Harberger's triangle and marginal excess burden (MEB)

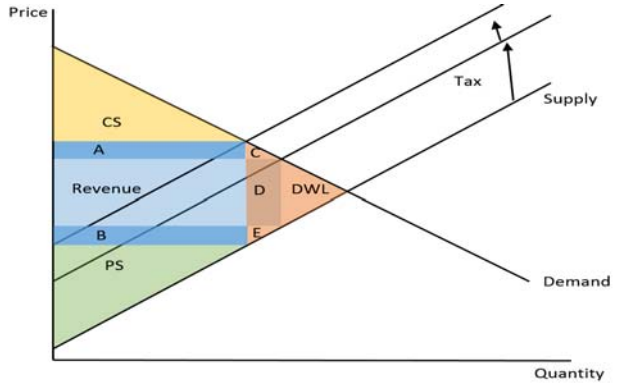



Figure: Marginal excess burden of a tax increases

- MEB = $\Delta$ welfare / $\Delta$ revenue= (C+D+E)/(A+B-D).

## Welfare costs of capital income taxes

- Using a marginal excess burden (MEB) analysis
  - MEB=(Marginal change in welfare)/(Marginal change in revenue)
- quantify the welfare losses of three capital taxes
  - Corporate income tax (CT), dividend tax (DT) and capital gain tax (CGT)

## Marginal excess burden (MEB): Efficiency effect

| Model | CT | DT | CGT | DT&CGT | LIT |
|---|---|---|---|---|---|
| Benchmark | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |

Table: Marginal excess burden of raising 1 dollar revenue in NPV terms

- CT: Corporate tax;
- DT: Dividend tax;
- CGT: Capital gain tax;
- LIT: Labor income tax

## Distribution of MEB: Distributive effect

| | CT | DT | CGT | DT&CGT | LIT |
|---|---|---|---|---|---|
| Aggregate | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |
| Retired | \$0.12 | \$0.23 | \$0.15 | \$0.09 | -\$0.81 |
| Working | \$0.77 | \$1.40 | -\$0.48 | \$0.61 | \$0.16 |
| Future | \$0.75 | \$1.59 | -\$1.15 | \$0.55 | \$0.59 |
| Low skill | -\$0.35 | -\$0.07 | -\$0.95 | -\$0.42 | -\$0.47 |
| Medium skill | \$0.44 | \$1.02 | -\$0.78 | \$0.29 | \$0.07 |
| High skill | \$2.52 | \$3.87 | -\$0.28 | \$2.17 | \$1.44 |

Table: MEB by skill and age group

## Model features and marginal excess burden (MEB)

| Model | CT | DT | CGT | DT&CGT | LIT |
|---|---|---|---|---|---|
| Benchmark | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |
| Neoclassical | \$0.65 | \$0.66 | \$0.57 | \$0.65 | \$0.18 |

Table: MEB of raising 1 dollar revenue in NPV terms in different models

- Benchmark model: Heterogeneous firms, life-cycle households, financing constraint, and DRS technology
- Neoclassical model: Representative firm, representative household, and CRS technology

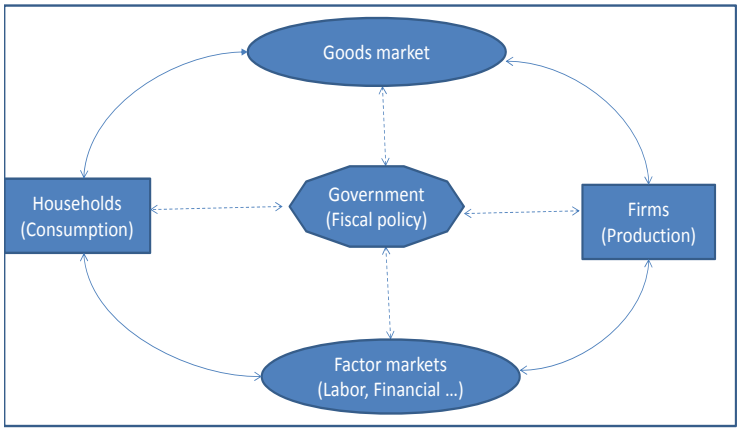
## Related literature

- Capital income taxation:
  - Zero capital tax: Judd (1985), Chamley (1986)
  - Positive capital tax:
    - Liquidity constraints: Hubbard and Judd (1986)
    - Lifecycle households: Erosa and Gervais (2002)
    - Uninsurable idiosyncratic income risk: Aiyagari (1995), Imrohoroglu (1998)
    - A mix of all features: Conesa, Krueger and Kitao (2009)
- Capital taxes, investment and aggregates
  - Corporate taxes: McGrattan and Prescott (2005), Santoro and Wei (2011) and Anagnostopoulos, Carceles-Poveda and Lin (2012) , Anagnostopoulos, Carceles-Poveda and Lin (2012)
  - Dividend and capital gains taxes: Gourio and Miao (2010) and Gourio and Miao (2011)
  - Firm heterogeneity and corporate taxes: Anagnostopoulos, Atesagaoglu and Carceles-Poveda (2015) and Wills and Camilo (2017)

## The model: Overview

- Dynamic general equilibrium closed economy model
- Life-cycle households as in Auerbach and Kotlikoff (1987): Skill heterogeneity and borrowing constraints.
- Heterogeneous firms as in Gourio and Miao (2010): Idiosyncratic productivity shocks, financing constraints and financial policy
- Calibrated to the US data in early 2010s

## Model overview




## Households I

- Demographics: 20 to 100 years
- Preferences: Households value consumption and leisure and maximize the discounted lifetime utility
- Endowments: Newborns with different skills that define the life-cycle profiles of labor efficiency units

- A household begins with zero assets and chooses consumption, labor supply and asset holdings to maximise its utility over its lifetime.
- Saving technology: equity, $\theta_{i,j,t}$, and bonds, $B_{i,j,t}$, but can not short sell equity or debt $\theta_{t,j,i} \geq 0, B_{t,j,i} \geq 0$.
- Income sources: labor income, dividends, $d_t(\mu_t)$, capital gains, interest payments, accidental bequests, $BQ_{t,i}$, and government transfers $T_{t,j,i}$.

