Società italiana di economia pubblica
XXI CONFERENZA

PUBLIC CHOICE E POLITICAL ECONOMY
I fondamenti positivi della teoria di finanza pubblica

Pavia, Università, 24-25 settembre 2009

PUBLIC INFRASTRUCTURE INVESTMENT AND TAXATION: THE CASE OF TRANSPORT POLICY IN THE EUROPEAN UNION

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PUBLIC INFRASTRUCTURE INVESTMENT AND TAXATION: THE CASE OF TRANSPORT POLICY IN THE EUROPEAN UNION

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Abstract. Public infrastructure investment includes the building of roads, ports, schools, hospitals, etc. It has been recognized important for economic growth, but the aspects related to the impacts of public infrastructure investment coupled with taxation on macroeconomic indicators and cost redistribution over time have been neglected in literature. This paper aims to discuss them analyzing as case study the public investment for transport infrastructure in the EU. A computable general equilibrium (CGE) model, called GTAP-CTI, has been applied to include the predicted variations in the public investment expenditure. Two sets of scenarios have been simulated. The first set compares the application of consumption and income taxation to face the increase of the public investment expenditure. The second set of scenarios compares the application of taxation in 2010 and 2050 facing the question of redistribution over time of the public investment expenditure. The framework employed in the paper is highly specialized and the results may not hold generally, but they mark two policy recommendations. Firstly, the choice of the tax instrument matters to avoid the crowding out effect on private expenditure. Secondly, consumption taxation is better than income taxation. At international level, there are gains in terms of trade, but global welfare decreases.

Keywords: *computable general equilibrium; taxation; public investment; redistribution; transport policy.*

JEL Code C68 – H23 – H54

1. Introduction

Public investment in infrastructure has been recognized important for economic growth. Over the last twenty years different studies have faced the debate on the relationship between public investment and economic growth (e.g. Barro (1991), Banister (2001)). Their common finding is that public investment promotes economic growth at regional and local levels.

Initially, empirical studies on this literature have typically used an econometric approach (e.g. Ford and Poret (1991), Gramlich (1994)). Furthermore, several studies have attempted to take into account the impact of public investment using a computable general equilibrium (CGE) approach. For example, Jung and Thorbecke (2003) suggest that increasing investment in education must be coupled with policies that enhance the demand for labor through an appropriate pattern of economic growth. Rioja (2001) and Seung *et al.* (2001) show that more infrastructure investment may reduce welfare. More recently, Atolia (2008) shows that when stricter enforcement is used as a tool to raise revenue for public investment, the positive impact on growth from increased public investment is tempered by the negative general equilibrium effect on private capital accumulation. Berrittella (2009) shows that public investment on one country affects negatively on economic growth of the other countries.

An important concern that has not been appropriately analysed in the literature on CGE modelling is the redistribution effect over time of public infrastructure investment in different tax structures. Since the important result due to Atkinson and Stiglitz (1976), the literature on the design of tax structure has significantly growing (e.g. Christiansen (1984), Boadway *et al.* (1994), Naito (1999), Cremer *et al.* (2001), Saez (2004), Kaplow (2006)). However, these studies are mainly theoretical and have been concentrated on partial equilibrium analysis. Adam and Bevan (2006) compare various infrastructure investment funded with different fiscal tools using a CGE approach, but they do not face the distributive effects over time. Forni *et al.* (2009) discuss the general equilibrium effects of fiscal policy in the Euro area, but they restrict their analysis to a closed economy setup and to indirect taxation.

In this context, the analysis in this paper is novel in two aspects. Firstly, the paper aims to discuss the general equilibrium feedback effects in short and long run of increasing public infrastructure investment with different tax structures. In more details, the experiments have been split in two sets. The first set compares the application of consumption and income taxation to face the increase of the public investment expenditure. The second set of scenarios compares the application of taxation in 2010 and 2050 facing the question of redistribution over time of the public investment spending. A computable general equilibrium (CGE) model, called GTAP-CTI, has been applied to include the predicted variations in the public investment expenditure. Secondly, the contribution is empirical. The public investment planned in the Trans-European Transport (TEN-T) network for transport infrastructure has been taken as case study, which refers to already decided infrastructure investments or budget allocations, as provided by the experts from national ministries in the European Union (Planco Consulting, 2003).

