WELFARE IMPACTS OF ROAD CONSTRUCTION USING A PUBLIC - PRIVATE PARTNERSHIP: A CGE Analysis of a Project

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Abstract

- Impacts of road projects have been analysed through different perspectives.
- Our aim: analyse their welfare impact through equivalent variation.
- In the current paper a **dynamic CGE model** is used to study the issue,
- Disaggregates impacts by 6 **household** categories
  - The following scenarios are considered:
    - a reduction in the transport margins that should improve the efficiency of the economy;
    - an increase in the income tax levied;
    - a reduction in the transfers to the households equal to the amortisation. and, finally;
  - Conclusions:
    - The benefits derived from the construction of the road in the short term tend to fall short of the costs incurred in the future, making the road a poor investment.
    - It makes a difference whether the project is financed through tax increases, out of the current structure of expenditure or transfer cuts. In the first case higher income households pay more in the latter two lower income groups bear a greater burden.

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Introduction / The Project

- In 2006, to start in 2007, the regional government of the Azores contracted the construction/ repair of a major road in one of the islands of the archipelago – S. Miguel. This island accounts for about 60% of the economic activity of this region and for about 60% of its GDP. The project affects about 50% of the stock of major roads in the island and will impact on about 80% of the traffic.
- The project is as follows:
  - on a first, immediate phase, the government gives concession of existing roads to a private company that will assume its' upkeep and gets a payment of €17.624.608 on the first year and a payment of €846972 on the second year;
  - simultaneously, for a period of five years, the company constructs and repairs the predetermined road sections;
  - as of the sixth year, the government starts payment of the accumulated debt on a schedule that is expected to imply outlays of around €325 million. (current prices)
- Debt, comprising the initial payments by the private company, construction during five years, maintenance costs and interest on outstanding debt, accumulates during the first five years to determine the total that will be reimbursed as of the sixth year. Given the payment schedule, it is estimated that the base value of the project, consisting of new construction, will be €117 million, spread evenly along the five years (real values were substantially higher).

Introduction / The Project

Table <u>1</u>: Present Value of Construction Liabilities in time t+5 or year 2012

Heading	Value (€
1 Future value of investments from 2007 to 2011 in 2012	117.761.021
2 Future value of maintenance from 2007 to 2011 in 2012	3.435.818
3 Present value of maintenance from 2012 to 2036 in 2012	22.956.133
4 Future value of advances in 2007, 2008 in 2012	24.083.908
5 Total Liabilities in 2012 (5=1+2+3+4)	168.236.880

• The main question is what welfare gains and losses can we identify that are associated to this project.
• The gains will certainly come from the initial additional expenditures that, we will assume, trickles through the economy according to its current structure. Once the roads are completed, one should also expect that travel costs will be lower. In our model this will imply that transport margins are lower.

Introduction / The Project

• The costs will be associated to the reimbursement of the debt that is accumulated.

• Since it is assumed that the government will not be able to increase its debt stock, total payment will have to be made out of additional taxes from economic growth prompted from better and more economical roads, additional taxes on the citizens, or less transfers to the citizens, from the government.

The scenarios considered are, therefore, based on:

• the implicit reduction in transport margins on the land transport sector;
• imposition of an additional income tax on the households;
• reduction in the amount of transfers of the households.

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The Model

A modelling platform of the Azores economy is used which is represented by a dynamic multi-sector computable general equilibrium model (CGE), which incorporates the economic behaviour of six economic agents:

firms,
households,
regional government,
Mainland government,
European Commission and
the external sector

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DATA

2001 I-O matrix of the Azores
Other 2001 data on the Azores
2000 HH Inc/Exp Survey data
45 production sectors
6 Households
4 Trading partners
4 Levels of government

RESULTS

• The gains will certainly come from the initial additional expenditures that, we will assume, trickles through the economy according to its current structure. Once the roads are completed, one should also expect that travel costs will be lower. In our model this will imply that transport margins are lower.

•The costs will be associated to the reimbursement of the debt that is accumulated. Since it is assumed that the government will not be able to increase its debt stock, total payment will have to be made out of additional taxes from economic growth prompted from better and more economical roads, the current budget items in their respective weights, additional taxes on the citizens, or less transfers to the citizens, from the government, to the extent that the government does not wish to reduce other expenditures.

•The scenarios considered are, therefore, based on:
  • The implicit reduction in transport margins on the land transport sector;
  • Imposition of an additional income tax on the households;
  • Reduction in the amount of transfers of the households.

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RESULTS

• Five scenarios were created and compared with business as usual scenario.

