

*Tax competition in an open border scenario: An Evolutionary Game approach**

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Abstract

The work underlines the consequences of the globalisation¹ on the tax competition among different jurisdictions on goods. It is highlighted that the principal consequence of the globalisation on the possible goods trans-borders flow renders the problem of tax competition in this sector similar to the one that concerns the capitals.

Taken into account the complexity of the interrelations among the different phenomena that incises on the scenarios in which the tax competition is operating, the work begins with a review of the literature that underlines the contributions most meaningful with respect to: a) the effects of globalisation on the flows of goods and capital; b) the principles on which international fiscality of goods and capital are based; c) the effects of cross-border flows on the total revenue and /or on the welfare function; d) the applications of Game Theory to tax competition; e) the repeated games applied in this sector, both those that endogenise the behavioural variable (like savings) and those that endogenise the strategic variables (like public debt, the level of public expenditure or that of consumption) that lead to the evolutionary approaches if the ability of learning of the institutions is supposed.

Then, according to the approach of the game theory in condition of open borders an interpretative model of the tax competition is proposed. It is shown that the hypothesis of different size countries, used by many authors, is misleading if we consider more than two countries in condition of open borders. Besides it is underlined, that in the case of globalisation the characteristics of the trans-borders market in open borders result so much similar to those of the international capital flows that the interpretative models of optimal international tax competitions of the two phenomena have the tendency to coincide.

On this base, in open borders, the hypothesis of application of a scheme of the type "Prisoner's dilemma", usually adopted for the TC in the capital sector, also seems applicable to the goods market.

In literature it is underlined that the attainable results change according if the model is one of single or repeated games. It seems therefore necessary to use models of repeated games and evolutionary approaches. This is based on two considerations: the opportunity to endogenise the strategic behaviour - that is the choice of the strategies of interrelation among the countries - and the fact that in reality the countries modify or they can constantly modify their fiscality. In fact, every day, countries compare each other on the markets. Necessity is underlined to consider repeated and evolutionary games and the possibility that non single equilibria are reached.

Base of departure of the model has been the contribution of Kabur and Keen, subsequently modified to the purpose consider explicitly the problems leveraged by globalisation and by situations of open borders among more than two countries.

* Though the paper is the result of the work of both authors Alfano has written the survey of literature (§ 1, 2 and 3 a), Salzano has written the remaining part (§ 3 b, 4, 5, 6 and 7). The authors wish to thank Michael Keen for valuable comments.

¹ Globalisation may be defined as a "process that widens the extent and form of cross-border transactions among peoples, assets, goods and services and that deepens the economic interdependence between and among globalising entities, which may be private or public institutions or governments." Trends in Economic & Social Globalization: Challenges and Obstacles. <http://www.globalize.or/course/harvard.html>.

The used methodology takes into account what affirmed by Holland² about the opportunity to make use of simulations in the case of self-adaptive complex systems. Our study will be focused on cross-border movement of capital and goods. In fact, their the effect of globalisation on these tax bases might be similar. The significance of our choice seems not to be marginal. As an example, we could cite the fact that if the Cnossen's estimate in 1990, that the 15% of European population was interested in cross border shopping, we are now dealing at least with an involved population, perhaps, of more than 20 %.

1. Trans-jurisdiction migration of tax base

It is known that in a closed system the tax factor is potentially able to produce distortions. In an open system the differential in the tax rate³ of each country will produce additional distortions⁴, as a large part of the literature has shown⁵.

All jurisdictions are tempted to reduce their own tax rates in order to avoid a tax base erosion and/or attract resources⁶. Very often these jurisdictions are based on completely different principles and each has a different structure and size.

Resource allocation is influenced by tax rate diversity. So, countries "*engage in a race⁷ to cut down rates*" in order to attract tax base under their jurisdiction and/or to increase taxation on imported goods and/or to subsidise exported ones.

Such competition will cause the "*usurpation of the tax base*" and the "*export of the tax burden*"⁸. These externalities⁹ lead to a competitive game between countries. As a result the tax rate will be set at a Nash equilibrium. This scenario is valid for every sort of tax base.