## Households II

- Taxes: Consumption tax, labor income tax, and taxes on dividends, capital gains and interest income with rates $\tau^l$, $\tau^d$, $\tau^g$ and $\tau^i$ respectively.

- The household problem is given by

$$U = \sum_{j=20}^{100} S_j \beta^j \frac{\left(c_j^{\gamma} l_j^{1-\gamma}\right)^{1-\sigma}}{1-\sigma}$$

subject to

$$\begin{aligned}
&(1+\tau^c)C_j + \int p_t \theta_{j+1} d\mu_t + B_{j+1} \\
=&(1-\tau^l)W_t(1-l_t)e_j + +(1+(1-\tau^i)r_t))B_j + T_j + BQ_j \\
+&\int \left(p_t^0 + (1-\tau^d)d_t - \tau^g\left(p_t^0 - p_{t-1}\right)\right)\theta_j d\mu_{t-1}.
\end{aligned}$$

## Simplified household problem I

- No arbitrage condition implies

$$(1-\tau^i)r_{t+1} = \frac{E_t\left[(1-\tau^d)d_{t+1} + (1-\tau^g)(p_{t+1}^0 - p_t)\right]}{p_t}$$

- Assuming that households hold similar an equal share of each firm, so that we can express asset portfolios in terms of the representative asset

$$A_{t+1,j+1,i} = \left(\int p_t d\mu_t + B_{t+1}\right)\theta_{t+1,j+1,i}$$

and the return on the asset, $r_t^a$, is given by

$$r_t^a = \frac{(1-\tau^i)r_t B_t + \int\left[(1-\tau^d)d_t + (1-\tau^g)(p_t - p_{t-1})\right]d\mu_{t-1}}{B_t + \int p_{t-1}d\mu_{t-1}}.$$

- The household's budget constraint can be re-written as

$$(1-\tau^c)C_{t,j,i} + A_{t+1,j+1,i} = (1-\tau^l)W_t(1-l_{t,j,i})e_{j,i} + (1+r_t^a)A_{t,j,i}$$

$$+\mathrm{T}_{t,j,i} + BQ_{t,i}.$$

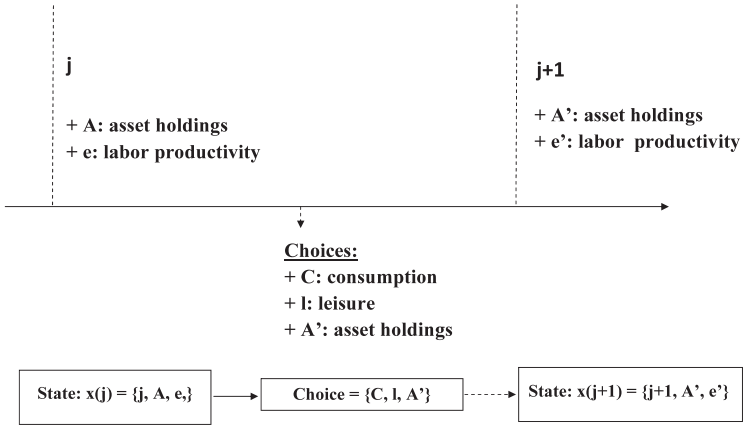
## Simplified household problem II

- The household's dynamic programming problem is given by

$$V_j(A_{t,j,i}) = \max_{\{C_{t,j,i}, l_{t,j,i}, A_{t+1,j+1,i}\}} \left\{ u\left(C_{t,j,i}, l_{t,j,i}\right) + \hat{\beta} sp_{j+1} V_{j+1}\left(A_{t+1,j+1,i}\right) \right\}$$

subject to the household's budget constraint, the credit constraint, $A_{t+1,j+1,i} \geq 0$, and the non-negativity of leisure and consumption $C_{t,j,i} > 0$ and $1 \geq l_{t,j,i} > 0$.

## Timing of household decision



## Firms

- The production sector consists of a continuum of ex-ante identical firms exposed idiosyncratic productivity shocks.
- The firms own capital and chooses investment, dividends, equity and labor demand to maximize their cum dividend equity price.
- Firms differ ex-post in terms of the histories of productivity shocks and their capital levels.

## Technology

- Production function

$$F(k, n; z) = zk^{\alpha_k} n^{\alpha_n}$$

  where $\alpha_k + \alpha_l < 1$ (DRS)
- Productivity evolves according to

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

  where $\epsilon_t$ IID $\mathcal{N}(0, \sigma^2)$
- Capital accumulation

$$k_t = (1 - \delta)k_{t-1} + i_t$$

- Investment cost

$$C(i) = i + \frac{\psi i^2}{2k}$$

- Earnings after wages

$$\pi = zk^{\alpha_k} n^{\alpha_n} - wn$$

## Corporate finance I

- The firm is owned by equity holders who receive a return on equity by receiving dividends $d_t$, and also capital gains on changes in the equity price.
- Investment finance: Internal finance from earnings after wages and taxes and external finance by issuing new equity, $s_t$.
- Non-negative dividends constraint

$$d_t \geq 0.$$

- Equity buy-backs constraint

$$s_t \geq -\bar{s}$$

- No dividend payout unless the firm is fully utilising its ability to pay out returns through the buy-backs giving the constraint

$$d_t(s_t + \bar{s}) = 0.$$

## Corporate finance II

- The value of a firm's equity after issuance is given by the pre-issuance value plus the value of issuance

$$p_t = s_t + p_t^0.$$

- The firm pays corporate tax on its income which is revenue minus wages, $\tau^k \left(z k^{\alpha_k} n^{\alpha_n} - w_t n_t\right)$.
- The firm can also deduct from its taxable income a fraction of its investment and capital depreciation.
- Using the households' first order condition for equity yields

$$(1-\tau^i) r_{t+1} = \frac{E_t\left[(1-\tau^d)d_{t+1} - (1-\tau^g)s_{t+1} + (1-\tau^g)(p_{t+1} - p_t)\right]}{p_t}.$$