• All scenarios consider the reimbursements of the project.

• Scenarios 1 and 2 ignore the benefits of the improved roads and distinguish the impacts of a tax increase and a transfer decrease, respectively. Scenario 3 analyses only the impact of improved transport margins while the project is being paid. Scenarios 4 and 5 combine repayment with transport margin improvements and tax increases and transfer decreases, respectively.

Scenario 1: 10% Increase in Income Taxes
Scenario 2: 10% cut in Transfers
Scenario 3: 10% decrease in Transport Margins
Scenario 4: 10% decrease in Transport Margins and 10% Increase in Income Taxes
Scenario 5: 10% decrease in Transport Margins and 10% Decrease in Transfers

The expected results for the first five years of all scenarios are positive since there is new "costless" investment and no reimbursements
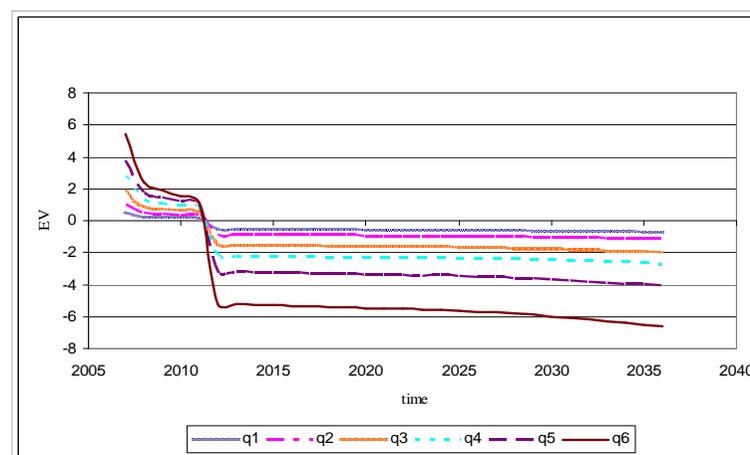
RESULTS

1. Increase In Income Tax by 10%

The increase in income tax adversely affects the households as it curtails the spending and leads to a substantial fall in the GDP as compared to other scenarios. The improvement of the current account balance captured by the excess of exports over imports is insufficient to compensate for the fall in GDP. The fall in output is accompanied with a rise in unemployment and falling wages. Thus an overall reduction in the incomes is largely responsible for the lower welfare.

Welfare losses are greater for the higher income groups since they bear a greater tax burden. The Figure depicts these results.

TABLE 2 - Equivalent Variation: Increase in Income tax by 10%.

| t	q1	q2	q3	q4	q5	q6
2007	0.5094	1.0510	1.7552	2.7844	3.7454	5.4146
2008	0.2563	0.5188	0.8580	1.3401	1.7943	2.4493
2009	0.2224	0.4427	0.7262	1.1190	1.4921	1.9232
2010	0.1996	0.3897	0.6328	0.9590	1.2716	1.5146
2011	0.1756	0.3340	0.5348	0.7916	1.0405	1.0869
2012	-0.4994	-0.8632	-1.4951	-2.1643	-3.1404	-5.1761
2013	-0.5063	-0.8707	-1.5092	-2.1782	-3.1684	-5.2150
2014	-0.5132	-0.8781	-1.5233	-2.1919	-3.1956	-5.2531
2015	-0.5202	-0.8857	-1.5373	-2.2055	-3.2223	-5.2906
2020	-0.5567	-0.9258	-1.6106	-2.2758	-3.3564	-5.4829
2025	-0.5892	-0.9555	-1.6665	-2.3155	-3.4504	-5.6322
2030	-0.6397	-1.0194	-1.7813	-2.4456	-3.6713	-5.9932
2035	-0.7027	-1.1049	-1.9344	-2.6321	-3.9756	-6.5028
2036	-0.7179	-1.1270	-1.9738	-2.6828	-4.0556	-6.6372

RESULTS

2. Cut In Transfers By 10%

Marginal adverse impacts start as the road payments begin. A fall in government expenditures on account of the payments and the reduction in transfers to the households lead to the fall in EV.
As the economy grows, the share of the fixed repayments in the GDP falls and the export lead growth contributes, albeit marginally to a positive welfare of the richer households. Lower income groups bare a greater burden of the negative impacts while higher income groups tend to benefit more in the long run. Table 3 shows the results while the figure portrays the tendencies.