Localisation principles of trans-national flows

A tax system applies the source criterion to impose the "res tax" and the residency or domicile to impose personal tax. Hence, each country might choose two different tax principles when defining goods tax bases: the origin principle - countries tax goods and services produced within their borders;

² Multiple agents, buildings block, internal model, perpetual novelty - taking all this together, said Holland, it's no wonder that complex adaptive systems were so hard to analyse with standard mathematics. Most of conventional techniques like calculus or linear analysis are well suited to describe unchanging particles moving in a fixed environment. But to really get a deep understanding of the economy, or complex adaptive systems in general, what you need are mathematics and computer simulation techniques that emphasise internal models, the emergence of new building blocks, and the rich web of interactions between multiple agents. See M. Mitchell Waldrop, *Complexity*, London 1992, pag.147

³ A group of researchers have focuses on the differential in tax as for example Mieszkowski (1966) and Mc Lure(1969).

⁴ Gordon (1986)

⁵ The main additional distortions to which we refer are: cross country differences in consumer marginal rates of substitution and cross country differences in producer marginal rates of transformation, see de Bonis (1997).

⁶ Much of economic analysis from public finance specialists have been considered in terms of allocative efficiency; Musgrave 1969), Oates (1972), Boskin (1973), Starrett (1980), Arnott and Grieson (1981), Broadway (1982) and Gordon (1983).

⁷ Given that they compete to attract the same tax base the choice of each country affects the welfare function of the others. In fact, this interdependence might involve a welfare loss for the country that imposes a higher tax rate. The greater interdependency and its implications for tax system see Owens, (1998).

⁸ See De Bonis (1997).

⁹ Then "the negative externality is present even if tax competition leads to tax rate uniformity, in the sense that rates are driven down to some common level. Even if tax rates are equal, however, countries could improve their situation by maximising their welfare jointly, or, in other words, by co-ordinating their policies and reaching a cooperative outcome. The cooperative equilibrium set of tax rates need not involve uniformity if countries have different preferences". De Bonis (1997). In the same way Tanzi (1998).

Fiscal externalities began most importantly when they operate though highly integrated markets as a market globalised, because they play a crucial role in the redistribution term (Keen, 1993). In fact, the mobility of factor could have large effects on the future revenue.

Substantial empirical and analytical study, Marseden, (1998) says: "The empirical evidence is clear. Tax competition is not harmful. Analysis of data for two group of countries, covering a twenty-year period, shows that incomes rose rapidly in countries that chose to compete by extracting less tax revenue form their enterprise and citizens. Lower taxes were associated with higher rates of growth of investment, employment, productivity and a private consumption. Countries that choose big government, and more public services financed by higher taxes, experienced slower economic growth."

or the destination principle - countries tax goods and services whose final consumption is within their borders.

According to the first principle, producers are indifferent between internal and external markets, there is efficiency in global exchange but inefficiency in global production. With regard to the second principle, consumers are indifferent between domestic and imported goods; there is efficiency in global production and inefficiency in global exchange.

All this implies that the choice of each principle is linked to the automatic choice between consumption and production inefficiencies. The two dimensions of economic efficiency are both equally important but each principle satisfies one but not the other. Therefore, countries have the option to adopt the origin principle and as a result, implicitly choose efficiency in global exchange. Instead, the destination principle implies that they choose efficiency in global production.

According to Diamond and Mirrelees, an optimal tax structure must preserve production efficiency. Even if their work does not fully capture the international aspects of the tax problem, their study creates a premise for a system based on the destination principle¹⁰.

However, each of the two principles encourages countries to adopt strategic behaviour whose effect is to increase their outcome. As can be seen in the works of Mintz and Tulkens (1986) and de Crombrughe and Tulkens (1990) some strategic behaviour can provide an incentive to set lower tax rates on domestic production (traded commodity) with respect to other countries. In so doing, a welfare loss is added to the collective welfare loss caused by low tax rates, brought about by tax competition¹¹.