The framework employed in the paper is highly specialized and the results may not hold generally, but they imply two marked policy recommendations. Firstly, the choice of the tax instrument matters to avoid the crowding out effect on private expenditure. Secondly, consumption taxation is better than income taxation. At international level, there are gains in terms of trade, but global welfare decreases.

2. Modeling framework

In order to assess the systematic general equilibrium effects of public investment and taxation, a computable general equilibrium (CGE) model, called GTAP-CTI, has been applied. It has been developed by Berrittella (2009) to include the variation in the public investment expenditure. GTAP-CTI is a refinement of the GTAP model, that is a comparative static, multi-commodity, multi-region CGE model with the assumptions of perfect competition and market equilibrium. Hertel (1997) and Adams (2005) report a detailed description of the GTAP model and on the interpretation of results from CGE simulations.

CGE models build upon general equilibrium theory, that combines behavioural assumptions on rational economic agents with the analysis of equilibrium conditions. To analyze the impact of change in government policy, the CGE modellers use the comparative methodology. Initially, the model is developed such that its equilibrium replicates the transactions observed in the data. This procedure, called calibration, refers to the estimation of structural parameters of the model, based on available information on prices and quantities, normally, obtained from a Social Accounting Matrix (SAM). Moreover, the policy change is simulated by altering the relevant parameters and calculating the new equilibrium. The main virtue of the CGE approach is its comprehensive micro-consistent representation of price-dependent market interactions. The simultaneous explanation of the origin and spending of the agents' income makes it possible to address both economy-wide efficiency, as well as distributional policy impacts. Since the first CGE application by Johansen (1960), CGE models have been widely employed by various national and international organizations (IMF, World Bank, OECD, etc.), the European Commission, research institutions and universities. For survey articles on CGE analysis see Shoven and Whalley (1992).

GTAP-CTI model has been applied by aggregating the world economy from 87 into 16 regions, with each representing either a single country, or a composite region of several countries (Table 1). Each region's economy is further divided into 17 industries or commodity groups with emphasis on agriculture products, energy products and related sectors (Table 2).

Commonly to the standard GTAP model, industries are modelled through representative firms minimizing costs and taking prices as given. The production functions are specified via a series of nested constant elasticity of substitution (CES) functions (Figure 1):

$$y_i = \left(\sum_{j=1}^{n} \theta_j x_j^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \qquad (1)$$

where y_i is the production of the good i, x_j is the input j, θ_j is a non-negative parameter with $\sum_j \theta_j = 1$, σ is the elasticity of substitution.

Table 1. Regional aggregation

Acronym	Region	Countries
USA	United States of America	United States of America
CAN	Canada	Canada
EU-15 and EFTA	Western Europe	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom
JPK	Japan and Korea	Japan, Korea
ANZ	Australia and New Zealand	Australia, New Zealand
EU-12	Central and Eastern Europe	Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
FSU	Former Soviet Union	Former Soviet Union
MDE	Middle East	Turkey, Rest of Middle East
CAM	Central America	Mexico, Central America, Carribean,
SAM	South America	Colombia, Perù, Venezuela, Rest of Andean Pact, Argentina, Brazil, Chile, Uruguay, Rest of South America
SEA	Southeast Asia	Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam
CHI	China plus	China, Hong Kong
ROW	Rest of world	Small Island States
SAS	South Asia	Bangladesh, India, Sri Lanka, Rest of South Asia
NAF	North Africa	Morocco, Rest of North Africa
SSA	Sub-Saharan Africa	Botswana, Rest of SACU, Malawi, Mozambique, Tanzania, Zambia, Zimbawe, Other Southern Africa, Uganda, Rest of Sub-Saharan Africa