TABLE 3: Equivalent Variation: Cut in transfers by 10%.

| t	q1	q2	q3	q4	q5	q6
2012	-1.0572	-0.6237	-1.0670	-1.7617	-2.3952	-3.9746
2013	-1.0741	-0.6125	-1.0478	-1.7264	-2.3500	-3.8879
2014	-1.0910	-0.6004	-1.0266	-1.6883	-2.3001	-3.7932
2015	-1.1079	-0.5872	-1.0037	-1.6472	-2.2457	-3.6907
2020	-1.1940	-0.5064	-0.8611	-1.3978	-1.9066	-3.0588
2025	-1.2754	-0.3808	-0.6410	-1.0242	-1.3933	-2.1385
2030	-1.3725	-0.2466	-0.4049	-0.6230	-0.8384	-1.1223
2035	-1.4778	-0.0812	-0.1143	-0.1303	-0.1564	0.1297
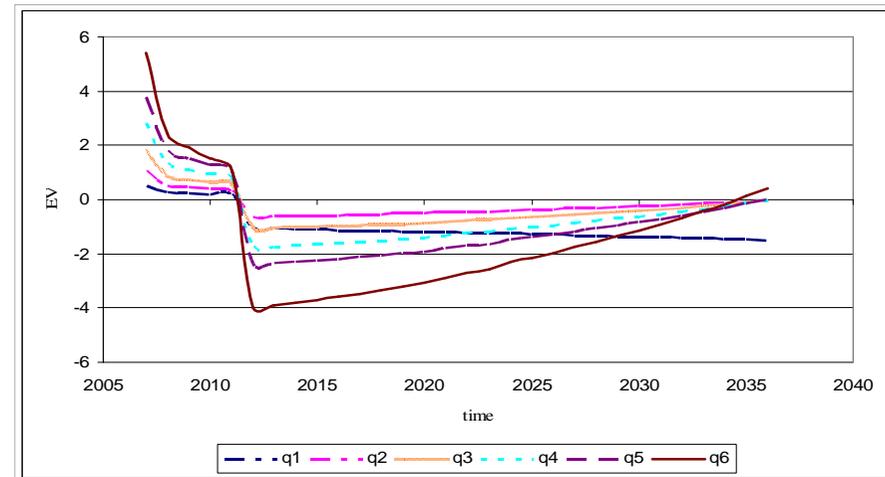
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RESULTS

3. Decrease In Transport Margins by 10%

The main objective of the private-public co-operative enterprise in building the new road was to improve transportation and cut commuting time. This is modelled through a reduction in the transport margins to all agents in the economy via an ad-hoc 10% reduction in the margins.

These results suggest a crowding out of other government projects as compared to the existing expenditure structure. Since in the long run it is the poorest income groups that tend to loose, the project will tend to penalize the poor in benefit of the higher income categories.

TABLE 4: Equivalent Variation: Decrease in transport Margins by 10%.

| t	q1	q2	q3	q4	q5	q6
2012	-0.2595	-0.5810	-0.9860	-1.6575	-2.2866	-3.8697
2013	-0.2550	-0.5687	-0.9656	-1.6200	-2.2380	-3.7770
2014	-0.2500	-0.5554	-0.9433	-1.5796	-2.1847	-3.6765
2015	-0.2444	-0.5411	-0.9191	-1.5362	-2.1267	-3.5681
2020	-0.2083	-0.4540	-0.7689	-1.2740	-1.7693	-2.9079
2025	-0.1498	-0.3213	-0.5390	-0.8855	-1.2362	-1.9600
2030	-0.0870	-0.1791	-0.2910	-0.4671	-0.6597	-0.9159
2035	-0.0095	-0.0047	0.0135	0.0452	0.0459	0.3648
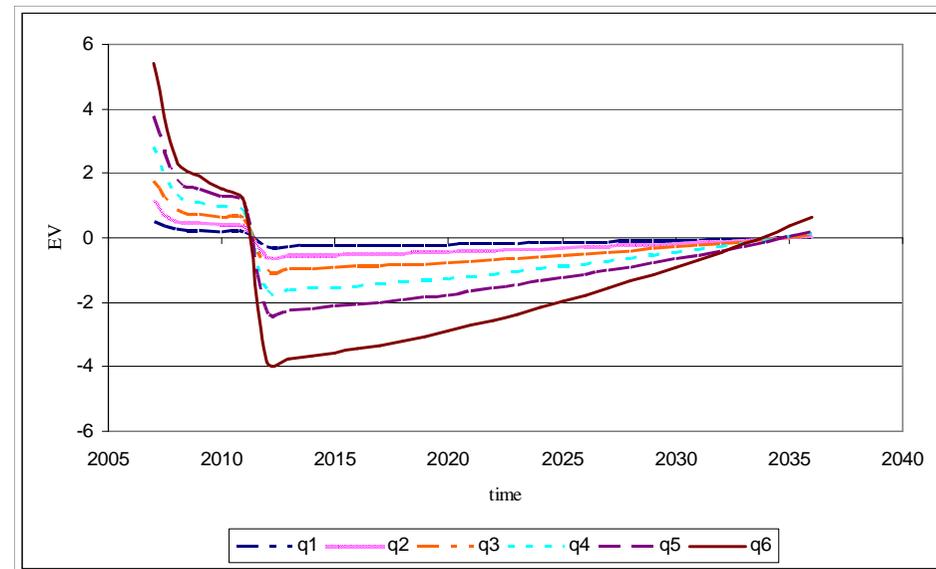
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RESULTS