Razin and Sadka (1991a) show that if “competing countries are sufficiently coordinated with the rest of the world then tax competition leads each country” to introduce the residence principle¹²; so in this case there are no gains from tax harmonization. If coordination is not sufficient, competition leads to a low capital income rate being applied and an additional tax burden will be distributed among internationally immobile factors.

Interdependence between jurisdiction

As national economies become more closely integrated, it becomes increasingly difficult for countries to conduct independent tax policies.

Tax base mobility of capital and goods manifests an elasticity with respect to tax rate differences. This elasticity¹³ may be different for each category and level. The consequence of economic agent mobility implies the migration of tax base between different jurisdictions. For each country the magnitude of this mobility will be affected by the tax policies of other countries as will the total revenue of each country.

Interdependence limits the capacity of each country to extract tax¹⁴. This limitation in the State's power follows the economic process of globalisation which has a dual effect; the State loses power both over firms (which use globalisation to reduce the tax burden) and other countries, which set lower tax rates to attract tax base

¹⁰ On this principle are based the harmonisation policy. If it is inefficient regarding consumption has the merit of reducing the collective cost of these distortions. In general harmonisation improves the collective welfare if the convergence point is the weighted average of compensated demand in the two countries. The harmonisation generally affect tax revenue and may product a collective gain but also direct gain to each country. Keen (1989) “establishes conditions under which harmonisation from a non cooperative equilibrium is Pareto-improving without any need of international transfers”.

¹¹ This competition might be mitigated by the application of minimum tax strategy responds to the more damaging by tax competition while preserving a considerable degree of formal discretion in national tax-setting. Kanbur and Keen (1993) show that a minimum tax constraint is indeed Pareto-improving also the low tax country increase the gains from the strategic interaction between countries and tax revenue will increase in both countries.

¹² The residence principle income is taxed at the rate applied in his resident country.

¹³ Increasing capital mobility in the 1980s suggests governments have become more sensitive to tax rate differentials. From some empirical study set of the Group of Seven countries, results that corporate tax rates decrease and converge to a central value. See, York (1993)

¹⁴ This limitation in state power follows the economic process of globalisation has a dual twofold effect the state lost power respect to the firms, that use the globalisation to reduce the tax burden, and respect others countries, that set lower tax rate to attract the tax base.

The effect of globalisation on Trans-jurisdiction migration

Globalisation¹⁵ means easier access to global markets. The fundamentals of globalisation are a decrease in communication and transaction costs. These reductions are produced by innovation processes which today allow easy long distance communication and integration of markets – in particular the capital market. In addition, commerce liberalisation, e-commerce and deregulation policies have promoted a rapid decrease in international transaction costs.

As a result, there is a greater possibility of tax base migration among different jurisdictions. The effect of globalisation on firms' and the States' power are reversed. While the former increase their capacity to reduce the tax burden through interjurisdictional migration, the State loses its economic control over the internal and external economy. In fact, firms could use globalisation to take advantage of opting to be taxed in the cheapest country, while every country would engage in tax competition to try to set the lowest rate and attract foreign tax base.

This means that the same competition existing in a non-globalised market among firms, which compete on the basis of efficiency, represents the next frontier for each jurisdiction in a globalised scenario¹⁶.

2. Tax competition

Tax competition (T.C.) could be defined as the possibility of countries to modify their tax base against the reduction of other countries' tax base. In this form of competition the total tax base could also be modified.

The objective of this tax base could range from personal to financial capital, including commodities. Each of these items has different characteristics which modify the way T. C. is dealt with. The main relevant characteristics of different tax bases for T. C. is mobility. This is strictly connected to transport costs.

We have to differentiate between the One Shot Game and Repeated Games¹⁷. Consumers of each region allocate their activity according to the structure of relative prices, taxes and transportation costs. In addition, there could be a cost for obtaining information regarding the conditions for each localisation.