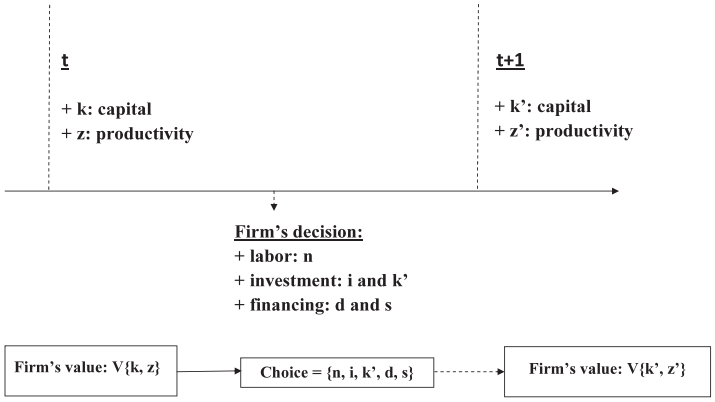
## Corporate finance III

- The no arbitrage condition for the fair price of equity is given by

$$p_t = \frac{E_t\left[(1-\tau^d)/(1-\tau^g)d_{t+1} + p_{t+1} - s_{t+1}\right]}{1 + r^i_{t+1}/(1-\tau^g)}.$$

Here $r^i_t = (1-\tau^i)r_t$ is the after tax interest rate.

## Timing of firm decision



## Firm problem I

- Each firm maximises its cum dividend value which is defined as

$$V_t = \frac{1-\tau^d}{1-\tau^g} d_t - s_t + p_t$$

- The firms problem can be written as

$$V_t(k_t, z_t) = \max_{d_t, s_t, i_t, n_t, k_{t+1}} \frac{1-\tau^d}{1-\tau^g} d_t - s_t + \frac{E_t\left[V_{t+1}(k_{t+1}, z_{t+1})\right]}{1 + r^i_{t+1}/(1-\tau^g)}$$

s.t.

$$i_t + \frac{\psi i_t^2}{2k_t} + d_t = (1-\tau^k)(z_t k_t^{\alpha_k} n_t^{\alpha_n} - w_t n_t) + \delta \tau^k k_t + s_t,$$

$$k_{t+1} = (1-\delta)k_t + i_t$$

$$d_t \geq 0 \ , \ s_t \geq -\bar{s} \ , \ d_t(\ s_t + \bar{s}) = 0.$$

## Government

- The government collects taxes to finance government consumption and transfers. The government budget is given by

$$B_{t+1} = TAX_t - G_t - T_t - (1 + r_t)\, B_t.$$

- $B_{t+1}$ is new government debt issued at time $t$ and $B_t$ outstanding government debt issued at time $t-1$.

## Competitive equilibrium I

Given the transition probability matrices and the exogeneous government policies, a competitive equilibrium is a collection of sequences of distributions of household decisions, aggregate capital stocks of physical and human capital, and market prices such that

- Households solve the consumer problem;
- Firms solve the firm problem and the F.O.Cs of firms hold;
- All markets clear and the general budget clear;
- The distribution is stationary;
- The aggregate resource constraint is given by

$$C_t + I_t + \Psi_t = Y_t$$

where

$$Y = \int y(k, z; w)\mu(dk, dz), \qquad L = \int l(k, z; w)\mu(dk, dz)$$

## Competitive equilibrium II

$$I = \int i(k, z; w)\mu(dk, dz), \qquad \Psi = \int \frac{\psi i(k, z; w)^2}{2k}\mu(dk, dz)$$

$$p^T = \int p(k, z; w)\mu(dk, dz), \qquad d^T = \int d(k, z; w)\mu(dk, dz)$$

$$s^T = \int s(k, z; w)\mu(dk, dz)$$

## Benchmark calibration

- To match the US economy in early 2010s
- Macroeconomic aggregate data
- Firm level data from COMPUSTAT

## Calibration value

| | Parameter | Value |
|---|---|---|
| Exponent on capital | $\alpha_k$ | 0.311 |
| Exponent on labor | $\alpha_l$ | 0.650 |
| Shock persistence | $\rho$ | 0.767 |
| Shock standard deviation | $\sigma$ | 0.211 |
| Depreciation rate | $\delta$ | 0.095 |
| Adjustment cost | $\psi$ | 0.890 |
| Equity buy-back constraint | $\bar{s}$ | 0.085 |
| Discount factor | $\beta$ | 0.983 |
| Consumption share | $\gamma$ | 0.25 |
| Inter-temporal elasticity | $1/\sigma$ | 0.4 |
| Corporate income tax | $\tau^k$ | 0.340 |
| Dividend tax | $\tau^d$ | 0.200 |
| Capital gains tax | $\tau^g$ | 0.200 |
| Interest income tax | $\tau^i$ | 0.250 |
| labor income tax | $\tau^n$ | 0.240 |
| Consumption tax | $\tau^n$ | 0.025 |
| Deductibility of depreciation | $\chi^\delta$ | 1.00 |
| Deductibility of investment | $\chi^I$ | 0.00 |

Table: Model Calibrations

## Experiments: Marginal excess burden analysis

- Raise 1 dollar of net tax revenue (in NPV terms) in each future period
- Compute the welfare costs of such tax increase
  - Using equivalent variation (EV) as a measure of the welfare costs
- Compute marginal excess burden (MEB) =(Marginal change in welfare)/(Marginal change in tax revenue)
- Taxes: Corporate tax (CT), dividend tax (DT), capital gains tax (CGT) and labor income tax (LIT)

## Harberger's triangle and marginal excess burden (MEB)

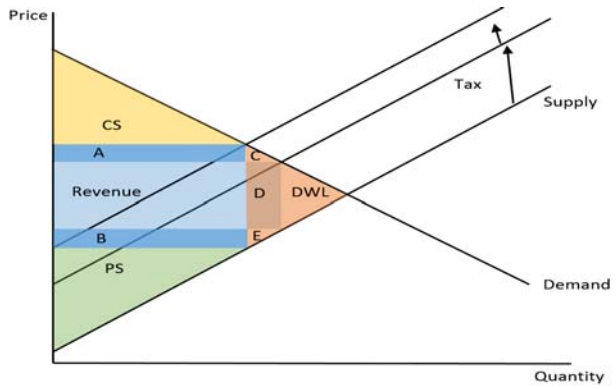



Figure: Marginal excess burden of a tax increases

- MEB = $\Delta$ welfare / $\Delta$ revenue= (C+D+E)/(A+B-D).