4. Decrease In Transport Margins By 10% And Increase In Income Taxes By 10%

we combine the tax increase and transfer cuts with the accrued benefits of transport margins. As expected the welfare losses are lower when the implicit gains from road construction are accounted for but are not large enough to offset the additional payment burden.
In this case, the higher income groups tend to bear a greater burden, as expected. Table 5 and the figure present the results.

TABLE 5: Equivalent Variation: Decrease in transport Margins by 10% and Increase in Income taxes by 10%.

t	q1	q2	q3	q4	q5	q6
2012	-0.4752	-0.8220	-1.4165	-2.0642	-3.0390	-5.0801
2013	-0.4813	-0.8275	-1.4280	-2.0730	-3.0596	-5.1051
2014	-0.4873	-0.8329	-1.4391	-2.0813	-3.0789	-5.1284
2015	-0.4933	-0.8382	-1.4500	-2.0891	-3.0972	-5.1505
2020	-0.5240	-0.8650	-1.5031	-2.1244	-3.1820	-5.2546
2025	-0.5486	-0.8774	-1.5311	-2.1175	-3.2122	-5.2925
2030	-0.5888	-0.9191	-1.6091	-2.1873	-3.3516	-5.5124
2035	-0.6387	-0.9767	-1.7149	-2.2968	-3.5525	-5.8431
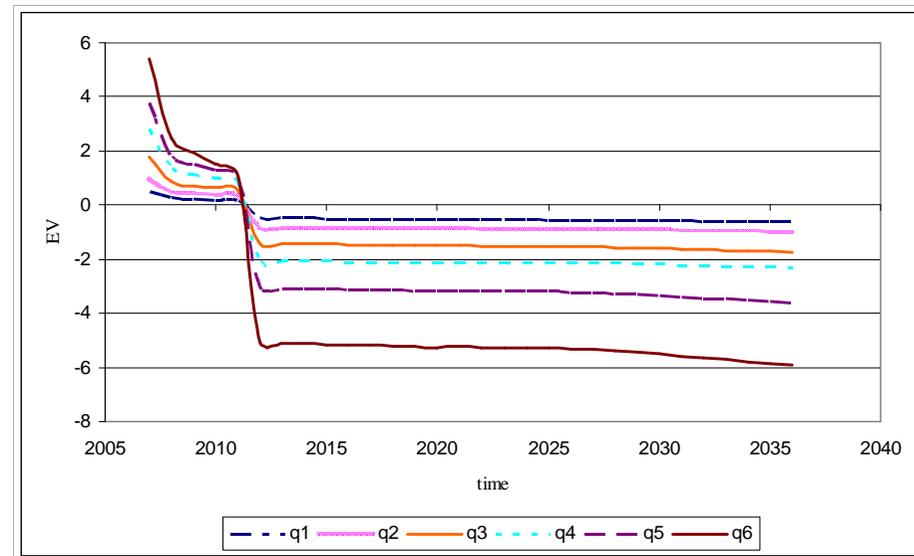
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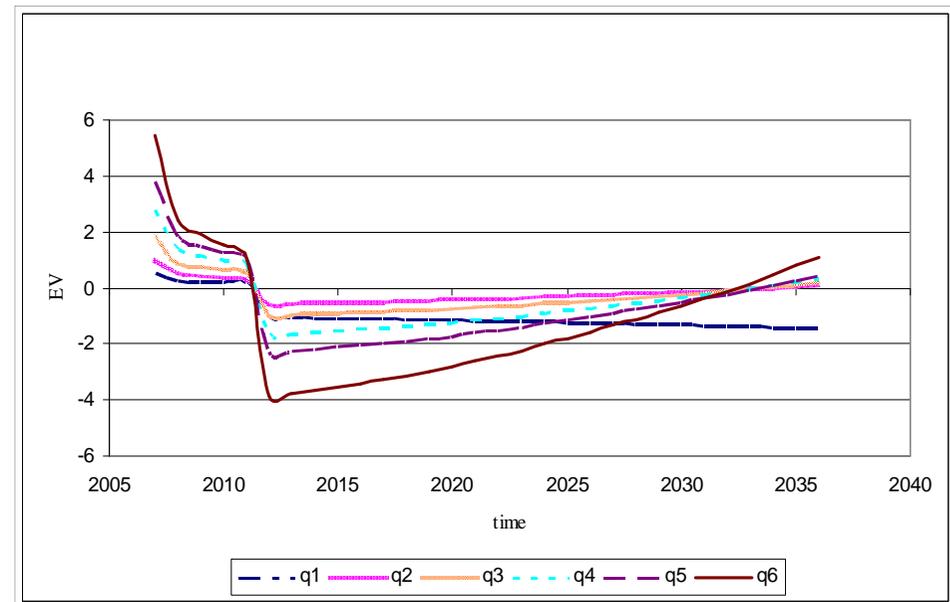
RESULTS