The literature on fiscal competition models focuses on the main economic effects of the interaction between two tax authorities when they set their own tax rate so as to attract a tax base which modifies other countries' tax bases through cross-border flows. As showed by Haufler (1998) "a tax increase in the low-tax country will hurt the high-tax region when the marginal transaction cost schedule is sufficiently elastic with respect to the level of cross-border shopping"

The relationship between jurisdictions may take place in a co-operative or non co-operative environment; however, in each situation we can identify a game where two jurisdictions play their strategy to obtain a better payoff.

One shot game: goods

Consumers of each region allocate their purchases of private domestic and non-domestic commodities according to relative prices, taxes, and transportation costs.

¹⁵ The economic globalisation, as defined by Trend in Economic & Social Globalization: Challenges and Obstacles, "involves a qualitative shift toward a system based on a consolidated global market place for production, distribution and consumption rather than on autonomous national economies. Equally important, globalisation involves more than economics or economic interconnectedness. (<http://www.globalize.org/courses/harvard.html>).

¹⁶ Vice versa, in a globalised scenario firms will compete mainly on the information.

¹⁷ Additional is the concept of evolutionary game theory that "studies the robustness of strategic behaviour with respect to evolutionary forces in the context of games played many times in large populations of boundedly rational agents... A Key concept in the evolutionary game theory is that of an evolutionary stable strategy (ESS), a concept due to Maynard Smith and Price (1973). Such strategy is robust to evolutionary pressures in a specific sense: a population playing such a strategy is uninvadable by other strategy". Weibull (1997).

According to Mintz and Tulkens (1984), many tax competition models consider two regional economies which are two autonomous tax authorities but at the same time, part of a federation. These regions could choose a commodity tax levied in accordance with the origin or destination principle. The results of these models are characterised by the intrinsic discontinuities in best responses.

In the case of tax levied adopting the origin principle, Mintz and Tulkens (1984) show that a non co-operative equilibrium in pure strategy cannot, in general, be shown to exist.

Differences in public sector size and level of tax in the two regions at a non co-operative equilibrium may be produced, not only from differences in endowments, “but also from purely strategic behaviour”.

In a two region economy, “Pareto improving tax changes cannot lower both of the tax levels that prevail at noncooperative fiscal equilibrium” and “always increase the tax of a tax importing region” “but are ambiguous for the tax base of the other”.

In the search for conditions under which equilibrium exists, the main hypothesis tested is connected to the concavity of *regions' welfare functions*. Even if such an equilibrium exists it could be inefficient. de Crombrugghe and Tulkens (1990)¹⁸ identified a class of such equilibria that are always efficient. In the case in which it is inefficient they show that “Pareto improving changes will be positive for the taxes of both regions, under concavity of the regions welfare functions”.

What is more, Haufler (1998) highlighted that if the “welfare function of jurisdiction that applies high-tax is concave in the tax rate of the low-tax jurisdiction”,¹⁹ tax competition will result in tax rates “being too low in both countries, even though there are counteracting private and public consumption effects for the high-tax region”.

In the case of two independent tax authorities, Kanbur and Keen (1993) *capture* the main features of the interactions. The model is closer to that of Mintz and Tulkens (1986) and that of de Crombrugghe and Tulkens (1990). This model is characterised by: an absence of an overarching sovereign authority²⁰ and a different tax principle (tax rate levied on the destination principle²¹). Each government behaves in the Nash manner: it chooses its own tax rate to maximise its tax revenue²² considering the tax rate set by other countries to be fixed and estimates the impact of cross-border shopping.

The result of this model shows that a competitive game among jurisdictions leads to an “equilibrium of inefficient outcome when the countries are identical but in different cases, the outcome could be even worse”. The optimal choice for maximising the country's revenue is cooperative behaviour²³ equilibrium.

In an open border situation, with unrestricted tax competition²⁴, the population chooses to cross borders taking into account only the tax rate difference and the amount of travel costs. Comparing the Nash equilibrium in an open border and in a closed border situation it is possible to ascertain that in “open border” the bigger country will be worse off because it will lose a part of its revenue from its citizens' cross-shopping.