## Marginal excess burdens (MEB)

| Model | CT | DT | CGT | DT&CGT | LIT |
|---|---|---|---|---|---|
| Benchmark | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |

Table: Marginal excess burden of raising 1 dollar revenue in NPV terms

## Distributional effects

| | CT | DT | CGT | DT&CGT | LIT |
|---|---|---|---|---|---|
| Aggregate | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |
| Retired | \$0.12 | \$0.23 | \$0.15 | \$0.09 | -\$0.81 |
| Working | \$0.77 | \$1.40 | -\$0.48 | \$0.61 | \$0.16 |
| Future | \$0.75 | \$1.59 | -\$1.15 | \$0.55 | \$0.59 |
| Low skill | -\$0.35 | -\$0.07 | -\$0.95 | -\$0.42 | -\$0.47 |
| Medium skill | \$0.44 | \$1.02 | -\$0.78 | \$0.29 | \$0.07 |
| High skill | \$2.52 | \$3.87 | -\$0.28 | \$2.17 | \$1.44 |

Table: MEB by skill and age group

## Corporate tax reforms

- Cut taxes on corporate income (Firm)
- Shift tax burden to personal income (Household)
  1. Dividend tax
  2. Dividend and capital gains taxes
  3. Labor income tax

## Reform 1: Corporate tax cuts financed by dividend tax

| Corporate tax rate (%) | -0 | -8 | 16 | 24 | 32 |
|---|---|---|---|---|---|
| Output change (%) | - | - | 0.5 | -0.3 | -0.4 |
| Welfare change (%) | - | - | -1.98 | -1.42 | -0.35 |
| Retired welfare $\Delta$ (%) | - | - | -5.46 | -2.86 | -0.26 |
| Working welfare $\Delta$ (%) | - | - | -2.49 | -1.6 | -0.33 |
| Future welfare $\Delta$ (%) | - | - | -0.3 | -0.76 | -0.39 |
| Low skill $\Delta$ (%) | - | - | -1.6 | -1.23 | -0.34 |
| Medium skill $\Delta$ (%) | - | - | -1.9 | -1.39 | -0.35 |
| High Skill $\Delta$ (%) | - | - | -2.15 | -1.51 | -0.36 |
| Population support (%) | - | - | 0 | 0 | 0 |
| $\tau^d$ (%) | - | - | 73.8 | 53.9 | 26.3 |

Table: The welfare effects of the corporate tax cuts financed by dividend tax.

## Reform 2: The tax cuts financed by dividend and capital gains taxes

| Corporate tax rate (%) | 0 | 8 | 16 | 24 | 32 |
|---|---|---|---|---|---|
| Output change (%) | 0.9 | 0.8 | 0.6 | 0.4 | 0.1 |
| Welfare change (%) | 0.22 | 0.29 | 0.29 | 0.22 | 0.06 |
| Retired welfare $\Delta$ (%) | -0.34 | -0.19 | -0.07 | 0 | 0.01 |
| Working welfare $\Delta$ (%) | 0.16 | 0.23 | 0.24 | 0.19 | 0.05 |
| Future welfare $\Delta$ (%) | 0.32 | 0.38 | 0.37 | 0.27 | 0.07 |
| Low skill $\Delta$ (%) | 0.29 | 0.33 | 0.31 | 0.23 | 0.06 |
| Medium skill $\Delta$ (%) | 0.24 | 0.29 | 0.29 | 0.22 | 0.06 |
| High Skill $\Delta$ (%) | 0.19 | 0.27 | 0.28 | 0.21 | 0.06 |
| Population support (%) | 34 | 45 | 55 | 84 | 100 |
| $\tau^d, \tau^g$ (%) | 53.4 | 47.8 | 41.1 | 33 | 22.9 |

Table: Impact of replacing corporate tax with dividend and capital gains tax.

## Reform 3: Corporate tax cuts financed by labor income tax

| Corporate tax rate (%) | 0 | 8 | 16 | 24 | 32 |
|---|---|---|---|---|---|
| Output change (%) | 2.2 | 1.9 | 1.5 | 0.9 | 0.2 |
| Welfare change (%) | 0.82 | 0.72 | 0.57 | 0.36 | 0.08 |
| Retired welfare $\Delta$ (%) | 10.35 | 8.1 | 5.74 | 3.26 | 0.67 |
| Working welfare $\Delta$ (%) | 1.39 | 1.2 | 0.94 | 0.59 | 0.13 |
| Future welfare $\Delta$ (%) | -2.97 | -2.03 | -1.22 | -0.56 | -0.09 |
| Low skill $\Delta$ (%) | -0.13 | 0 | 0.08 | 0.1 | 0.03 |
| Medium skill $\Delta$ (%) | 0.64 | 0.58 | 0.47 | 0.31 | 0.07 |
| High Skill $\Delta$ (%) | 1.25 | 1.04 | 0.78 | 0.48 | 0.11 |
| Population support (%) | 81 | 81 | 81 | 82 | 82 |
| $\tau^n$ (%) | 27.3 | 25.3 | 23.3 | 21.1 | 18.9 |

Table: The welfare effects of the corporate tax cuts financed by labor income tax.

## Different modeling approaches

- Benchmark model
  - Heterogeneous firms, lifecycle households, endogenous investment finance regimes, DRS technology
- Different models:
  1. Model A: Rep. firm, lifecycle households, internal finance, DRS
  2. Model B: Rep. firm, lifecycle households, external finance, DRS
  3. Model C: Heterogeneous firms, rep. household, DRS
  4. Model D: Rep. firm, rep. household, internal finance, DRS
  5. Model E: Rep. firm, rep. household, external finance, DRS
  6. Model F: Rep. firm, rep. household, CRS technology (Neoclassical model)