Table 2. Industry aggregation

Acronym	Industry	Sectors
Rice	Rice	Paddy rice
Wheat	Wheat	Wheat
CerCrops	Cereals and Crops	Cereal grains, crops
VegFruits	Vegetables and Fruits	Vegetables, fruit, nuts, oil seeds, sugar cane and beet, plant-based fibers
Animals	Animals	Cattle, sheep, goats, horses, animal products
Forestry	Forestry	Forestry
Fishing	Fishing	Fishing
Coal	Coal	Coal
Oil	Oil	Oil
Gas	Gas	Gas, gas manufacture and distribution
Oil_Pcts	Oil Products	Petroleum, coal products
Electricity	Electricity	Electricity
Water	Water distribution services	Water distribution services
En_Int_Ind	Energy Intensive Industries	Minerals, chemical, rubber, plastic products, mineral products, ferrous metals, metals
Oth_Ind	Other Industries	Raw milk, wool, silk-worm cocoons, meat, vegetable oils and fat, dairy products, processed rice, sugar, food products, beverages and tobacco products, textiles, wearing apparel, leather products, wood products, paper products, publishing, metals products, motor vehicles and parts, transport equipment, electronic equipment, machinery, manufactures
Mserv	Market Services	Construction, trade, surface transport, sea transport, air transport, communication, financial services, insurance, business services, dwellings, recreation and other services
NMServ	Non-market Services	Public administration, defence, health and education

Each primary factor (Labor, Capital, Land and Natural Resources) is supplied to industries from its fixed regional endowment. Labor and capital are perfectly mobile endowments earning the same market return. Land and natural resources are sluggish endowments to adjust and, hence, they sustain differential returns in equilibrium. Domestic and foreign inputs are not perfect substitutes, according to the so called "Armington assumption", which accounts for product heterogeneity (Armington, 1996).

A representative household receives income, which is used to finance three classes of expenditure: private consumption, public consumption and savings. Her utility function is specified by a Cobb-Douglas structure (Figure 2). Furthermore, a constant-difference-elasticity (CDE) utility function is used for determining private consumption. Public consumption is determined by the maximization of a Cobb-Douglas utility function. Both public and private demands are split in a series of alternative composite Armington aggregates.