At the same time the smaller country loses part of its ability to extract surplus from its citizens but gains revenue from cross-border shopping if and only if the tax differential is sufficiently great.

An increase in transport costs reduces the extent of cross-border shopping so that it is strictly Pareto improving. From this model we can observe that a disparity reduction between the size of the two countries is strictly Pareto-improving. This situation takes into account a non globalised market

¹⁸ de Crombrugghe and Tulkens (1990) state that asymmetric commodity tax competition always leads to tax rates being too low in both countries, even though there are counteracting private and public consumption effects for the high-tax region.

¹⁹ The authors point out that this assumption cannot generally be met in the underlying Mintz and Tulkens (1986) model.

²⁰ The authors point out their analysis thus have bearing on problems of fiscal federalism, the absence of an overarching sovereign authority with considerable revenue-raising powers of its for establishing the practical policy options in the international context. See Kanbur, Keen (1993).

²¹ In the sense that each store must charge the tax rate of the jurisdiction in which is located.

²² Assumption that the governments to be Leviathans from which tax competition emerges as a useful constraint on policymakers See Edwards, Keen (1996)

²³ The practice cooperative behaviours individuated by the authors are the harmonisation or imposition of a minimum tax rate.

²⁴ In this way the trade between them is free so the consumer can buy goods at marginal cost tax inclusive and the reservation prices are identical and infinite within each country.

where one of the two countries will be correctly considered small with respect to the total market. On the contrary, as we mentioned above, the globalisation phenomenon has different effect on transportation costs. Therefore, Pareto improving hypothesis may not survive in a more general model or in a model where these costs are very slight (i.e. Capital mobility²⁵).

Unrestricted tax competition leads to tax rates that are unambiguously too low. The reason is obvious; when choosing its tax rate each country ignores the beneficial effect that raising it would have on the revenues of the other country by pushing cross-border trade in its direction. This inefficiency creates scope for mutually advantageous cooperation²⁶.

Lockwood (1993) shows, in contrast to the conventional wisdom that tax competition reduces taxes, that border-control abolition "introduces a negative spillover from taxes which tends to bias equilibrium taxes upwards" and it is also possible that consumer welfare will rise.

One shot game: capital

The economic literature on tax competition models generally takes into account the competition outcome and the connected welfare modification (through public goods provision and income redistribution). This is usually made in total terms²⁷.

The main differences in tax competition models are linked to the hypothesis of exogenising the savings decisions, or to consider it as endogenous, as does Kehoe (1989) and Coates. This leads to different and sometimes opposite conclusions about the preference of cooperation or competition behaviour between jurisdictions.

The analysis of capital tax competition is characterised, unlike with the goods, by lower transport costs that are uncorrelated to distance. However, capital mobility has the cost of cross-border migration linked to exchange rates and also the risk to the country in question.

Tax competition among jurisdictions leads to inefficient low levels of taxes from which results underprovision of local public goods results, as is shown in the model by Wilson (1991), Zodrow and Mieszkowski (1986) et al.

The mobility of capital and an immobile factor is considered at interregional levels as elaborated by the Zodrow-Mieszkowski et al. models. Generally speaking, models disregard labour mobility but the results should not change considering Wilson's (1986) suggestion²⁸.

The basic assumption prevailing in this literature is that the source principle²⁹ is used in capital income taxation. Indeed, some governments face substantial obstacles when using residence-based capital taxes. In fact, each central authority possesses more policy tools than each local authority, and may influence capital mobility across national borders.

Gordon (1986) demonstrates that regions choose not to use the source principle when the other two taxes are available, even though these other taxes are distortionary. So, the jurisdiction establishes a source-based property tax on capital income in order to finance expenditure policy³⁰ which maximises the well-being of a representative resident. The use of a source-principle tax should not distort the trade of factors in the case of taxation in a small open economy, as in Gordon's study. This is the implication of Diamond and Mirrlees' results³¹ (1971).