5. Decrease In Transport Margins By 10% And Decrease In Transfers by 10%

In the final scenario, we assume that the benefits of reduction in transport margins of 10% accrue to all, but now reduce transfers by 10% to meet the cost of the road. As expected the poorest (q1 households) are affected as transfers form a larger part of their income, while the rich (q6) are not so greatly affected. This is of course better than the case where we did not consider a reduction in transport costs. Again, as expected, the conclusion is that the lower income groups stand to loose more than the higher income categories due to the fact that more resources are being taken from programs that generally favour the poorest.

TABLE 6: EV for Decrease in Transport Margins and Decrease in Transfers by 10%.

t	q1	q2	q3	q4	q5	q6
2012	-1.0331	-0.5825	-0.9884	-1.6616	-2.2938	-3.8789
2013	-1.0491	-0.5692	-0.9664	-1.6211	-2.2410	-3.7780
2014	-1.0651	-0.5550	-0.9423	-1.5775	-2.1832	-3.6685
2015	-1.0811	-0.5396	-0.9162	-1.5306	-2.1203	-3.5505
2020	-1.1613	-0.4454	-0.7533	-1.2460	-1.7316	-2.8297
2025	-1.2348	-0.3024	-0.5051	-0.8257	-1.1543	-1.7974
2030	-1.3216	-0.1461	-0.2322	-0.3640	-0.5177	-0.6395
2035	-1.4139	0.0473	0.1057	0.2056	0.2676	0.7915

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RESULTS

Scenario Comparisons:

To have a meaningful comparison across scenarios, we compare the net present value of the equivalent variation for all the scenarios mentioned. The results substantiate the intuition that the reduction in welfare is the least without any additional burden. The welfare loss increases with cut in transfers and is maximum for the increase in income tax. These effects are mitigated due to the presence of the reduction in transport margins on account of the new road. The poorest strata of society (q1 households) are susceptible to cut in transfers while the richest (q6 households) are adversely affected by the rise in income taxes.

TABLE 7 – NPV of Equivalent Variation.

t	q1	q2	q3	q4	q5	q6
Scenario 1	-0.5270	-1.3131	-2.2824	-4.1169	-5.9824	-11.6538
Scenario 2	-3.7536	-5.8508	-10.3646	-14.1031	-21.5646	-37.3068
Scenario 3	-9.1277	-1.7685	-3.0825	-5.1900	-7.1738	-12.9613
Scenario 4	-3.4499	-5.2783	-9.3548	-12.6589	-19.8681	-34.9884
Scenario 5	-8.8241	-1.1946	-2.0700	-3.7424	-5.4726	-10.6356

Scenario 1: 10% Increase in Income Taxes
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CONCLUSIONS

- The current paper set out to measure the impact of a major road project under a private-public partnership in the Azores, using a multi sector, multi household, dynamic CGE model, calibrated using a SAM matrix constructed with 2001 data.
- As expected, the project has an initial positive impact given that, during the first five years, there are no payments made to the private partner. The negative impact sets in after construction is completed and the investment has to be repaid.
- Account is taken of the fact that trade margins should be reduced because of improvement of land transportation.
- Overall, it does not seem that the initial positive impacts on welfare compensate the subsequent welfare loss due to the payments that have to be made.
- There is an unambiguous fall in welfare by the imposition of an additional income tax.
- Lower income households tend to bear a greater burden if the payment is done by reducing transfers as opposed to increasing taxes. In this case it is the higher income groups that pay more.
- No reasonable scenario provides sufficient efficiency gains to justify the investment undertaken.