Figure 1 –Nested tree structure for industrial production process

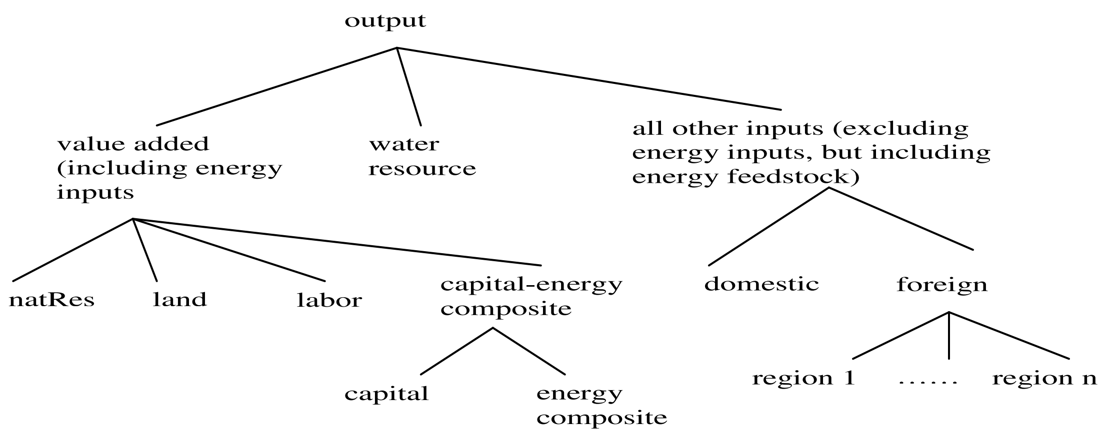
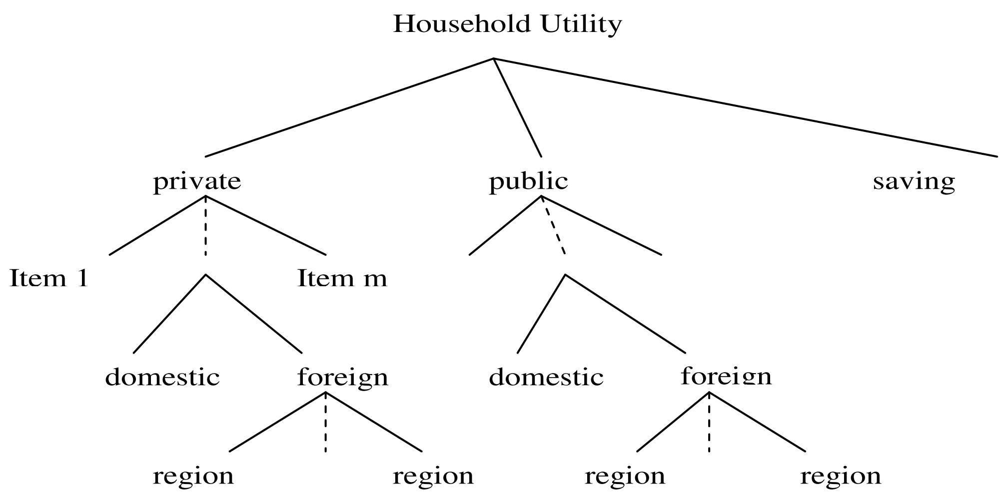


Figure 2- Nested tree structure for final demand



In the standard GTAP framework, regional investment, REGINV(r) is an endogenous variable. Also, regional savings, SAVE(r), and investment are not equalized domestically, but only at the global scale. In more details, there is a composite investment good (GLOBINV), based on a portfolio of net regional investment (gross investment less depreciation), and offered to regional households to satisfy their savings demand such that:

$$\sum_{r \in REG} REGINV(r) = GLOBINV = \sum_{r \in REG} SAVE(r) \tag{2}$$

All savers face a common price for the savings commodity (PSAVE). Investors behave in such a way that changes in regional rates of return are equalized across regions:

$$rore(r) = rorg \tag{3}$$

where *rore(r)* is the percentage change in region's rate of return and *rorg* is the percentage change in global rate of return.

The percentage change in global supply of new capital goods (*globalcgds*) is computed as follows:

$$globalcgds = \sum_{r \in REG} \left\{ \frac{REGINV(r)}{GLOBINV} qcgds(r) - \frac{VDEP(r)}{GLOBINV} kb(r) \right\} \tag{4}$$

where *qcgds* and *kb* are, respectively, the percentage change of capital goods demand and beginning-of-period capital stock, in region r, and *VDEP* is the value of capital depreciation in *r*.

If (1) all other markets are in equilibrium, (2) all firms earn zero profits and (3) all households are on their budget constraint, then global investment must equal global savings by Walras'law.

In GTAP-CTI, investment has been fixed exogenously for the EU-15 and EFTA countries augmenting the calibration value by the percentage change, which accounts for the specific additional investment expenditure planned in the TEN-T network. In more details, the following two equations must be satisfied to obtain the equilibrium for capital goods demand :

$$qcgds(r) = qo(r) \quad \forall r \tag{5}$$

$$qcgds(EU-15\ \ and\ \ EFTA) = investment(EU-15\ \ and\ \ EFTA) \tag{6}$$

where *qo(r)* is the percentage change of capital goods output in region r.

Furthermore, to ensure the equalization of global savings and investment, an endogenous adjustment of regional saving, *qsave(r)*, has been set up assuming that all regional investments increase by the same percentage:

$$qsave(i) = qsave(j) \qquad \forall i \neq j \tag{7}$$

In this way, the assumption of perfect international mobility of capital is respected.