## Marginal excess burden of taxes: Model comparison

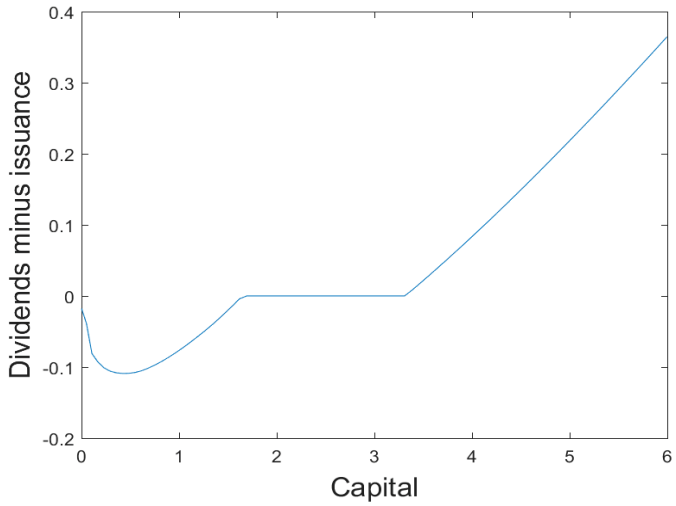
| Model | CT | DT | CGT | D&CGT | LIT |
|---|---|---|---|---|---|
| 0. Bench. Model | \$0.70 | \$1.37 | -\$0.71 | \$0.53 | \$0.23 |
| 1. Mod. A: R firm, IF | \$0.57 | \$0.14 | \$1.64 | \$0.55 | \$0.25 |
| 2. Mod. B: R firm, EF | \$0.57 | \$0.69 | \$0.23 | \$0.55 | \$0.25 |
| 3. Mod. C: R HH | \$0.60 | \$1.34 | -\$0.68 | \$0.44 | \$0.15 |
| 4. Mod. D: R HH, R Firm, IF | \$0.49 | \$0.00 | \$1.21 | \$0.48 | \$0.16 |
| 5. Mod. E: R HH, R Firm, EF | \$0.49 | \$0.63 | \$0.11 | \$0.48 | \$0.16 |
| 6. Mod. F: R HH, R Firm, EF, CRS | \$0.65 | \$0.66 | \$0.57 | \$0.65 | \$0.18 |

Table: Marginal excess burden

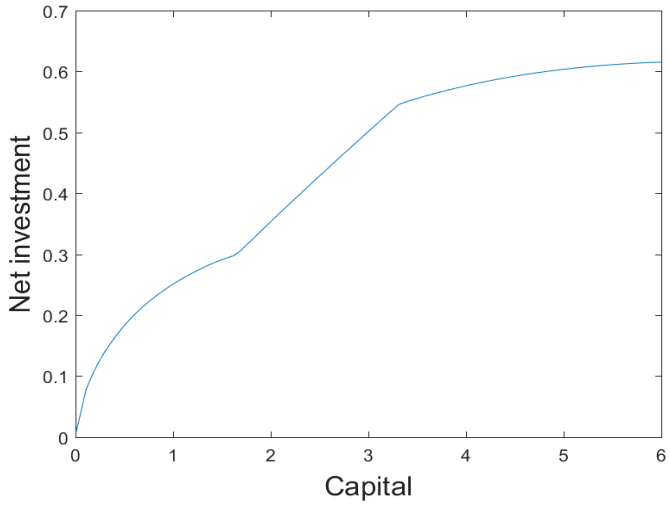
## Firm heterogeneity and capital taxes

- Productivity and capital levels
  - Technology shocks
  - Investment and capital accumulation
  - Age of firms
- Investment finance
  - Internal financing through retained profits
  - External financing through equity issuance
- Different capital taxes affect firms differently.
- Tax distortions and financial constraints lead to inefficient allocation of capital across firms.