Assuming fixed total stock of capital in identical regions, the Zodrow-Mieszkowski model shows the existence of disincentive for capital investment which implies that local governments impose inefficient low rates on the tax base. Hence, from this tax competition model the underprovision of

²⁵ In this situation the travel cost are very slight and the undesirable features of tax competition may alternatively be mitigated by imposing restriction on international capital flows; see Rasmussen 1997.

²⁶ Two strategies are possible around which particular policy interests are currently focused, the harmonisation and imposition of a minimum rate

²⁷ Perhaps, different conclusions could be reached by in terms of relevance respect to total budget.

²⁸ The authors includes the labour mobility as a third factor; see Wildasin (1991).

²⁹ Slemrod notes in a short comment included in the volume of Tanzi (1995) "although it is not desirable to tax capital on a source basis, it is not administratively feasible to tax capital on a residence basis."

³⁰ One of the criticism made to the Zodrow-Mieszkowski model is due to the fact that it does not permit to regions to use other type of tax for financing the public output.

³¹ Diamond and Mirrelees show that aggregate production efficiency is desirable when all commodities can be taxed optimally; see Wildasin (1991).

public goods may result. Reconsidering and extending the analysis of Zodrow and Mieszkowski (1986), regarding public inputs, Matsumoto (1998) shows that when firms are also mobile across jurisdictions, local governments competing for capital choose inefficiently low levels of public inputs.

The results of non-cooperative policies in tax and expenditure which lead to inefficient outcomes, have caused several parts of the literature to investigate the scope for coordinating policies among jurisdictions³².

In addition to the above considered inefficiency, there are the objective difficulties³³ of taxing foreign-source income. The Bucovetsky and Wilson analysis take into account a system of identical regions which do not have access to tax capital on the residency principle. The source principle for taxing capital is not used in a world where each region is a price-taker in world capital markets³⁴. Instead, the source principle for taxing capital will be applied if a region is a leader in world capital markets.

The regional size differences in the tax competition between jurisdictions develops a Nash game in tax rates on mobile capital as Wilson³⁵ shows according to the Zodrow-Mieszkowski assumptions. In this case the relatively small region is better off than the large region. Hence, the relatively "small region responds to high elasticity by choosing a relatively low tax rate on capital". So, the result of interregional tax differentials develops a "capital flow from the large region to the small region, leaving the small region³⁶ better off in the Nash equilibrium."

A sufficiently large difference in the sizes of the two regions will leave the smaller region better off than it would be under a regime with Pareto-efficient taxes and public goods levels for the two regions. This finding qualifies the message from the trade literature that, being large is advantageous when it comes to tariff wars. The benefits of largeness apparently depend on the type of interaction which takes place between regions or countries³⁷.

Tax base control: Razin and Sadka (1991b) point out that severe difficulties exist for a small open economy (which is a capital exporters) to tax foreign-source capital. These difficulties and the lack of information on foreign-source capital income, lead Razin and Sadka (1991b) et al. to consider the opportunity of introducing restrictions on capital flow.

Capital control in the case of symmetric countries, as suggested by Rasmussen, is "a blessing, since their presence leads to a Pareto-improvement relative to the tax competition equilibrium". The introduction of strict control is optimal. In the case which countries are of different sizes, the larger country has incentives to fix strict capital controls which are able to hurt the small country. Thus, if the countries choose optimal capital³⁸ control "no non-cooperative equilibrium" is fully efficient, and also there is good reason to cooperate.

But as Gordon (1992) said, few countries have in practice imposed capital controls. This leads economists to consider capital flight taxation in their studies. The results of these studies were the inverse relationship between the number of countries and the tax rate on capital income ($n \rightarrow \infty, t \rightarrow 0$)

³² Rasmussen (1997) say that interpreting jurisdictions as countries, the results are easily transformed into implications of having national tax authorities competing with each other.

³³ There is a strong evidence that the government has encountered greater difficulties to tax foreign-source capital income due to lack of information Young (1996). Bjerksund and Chjelderup (1995) have shown that if the foreign earnings of firms can be costlessly monitored while foreign earnings of households are unobservable hence, the optimal policy should only disallow capital exports from households. Young (1996) says that the earlier economists, who studied tax competition, used to implicitly assume that the exporter country has perfect information regarding the income gained by its residents abroad.