CONCLUSIONS

- Shortcomings of the model:
  - Data;
  - Perfect competitions assumption;
  - Aggregate consideration of nine islands,
- Areas of improvement:
  - Update data (2005);
  - Test assumptions of imperfect competition;
  - Disaggregate by island (?)
- Extensions:
  - Develop measures of sensitivity to shocks (weight scenarios)
  - ...
- Other applications of shocks:
  - US air base closure
  - T-TIP
  - Tax increases/decreases

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The Model

A modelling platform of the Azores economy is used which is represented by a dynamic multi-sector computable general equilibrium model (CGE), which incorporates the economic behaviour of six economic agents:

firms,
households,
regional government,
Mainland government,
European Commission and
the external sector

The Model

FIRMS

1. Operate in perfectly competitive markets and maximize profits (or minimize costs) to determine optimal levels of inputs and output, given their production technology
2. Production prices equal average and marginal costs, implied from profit maximization for constant returns to scale technology
3. Gross output for each sector is determined from a nested production structure
4. At the outer nest producers are assumed to choose intermediate inputs and a capital-labour (KL) bundle, according to a Leontief production function, which assume an optimal allocation of inputs
5. At the second nest, producers choose the optimal level of labour and capital, according to a constant elasticity of substitution (CES) function which assumes substitution possibilities between labour and capital
6. Domestic production is valued at basic prices net of taxes but including subsidies (various)

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The Model

HOUSEHOLDS
1. receive income from
   i) labour
   ii) a fixed share of the capital income and
   iii) transfers from the government as unemployment benefits
   iv) Transfers from the regional government
2. pay taxes on
   i) income to government and
   ii)save a fixed fraction of net (money) income
3. budget devoted to consumption is given by the total income minus the taxes and savings

The disposable budget for consumption is allocated between different goods and services according to a Stone-Geary utility function

$$U(C_{c,qu}) = \prod_c (C_{c,qu} - \mu H_{c,qu})^{\alpha H_{c,qu}}$$

The Model

HOUSEHOLDS

In the allocation process, the consumer first decides on the minimum (subsistence) level of consumption of commodity c. Then, the marginal income is allocated between different types of commodities according to the marginal budget shares .

Household welfare gains/losses are valued using the equivalent variation in income which is based on the concept of a money metric indirect utility function

$$EV_{qu} = \prod_{c} \{\{[PZ_c + \sum_{ctm} tchtmz_{ctm,c,qu} \cdot PZ_{ctm}] \cdot (1 + texcz_{c,qu}) \cdot (1 + tcz_{c,qu} + vatcz_{c,qu})\} /$$

$$\alpha H_{c,qu}\}^{\alpha H_{c,qu}} \cdot (VU_{qu} - VUI_{qu})$$

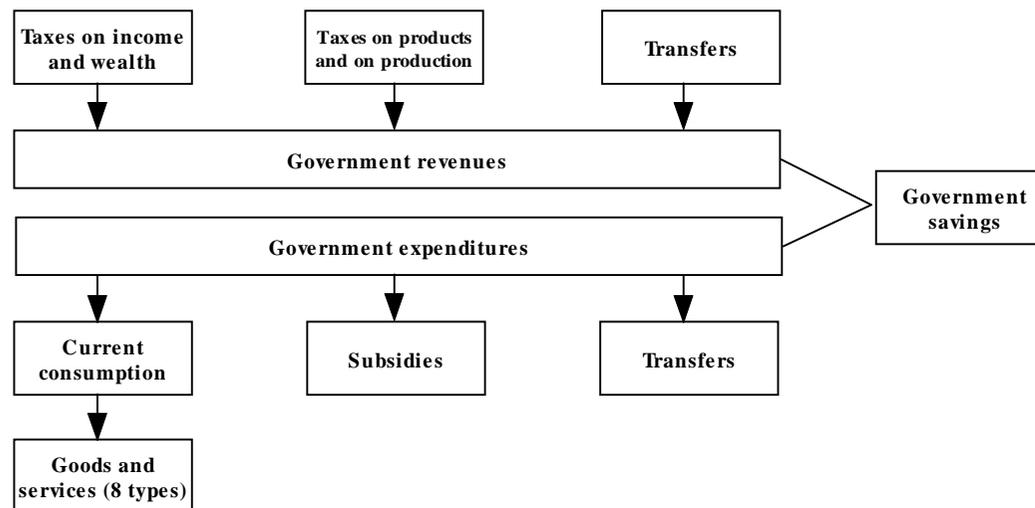Scenario Utility   Benchmark Utility

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The Model

GOVERNMENT - Regional

Government revenues consist of

    1. taxes on corporate and households' income,

    2. consumption taxes,

    3. taxes on investment goods and production

    4. transfers received from

  i) the central government from; ii) the EU and; iii) the external sector

The optimal allocation of the public current consumption between different types of goods and services is given by the maximization of a Cobb-Douglas function