3. Experiment design and data

Public investment in the EU related to transport infrastructure as planned by the TEN-T network, includes the construction of four lines: (i) North-South line; (ii) Betuwe line; (iii) France-Italy line; (iv) East European line. The expected public investment spending is almost $ 50,000 Millions[1]. The expected social benefits are mainly reduction of the journey times and pollution, increase of road safety and infrastructure capacity.

As this public investment is planned to end by 2010, the approach is based on a two-stage procedure. Firstly, counterfactual equilibria of the world economy are generated by "*pseudo-calibration*" from 1997 to 2010. This entails changing the initial calibration data in the model to forecasted values of some key economic variables for 2010. The calibration data comes from the GTAP database, version 5, that contains the 1997 world economy data. The forecasted values for 2010 include estimates of population growth, endowments change of labour, capital and natural resources, productivity change of labour and land (Table 3). The resulting scenario is called "*benchmark*"[2].

Subsequently, conventional comparative analysis is conducted simulating five scenarios for EU-15 and EFTA countries (Table 4): (i) investment in 2010 (*Scenario 1*); (ii) investment and income taxation in 2010 (*Scenario 2*); (iii) investment in 2010 and income taxation in 2050 (*Scenario 3*); (iv) investment and private consumption taxation in 2010 (*Scenario 4*); (v) investment in 2010 and consumption taxation in 2050 (*Scenario 5*).

The exogenous change of investment in country r induced by the variation in investment has been computed as follows:

$$\mu = \frac{I_{Tr}}{I_b} \times 100 \tag{8}$$

where I_{Tr} and I_b are, respectively, investment for transport infrastructure and total investment in the EU-15 and EFTA countries. Moreover, the value of I_{Tr} is the planned investment in the TEN-T network programme. The value on denominator is obtained from the *benchmark* scenario, and it is equal to the sum of the domestic and foreign investment demand.

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[1] Investment is expressed in euros in the TEN-T network programme, whereas GTAP database is in dollars. Euro values have been converted into dollars employing an exchange rate of euro 1:1.4819 dollars, that is the average exchange rate in 2008. See Planco Consulting (2003) for more details on combined transport investment in Western Europe.

[2] These estimate values have been widely used for analyzing climate change impacts (Berrittella *et al.*, 2006) and sustainability (Zhang *et al.,* 2007).

Table 3. Estimates (% change from 1997 to 2010)

Region	Population growth (%)	Capital stock change (%)	Labour stock change (%)	Labour productivity change (%)				Land productivity change (%)
				Agr[1]	Ene[2]	Elec[3]	Others[4]	
USA	11.29	42.19	35.74	23.18	0	14.95	29.52	78.24
CAN	9.99	32.47	40.69	26.17	2.35	29.09	29.09	135.5
EU-15 and EFTA	1.11	22.79	39.92	27.64	3.63	19.12	32.24	44.66
JPK	-0.9	53.68	20.17	26.06	0	17.64	29.86	106.41
ANZ	10.38	32.15	40.69	25.91	2.32	28.80	28.80	135.5
EU-12	-2.27	33.08	34.83	45.35	18.45	35.80	45.35	117.7
FSU	-2.26	35.03	34.83	48.03	19.54	37.92	48.03	117.7
MDE	31.85	51.82	72.47	56.17	26.78	45.73	51.65	203.93
CAM	21.79	37.51	74.04	57.79	27.55	47.04	64.14	203.93
SAM	18.73	41.10	74.04	63.32	30.19	51.55	70.29	203.93
SEA	22.89	52.29	42.32	62.42	29.76	50.82	69.02	206.25
CHI	20.27	33.64	74.04	51.83	24.71	42.20	57.53	203.93
ROW	11.85	45.39	42.32	54.19	25.84	44.12	59.92	206.25
SAS	30.53	28.12	74.04	43.32	20.65	35.27	48.09	203.93
NAF	36.23	37.56	74.04	57.87	27.59	47.11	64.24	203.93
SSA	17.25	42.16	74.04	64.95	30.96	52.87	72.09	203.93

[1]Agr includes Rice, Wheat, CerCrops, VegFruits, Animals, Forestry, Fishing. [2]Ene includes Coal, Oil, Gas, Oil_Pcts, En_Int_Ind. [3]Elec includes electricity. [4] Others includes Water, Oth_Ind, MServ, NMServ.