## Equity issuance or dividend distribution



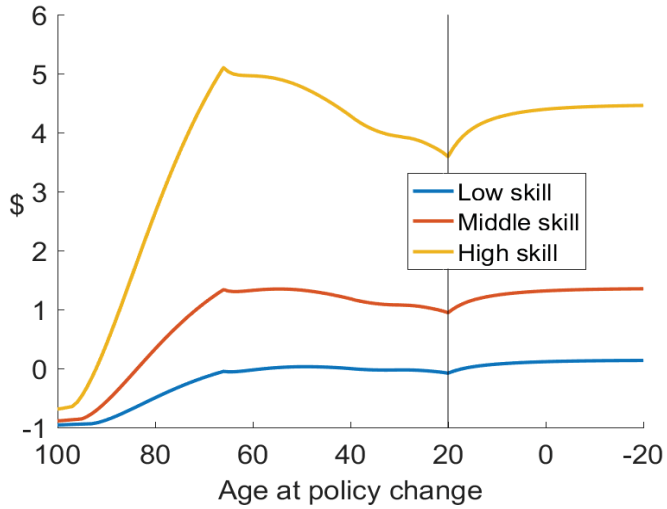
## Net investment by capital level



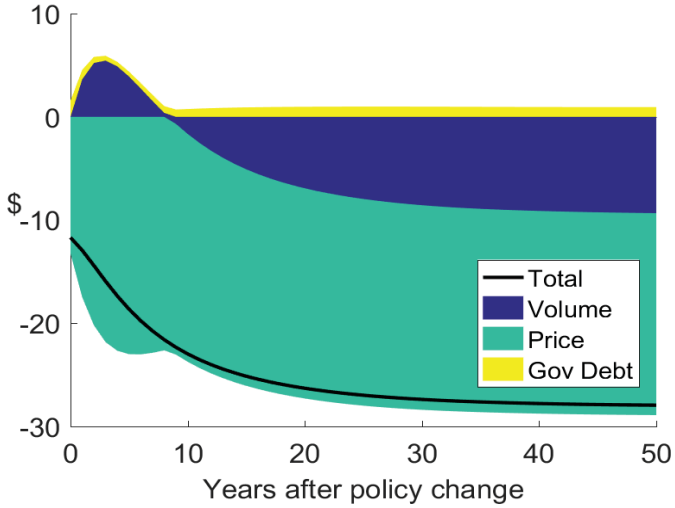

## Dividend tax (DT)

Dividend tax increase

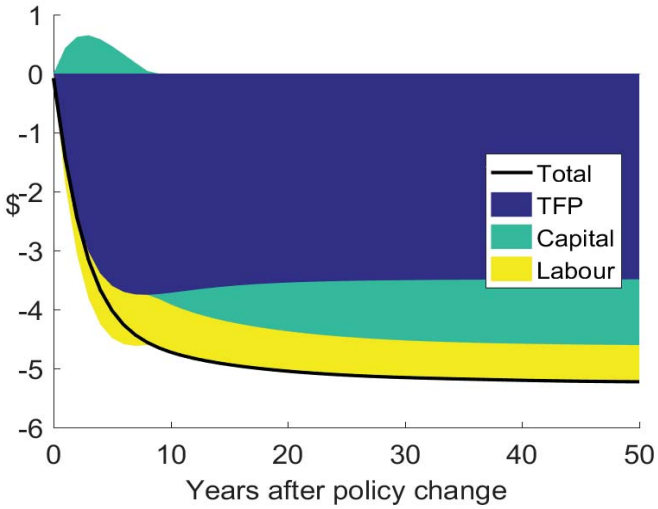
## Dividend tax: Welfare change



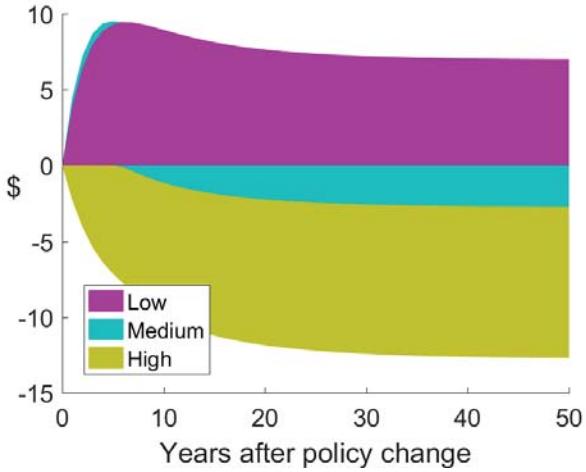

## Dividend tax: Assets



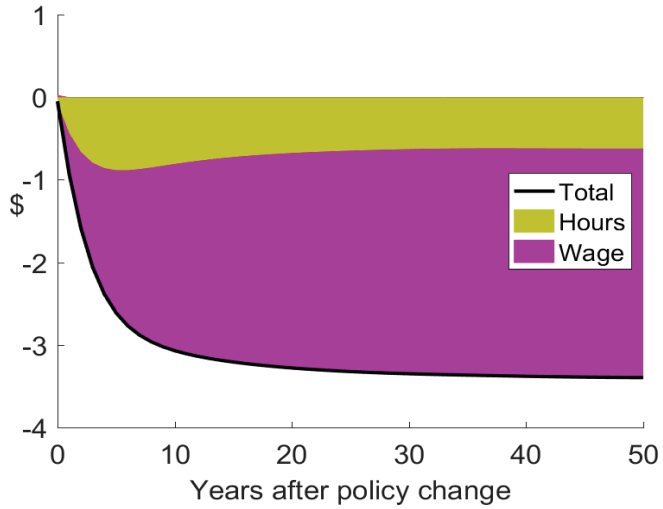
## Dividend tax: Output



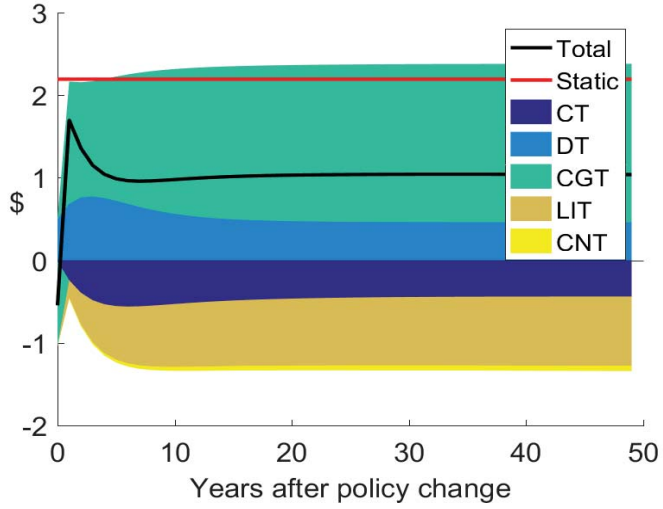

## Dividend tax: Capital by productivity



## Dividend tax: Labor income



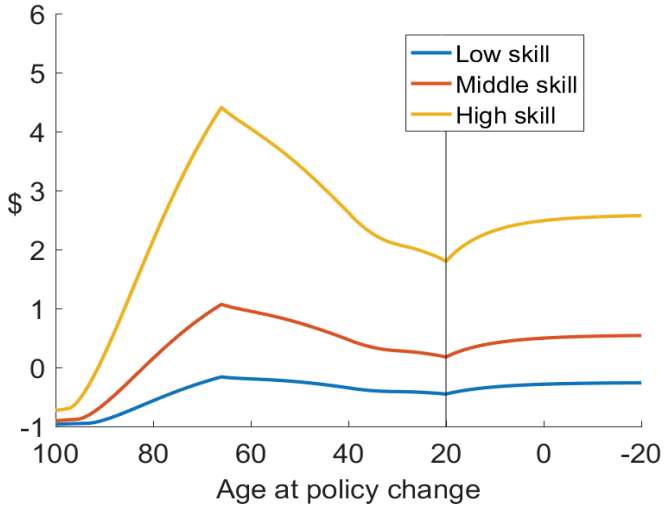

## Dividend tax: Revenue



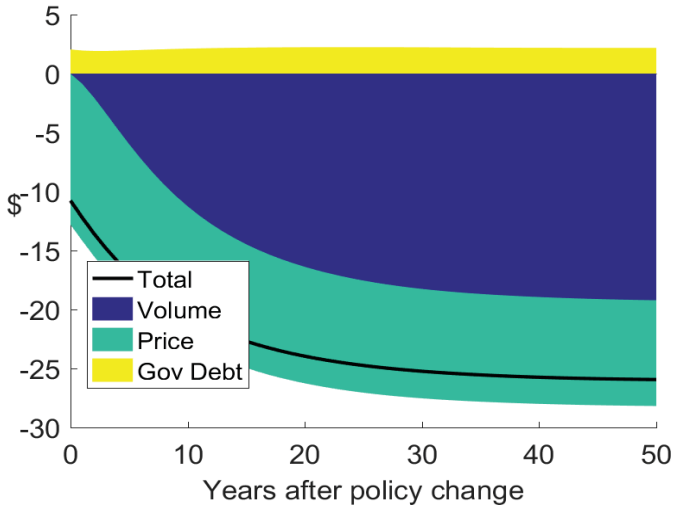
## Corporate tax (CT)