$$U(CG_c) = \prod_c CG_c^{\alpha CG_c}$$

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The Model

FOREIGN TRADE

1. small-country assumption, meaning the region is a price taker
2. world import prices and world export prices are exogenously fixed
3. four main groups of trading partners are distinguished in the model: the Mainland, EU, USA and ROW
4. limited substitution possibilities between domestically produced and imported goods is assumed (Armington (1969)
5. domestic consumers use composite goods of imported and domestically produced goods, according to a CES function

The Model

INVESTMENT

1. Total regional savings are given by the sum of household firm and government savings, plus savings from the rest of the world plus depreciation.
2. Demand for investment commodities by type of commodity is modelled in a simple way, by maximizing a Cobb-Douglas utility function.
3. The maximization process yields the demand equations for investment commodities by type of commodity

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The Model

PRICES

1. the economy is initially in equilibrium with the quantities normalized in such a way that prices of commodities equal unity
2. due to the homogeneity of degree zero in prices, the model only determines relative prices
3. a particular price (GDP deflator) is selected to provide the *numeraire*
4. *Different prices are distinguished for all producing sectors, exports and imports*
5. Trade and transport margins on intermediate consumption, private consumption and investment goods are taken into account in price determination.
6. The consumer price index (*INDEX*) used in the model is of the Laspeyres type

The Model

LABOUR MAR

1. Labour services are used by firms in the production process;
2. The model also allows for endogenous unemployment;
3. The average wage rate is determined by a wage curve;
4. The labour supply curve, assumed to exhibit a positive correlation between the domestic labour supply and the real average wage rate, is used to endogenize labour supply in the model

$$\sum_s LSK_s = LSR - UNEMP$$

LSK: number of emplyees in industry
LSR: active population
UNEMP: unemployed workers

The Model

LABOUR MARKET

The responsiveness of real wage to the labour market conditions is surprised by a wage curve (Sanz-de-Galdeano & Turunen, 2006):

$$log(PL/PCINDEX) = elasU \cdot log(UNRATE) + err$$

The labour supply is provided by the following equation:

$$LSR = LSRI \cdot \{ [PL \cdot (1 - tyavr) \cdot PCINDEXZ]/[PLZ \cdot (1 - tyavrz) \cdot PCINDEX] \}^{elasLS}$$
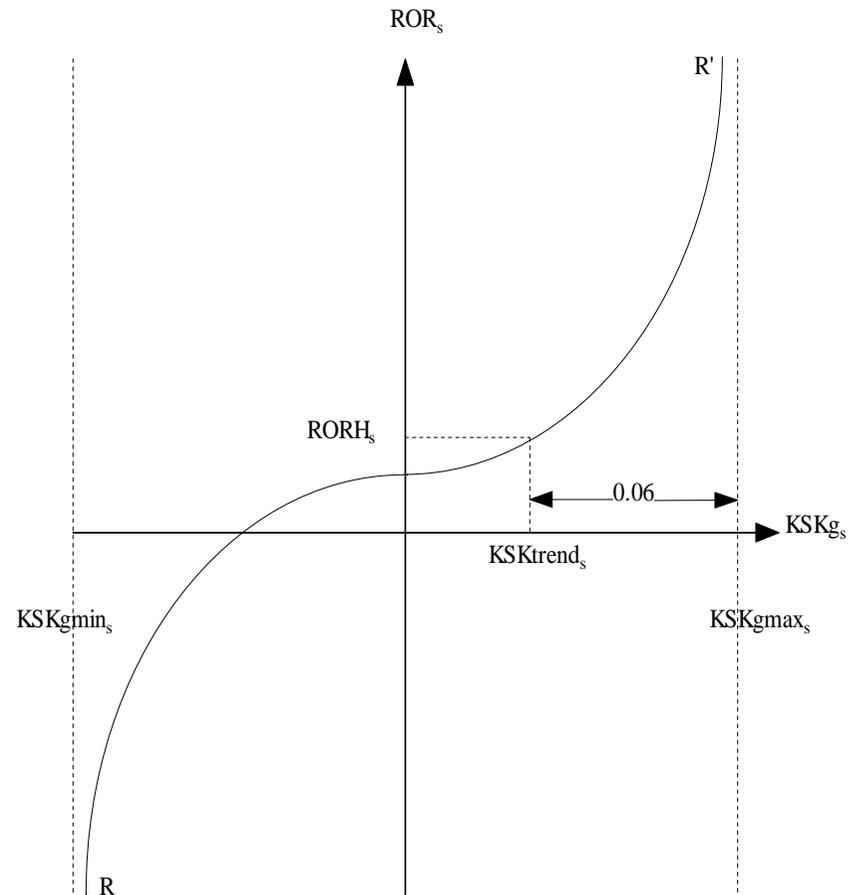
The Model