Table 4. Experiment design (percent change from benchmark scenario)

Scenarios	%
Scenario 1	
Investment change in 2010	2.564
Scenario 2	
Investment change in 2010	2.564
Change in share of private consumption taxation on income in 2010	0.008
Scenario 3	
Investment change in 2010	2.564
Change in share of private consumption taxation on income in 2050*	0.024
Scenario 4	
Investment change in 2010	2.564
Change in share of income taxation on income in 2010	0.005
Scenario 5	
Investment change in 2010	2.564
Change in share of income taxation on income in 2050*	0.016

* Discount rate 3%.

Any additional public investment is financed by raising, exogenously, taxes. In particular, for direct tax scenarios (*Scenario 2* and *3*), the share of income tax on income has been exogenously set. Moreover, in the short run, that is 2010, labour supply is assumed to be exogenous and individuals cannot change it. In the long-run, that is in 2050, labour supply is assumed to be endogenous. This is a realistic assumption, because individuals choose their supply on the relative after-tax rewards. For indirect taxation scenarios (*Scenario 4* and *5*), the share of private consumption tax on income has been exogenously set. The choice to tax only private consumption finds reason in the fact that the users of the four lines will be mainly private rather than public users.

If taxation is applied in 2010, the investment and taxation are faced by the same generation. Introduction of taxation in 2050 allows for analyzing intergenerational redistribution. In fact, if I assume that in 2010 and 2050 live two different generations, respectively, current and future generation, *Scenario 3* and *5* imply that in 2010 the current generation has the benefits of the public investment, in 2050 the future generation sustains the investment cost, paid by taxation.

4. Simulation results

This section presents the short and long run effects on key macroeconomic indicators and redistribution over time due to the additional public investment for transport infrastructure, financed by taxation, in the EU-15 and EFTA countries.

Table 5 reports the results in terms of GDP, employment, private and public expenditure for the EU-15 and EFTA countries. In *scenario 1* and *2*, the effects of additional investment on GDP are positive However, in *Scenario 3, 4* and *5* the effects on GDP of investment coupled with taxation become negative; particularly, in the income taxation scenarios (*Scenario 4* and *5*), the negative effects on GDP significantly increase. By assumption, in *scenario 5*, labour supply is endogenous and the result on employment shows that the household reduces her labour supply on the relative after-tax rewards. This result is due to the substitution effect, that is, the increase of the share of income tax on income reduces the net wage making labor less attractive. Comparing the public and private expenditure, the results show that they follow the same pattern. Only in *scenario 5* they become negative. This means that the crowding out effect on private expenditure only appears at a certain high level of taxation and for income taxation. This result suggests that the choice of the tax instruments matters to avoid the crowding out effect, and not only the taxation amount.

Table 5. Macroeconomic effects of raising public infrastructure investments in the EU-15 and EFTA countries (change from benchmark scenario)

	Scenario 1 Investment in 2010	**Scenario 2** Investment and consumption taxation in 2010	**Scenario 3** Investment and consumption taxation in 2050	**Scenario 4** Investment and income taxation in 2010	**Scenario 5** Investment and income taxation in 2050
GDP (%)	0.048	0.024	-0.038	-0.584	-3.110
Employment (%)	0	0	0	0	-5.806
Private expenditure (%)	0.298	1.245	3.367	0.192	-3.362
Government expenditure (%)	0.453	1.273	3.111	0.355	-2.929