# Corporate tax increase

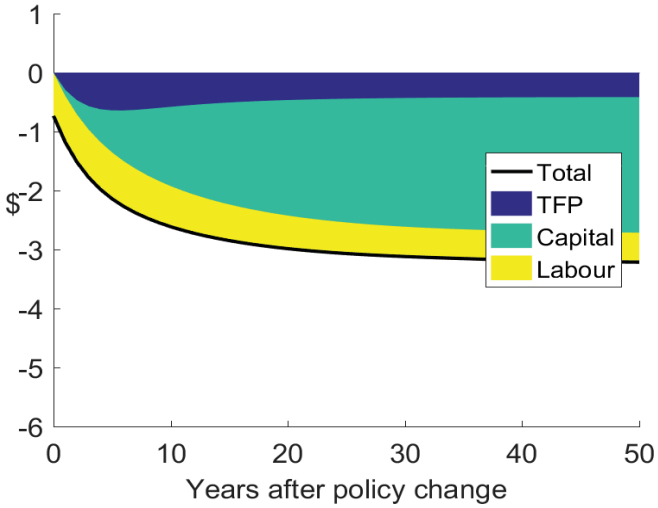
## Corporate tax: Welfare change



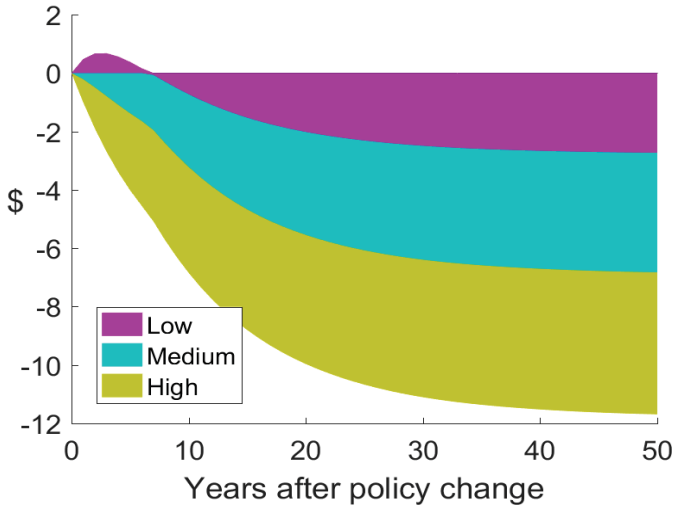
## Corporate tax: Assets



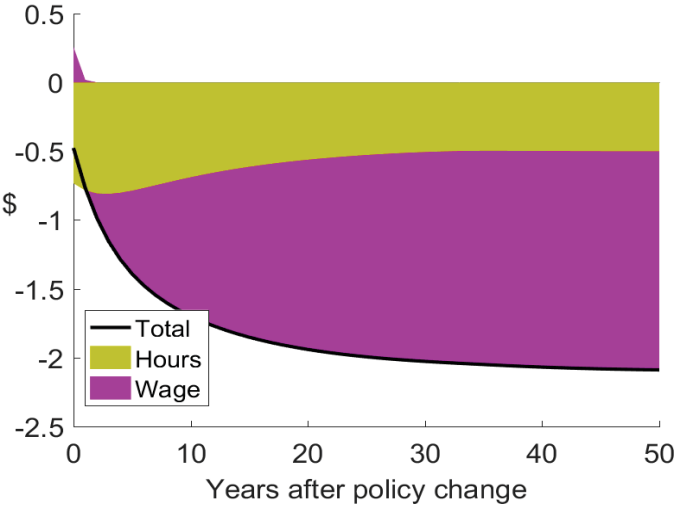

## Corporate tax: Output



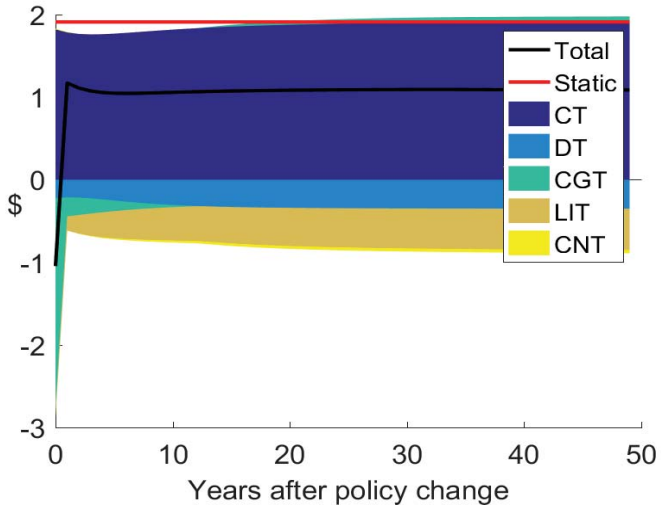
## Corporate tax: Capital by productivity