DYNAMICS

1. AzorMod has a recursive dynamic structure composed of a sequence of several temporary equilibria;
2. The equilibria are connected to each other through capital accumulation;
3. The endogenous determination of investment behavior is essential for the dynamic part of the model;
4. Investment and capital accumulation in year *t* depend on expected rates of return for year *t+1*, which are determined by actual returns on capital in year *t;*

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The Model

DYNAMICS

The normal rate of return to capital in branch *s,* is specified as an inverse logistic function (see Figure) of the proportionate growth in sector's *s* capital stock (Dixon and Rimmer, 2002):

$$ROR_{s,t} = RORH_s + (1/B_s) \cdot [ln(KSKg_{s,t} - KSKg\,min_s) - ln(KSKg\,max_s - KSKg_{s,t}) -$$

$$ln(KSKtrend_s - KSKg\,min_s) + ln(KSKg\,max_s - KSKtrend_s)]$$

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The Model

DYNAMICS

Parameter Bs reflects the sensitivity of capital growth in branch *s* to variations in its expected rate of return

$$B_s = SEA \cdot \left[\frac{KSKg\,max_s - KSKg\,min_s}{(\,KSKg\,max_s - KSKtrend_s\,) \cdot (\,KSKtrend_s - KSKg\,min_s\,)} \right]$$

$$SEA = \left(\frac{\partial ROR_{s,t}}{\partial KSKg_{s,t}} \right)^{-1} \qquad\qquad SEA = \left(\frac{\partial ROR_{s,t}}{\partial KSKg_{s,t}} \bigg| KSKg_{s,t} = KSKtrend_s \right)^{-1}$$

is the reciprocal of the slope of the RR' in Figure

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The Model

DYNAMICS

The present value of investing a unit of capital

$$PVK_{s,t} = -PI_t + [PK_{s,t+1} + PI_{t+1} \cdot d_s + PI_{t+1} \cdot (1 - d_s)] / [1 + NINT_t]$$

nominal interest rate

The expected rate of return on investment in industry (dividing by PI)

$$ROR_{s,t} = -1 + [PK_{s,t+1} / PI_t + PI_{t+1} / PI_t] / [1 + NINT_t]$$

The Model

DYNAMICS

The weighted average real return to capital has been taken as a proxy for the real interest rate in AzorMod. The return to capital is expressed in real terms using the production price index:

$$RINT_t = \sum_s [(PK_{s,t} / PD_{s,t}) \cdot KSK_{s,t}] / \sum_s KSK_{s,t}$$

The capital stock in industry next period

$$KSK_{s,t+1} = (1 - d_s) \cdot KSK_{s,t} + INV_{s,t}$$

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A CGE Analysis of a Project

The Model

MARKET CLEARING

1. Equilibrium in the product, capital and labour markets requires that demand equals supply at the prevailing prices
2. clearing equation for the labour market
3. the sum of demand for intermediate inputs, of demand for government and households consumption, of demand for investment goods and inventories must equal the supply of the composite good from domestic deliveries and imports
3. Total demand for trade and transport services is further given by the sum of demand for trade and transport services on intermediate consumption, on private consumption and on investment goods.
4. capital stock is sector specific.
5. Additional assumptions are needed with regard to regional government behaviour in AzorMod. First, regional government savings are fixed in real terms while regional government total current consumption adjusts to achieve the target set with respect to the government savings. The allocation between the consumption of different goods and services is provided by a Cobb-Douglas function. Secondly, the transfers received by the regional government from the Mainland government, from the EU, from the US and from the ROW are fixed in real terms. On the expenditure side, the regional government transfers to the households are also fixed in real terms.
6. For the external balance, the exchange rates are kept unchanged in the simulations, while the balances of the current accounts adjust. An alternative closure is also possible where the balances of the current accounts corresponding to US and ROW are set while the real exchange rates adjust. The setup of the closure rules is important in determining the mechanisms governing the model. Therefore, the closure rules should be established also taking into account the policy scenario in question.