EU-15 and EFTA countries gain from additional public investment, except in *scenario 5* (Table 6). Additional infrastructure investment can be beneficial, but welfare can be adversely affected again due jointly to the large increase in taxation and the selected tax structure. Decomposing the welfare change in its components, change in welfare is due to the allocative and trade effects in *Scenario 1* and *2*. The contribution to welfare change of allocative effects becomes negative in the long run (*Scenario 3 and 5*). If income taxation is applied (*scenario 4* and *5*), the welfare change is due also to the endowments change from one sector to another for *scenario 4*, and also to the change of labour supply in *scenario 5*. Comparing the consumption and income scenarios, the main finding is that income taxation is sub-optimal and that redistribution of the investment cost should be achieved with consumption taxation. This result is opposite to that in Saez (2004), that shows that direct income taxation should be preferred to indirect tax instruments, such as consumption taxation. The contrast in the results is due to the general equilibrium effects.

At international level, the effects slightly differ amongst scenarios. In terms of trade, Table 7 shows that additional investment generates negative trade balance change in *scenario 1*. In fact, the EU-15 and EFTA countries increase imports, in particular, of manufacturing goods and market services. The other countries gain in terms of trade, except EU-12. This latter region increases the imports of market services from USA and Japan rather than from the EU-15 and EFTA countries. Moreover, it follows that USA and Japan benefit substantially in terms of trade due to the increase in the exports of manufacturing goods and market services. Also China and South-East Asia gain in terms of trade. China mainly increases the export of manufacturing goods, whereas South-East Asia also increases the exports of market services. Table 8 reports the effects on GDP. The EU-12 countries gain in terms of GDP, except if income taxation is applied in 2050. China gains in terms of GDP in any scenario, Japan gains only if income taxation is applied in 2050. In Scenario 1 and 2 the investment in European transport infrastructure increases global welfare (Table 9). In Scenario 3 global welfare change become negative. In Scenario 4 and 5 no country gains.

Table 6. Welfare contributions (Millions $ change, w.r.t. benchmark scenario)

	Welfare Change	**Contribution to welfare change of allocative effects**	**Contribution to welfare change of endowments change**	**Contribution to welfare change of trade effects**
Scenario 1 Investment in 2010	11512	5402	0	6231
Scenario 2 Investment and consumption taxation in 2010	8959	2652	0	6406
Scenario 3 Investment and consumption taxation in 2050	2117	-4290	0	6794
Scenario 4 Investment and income taxation in 2010	-58701	-306	-65704	7413
Scenario 5 Investment and income taxation in 2050	-339332	-28986	-335187	12344

Table 7. Trade balance ($ Millions change w.r.t. benchmark scenario 2010)

	Scenario 1 Investment in 2010	**Scenario 2** Investment and commodity taxation in 2010	**Scenario 3** Investment in 2010 and commodity taxation in 2050	**Scenario 4** Investment and income taxation in 2010	**Scenario 5** Investment in 2010 and income taxation in 2050
USA	9148	9150	9154	9186	9339
CAN	1289	1286	1281	1275	1220
EU-15 and EFTA	-41359	-41383	-41436	-41509	-42111
JPK	12889	12843	12742	12658	11735
ANZ	898	899	901	905	931
EU-12	-176	-175	-172	-170	-148
FSU	1219	1232	1261	1289	1569
MDE	1183	1230	1336	1422	2383
CAM	798	799	801	802	819
SAM	2853	2858	2870	2877	2971
SAS	1479	1476	1470	1468	1426
SEA	3954	3949	3938	3925	3810
CHI	4790	4781	4763	4739	4538
NAF	389	396	412	431	602
SSA	360	368	386	401	567
ROW	288	289	293	300	349

Table 8. GDP (% change w.r.t. benchmark scenario 2010)