## Corporate tax: Labor income



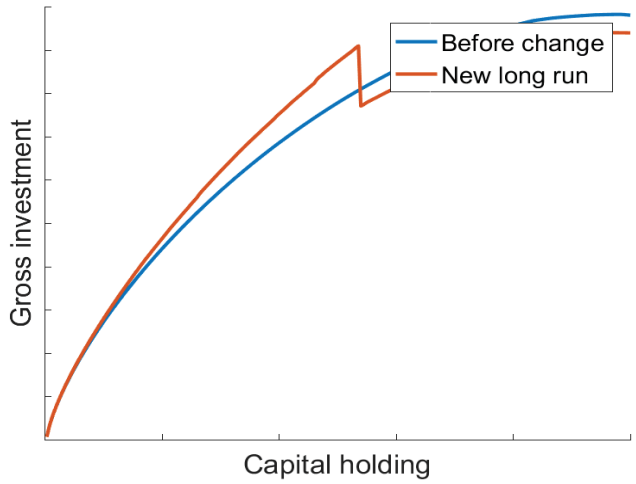
## Corporate tax: Revenue



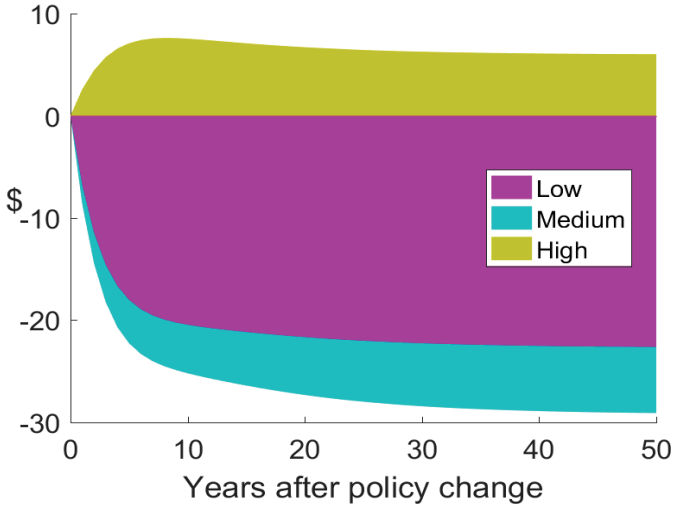

## Capital gains tax

# Capital gains tax increase

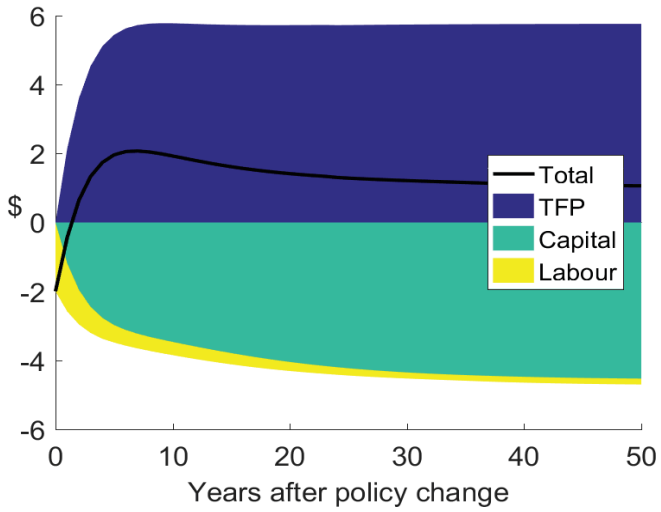
## Dividends plus buybacks by capital level




## Capital gains tax: Capital by productivity

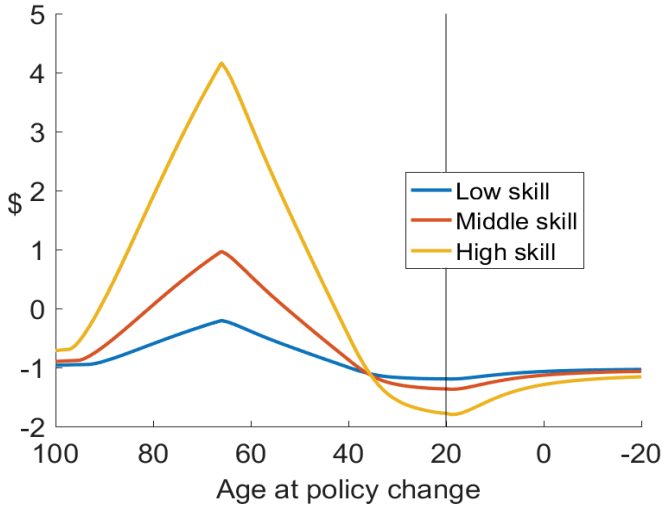


## Capital gains tax: Output




$$TFP = Y/(K^{\alpha_K} N^{\alpha_N})$$

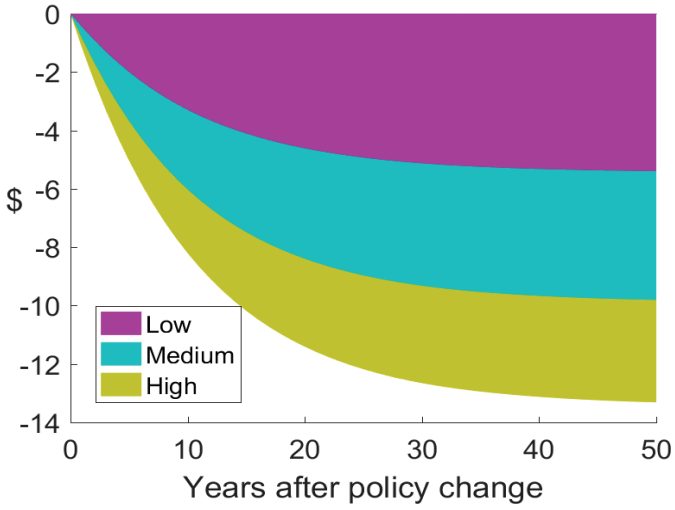
## Capital gains tax: Welfare change



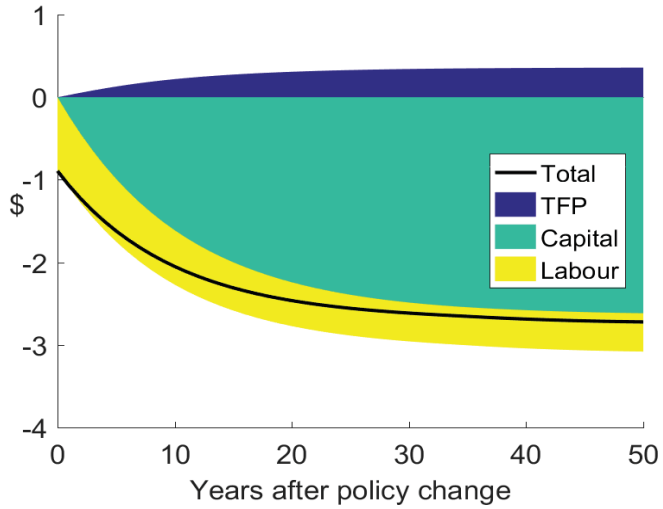
## Dividend and capital gains taxes

Dividend and capital gains tax increase

## Dividend and capital gains taxes: Capital by productivity



## Dividend and capital gains taxes: Output




## Conclusion

- The efficiency costs of capital taxes are relatively large.
- Corporate tax cuts improve efficiency, but lead to different welfare outcomes.
- The important model features are
  - Firm heterogeneity: Allocative inefficiency
  - Life-cycle structure: Saving and capital accumulation
  - Financing constraints: Investment and capital accumulation

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