³⁴ As point out Wildasin and Wilson (1991) "the ability to tax the worldwide income residents is not necessary for the disappearance of source-bases capital taxation.

³⁵ Wilson (1991) moving from the tax competition literature demonstrates the same results under the assumption that both the capital tax and a distortionary labour tax finance an exogenously, given level of public expenditures.

³⁶ For a small open economy that is a capital net exporter Razin and Sadka (1991a) have shown that once foreignsource capital cannot be taxed, severe restrictions on capital flows should be imposed.

³⁷ See: Wildasin and Wilson, page 324.

³⁸ The authors point out that the "option of imposing capital controls may ... affect the scope for cooperation, since the incentives of the countries to engage in tax cooperation depend on the non-cooperative equilibrium prevailing in case cooperation does not take place".

(Y. Yong 1996), hence, the small countries (as Frenkel et al.(1991)) showed should not tax capital income³⁹.

Instead, the large country, which is a capital exporter, can act as a Stackelberg leader when it sets the tax rate in competition. As Gordon (1992) said “this Stackelberg leader will use its unique position to set a tax rate world-wide”.

Two period game

In a two-stage game. First, the two governments set their tax rates independently and the individuals, only after having received the information about the two tax rates, do they decide to invest in the home country or abroad. According to Yang (1996) “in relation to the other government, each government is a Cournot player and, in relation to the two individuals, the two governments are Stackelberg leaders”.

At the Nash equilibrium, given the two tax rates, the individuals maximise their total incomes and each jurisdiction has no incentive to adjust its tax rate, since, the tax rate of the other jurisdiction is given.

In tax competition the situation is not static and will evolve continuously because if the tax rate of the foreign country is given, an increase in the domestic tax rate will produce an increase in capital flight volume into the foreign country or a decrease in foreign capital flight volume into the domestic country. Considering that in practice the jurisdiction might modify its fiscal policies many times, it would seem, as Coates suggests, that the application of repeated games is an appropriate analysis for highlighting the effects of these modifications.

This approach does not limit the consideration of positive effects that will be determined in a single period but it extends to the subsequent period⁴⁰ taking into account the future fiscal externality. The consideration of this effects by a repeated game, makes it likely that the equilibrium will differ from those found by Zodrow and Mieszkowski (1986). The principal result is, “unlike in the single-period game, the Nash equilibrium property tax rates are negative”⁴¹.

This result, which not possible in the single game, is produced by the capital which enters a jurisdiction in response to a negative tax and will be invested generating greater future output. Hence, if the jurisdiction avoids subsidising capital it has a lower utility than if it had competed⁴².

The consideration of a double period and the interrelation of reaction functions of jurisdictions gives rise to the necessity to consider "strategic positions" and "strategic interrelations" For the former there is the possibility that governments might use public debt to alter their strategic positions in future competition for scarce capital with other regions⁴³ as suggest by Jensen and Toma.

In this way the observation moves from a single-period into a two periods⁴⁴ and focuses on strategic interactions between two regions that compete for capital. A subgame-perfect equilibrium will take place. In this subgame each region chooses its first-period tax rate and correspondingly the public debt which maximises a representative resident's utility, in light of the tax rate and debt level chosen and the correctly anticipated effect of these choices on the Nash equilibrium tax rates in the next period⁴⁵.

³⁹ The absence of taxes on mobile capital does not eliminate the possibility that competition between regions products a low inefficient levels of public good provision. In fact, as shown Bucovetsky and Wilson, the existence of taxes on mobile capital does not necessarily imply underprovision if other taxes are available, hence the decentralisation decision-making of regional governments is efficient.

⁴⁰ In this way the author considers that the capital that is induced into the jurisdiction is there today and forever after.

⁴¹ Coates (1993)

⁴² As Coates (1993) say the tax competition is welfare enhancing for the individual jurisdiction.