	Scenario 1 Investment in 2010	**Scenario 2** Investment and commodity taxation in 2010	**Scenario 3** Investment in 2010 and commodity taxation in 2050	**Scenario 4** Investment and income taxation in 2010	**Scenario 5** Investment in 2010 and income taxation in 2050
USA	-0.001	-0.001	-0.001	-0.001	-0.001
CAN	-0.023	-0.023	-0.023	-0.023	-0.026
EU-15 and EFTA	0.048	0.024	-0.038	-0.584	-3.110
JPK	-0.004	-0.004	-0.003	-0.003	0.002
ANZ	-0.011	-0.011	-0.010	-0.011	-0.012
EU-12	0.006	0.006	0.004	0.002	-0.017
FSU	-0.009	-0.009	-0.011	-0.012	-0.025
MDE	-0.013	-0.014	-0.016	-0.018	-0.038
CAM	-0.006	-0.007	-0.007	-0.008	-0.013
SAM	-0.014	-0.014	-0.015	-0.015	-0.020
SAS	-0.003	-0.003	-0.002	-0.002	0.000
SEA	-0.004	-0.004	-0.004	-0.004	-0.004
CHI	0.005	0.005	0.005	0.005	0.007
NAF	-0.017	-0.019	-0.022	-0.027	-0.064
SSA	-0.005	-0.005	-0.007	-0.008	-0.024
ROW	-0.006	-0.006	-0.006	-0.007	-0.011

Table 9. Welfare change (millions $ w.r.t. benchmark scenario 2010)

	Scenario 1 Investment in 2010	**Scenario 2** Investment and commodity taxation in 2010	**Scenario 3** Investment in 2010 and commodity taxation in 2050	**Scenario 4** Investment and income taxation in 2010	**Scenario 5** Investment in 2010 and income taxation in 2050
USA	-1224	-1240	-1275	-1458	-2396
CAN	-399	-405	-418	-432	-560
EU-15 and EFTA	11512	8959	2117	-58701	-339332
JPK	-1800	-1773	-1714	-1701	-1301
ANZ	-233	-237	-245	-263	-380
EU-12	44	28	-8	-67	-516
FSU	-392	-424	-497	-548	-1171
MDE	-649	-732	-917	-1021	-2514
CAM	-174	-181	-198	-213	-372
SAM	-970	-990	-1033	-1071	-1472
SAS	-251	-248	-243	-249	-241
SEA	-424	-438	-471	-516	-885
CHI	-542	-547	-557	-563	-647
NAF	-181	-205	-260	-304	-798
SSA	-106	-129	-180	-218	-666
ROW	-85	-89	-99	-118	-249
World	**4126**	**1348**	**-5998**	**-67442**	**-353500**

5. Discussion and conclusions

This paper is a first attempt to discuss the macroeconomic and redistributive effects of public investment coupled with an exogenous taxation system in the European Union. A multi-country, multi-region CGE model, called GTAP-CTI, has been applied. Public investment for transport infrastructure in the EU has been taken as case study. Two sets of scenarios have been simulated. The first set compares the application of consumption and income taxation to face the increase of the public investment expenditure. The second set of scenarios compares the application of taxation in the short and long run facing the question of redistribution of the public investment spending.

The framework employed in the paper is highly specialized and the results may not hold generally, but they mark relevant policy recommendations. Income taxation has strong negative effects on GDP, employment and welfare. Consumption taxation may have also negative effects, but the redistributive effects in the long run are less negative than income taxation. The other countries gain in terms of trade, but they suffer welfare loss. Thus, differently to the results in literature, in a general equilibrium context, consumption taxation may be better than income taxation. Furthermore, policy makers must take into account that the choice of tax structure matters to avoid the crowding out effect on private expenditure and welfare loss.

However, these findings must be considered as preliminary results and merit to be further analyzed. In particular, this work calls for three potential future research lines. Firstly, analysis of the effects of increased productivity coupled with exogenous taxation due to additional infrastructure investment. Secondly, comparative analysis of public investment and taxation in countries with different social, economic and environmental context, such as between developing and developed countries. Finally, application of a dynamic CGE model to discuss rigorously the intergenerational redistribution effects due to public investment under different tax structure.

Acknowledgements. I would like to thank Jan Zhang for providing useful comments.

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