⁴³ The authors illustrate their findings by using a numerical example with quadratic production functions, where debt is positive, there is underprovision of the local public good in each period, and utilities are lower than they would be in the absence of debt.

⁴⁴ In the first period modelled as a source-based tax on capital income where the property taxation will be used in the second period to finance public good provision and repay the debt.

⁴⁵ In the purpose to isolate the pure strategic use of debt others functions, production and utility, are assumed to be identical across both regions and periods.

In this scenario, as shown by Jensen and Toma, the jurisdictions will have an incentive to issue debt because it reduces the standard tax competition problem of underprovision of government goods. The reaction curves in the second-period will result in each jurisdiction fixing its tax rate on the basis of the other jurisdiction's tax rate and its previous behaviour. If one jurisdiction increases its debt in the first period, then it will raise the tax rate applied in the second to pay off the debt. If the two reaction curves have a positive slope, then shifting one of the region's reaction curves will move the other region's Nash equilibrium tax rate outward in the second period. The first jurisdiction gains benefits from the increase in capital investment due to the higher tax rate in the other jurisdiction.

The strategic interaction between regions is considered by Wildasin's work which focuses on tax competition with endogenous⁴⁶ choices ranging from strategic variable taxes on capital or public expenditure levels to public expenditure levels or public good consumption levels. Then a two stage game takes place. In the former, Wildasin shows that the jurisdictions commit "to a fixed expenditure level". The fact that the jurisdictions commit "to a fixed expenditure level rather than to tax a rate induces the other region to lower its tax rate". The result of this behaviour implies that the capital supply of the other region will be more sensitive to the tax rate. Hence, a tax rate increase, in one region, implies that the capital will move to the other region. In this way each region engages in a strategic tax competition race because "each region wants to induce the other region to maintain a high tax rate ... (the) regions put for tax rates as their strategic variables". In the latter, committing to public expenditure levels turns out to be a dominant strategy for each region. This is possible because benefit spillovers between regions undo the fixed relation between public expenditure levels and public good consumption levels.

So a repeated games could be useful for dealing with the strategic interaction between regions and this seems to be strictly linked to the real standard tax competition problem.

3. Tax competition: a game theory approach

a) The Prisoner Dilemma

In the case of fiscal competition among independent jurisdictions, the agreement on the taxation of mobile sources has proved to be extremely difficult. In fact, each jurisdiction does not find itself in symmetrical competition, given that a very small country may choose to decrease its tax rates to attract tax base and consequently increase its total revenue. Instead, large countries cannot apply the same strategy because it leads to a very large loss in revenue. Hence, the implications of having national tax authorities which compete with each other for *usurpation of the tax base* and the *export of the tax burden*, are common characteristics of tax competition models which highlight the existence of non-cooperative tax policies. This behaviour will lead to inefficient outcomes⁴⁷. Therefore, the question of cooperation or non-cooperation in fiscal competition is better examined in terms of the theory of rational interrelated choices.

Generally speaking, the literature dealing with international relationships, borrows its models of cooperation and competition from Game Theory⁴⁸. Game Theory fundamentals are perfect rationality and absence of learning by experience⁴⁹.

The models of inter-jurisdictional tax competition generally focus on the effect of games between two or more jurisdictions (players) which are perfectly rational decision makers. The games which take place in the real world are played between independent jurisdictions; so these games develop in

⁴⁶ The two governments, like a duopoly, "might try establish certain types of Nash equilibria through the announcement of commitments to particular strategic variable".

⁴⁷ For these reasons several models declare that exist scope for co-ordinating policies among jurisdictions.

⁴⁸ For a good survey of literature see: Axeldor 1997.

⁴⁹ Sugden assumes that individuals are able to learn from their own experience and that an others what strategy yields the best results. The strategy that yields the best results is here take to be the strategy that as the highest average payoff in terms of utilities. J. Vromen, (1995).

an anarchical⁵⁰ environment which leads to the assumptions that players are selfish. Consequently, if they are short-sighted, the games are non-cooperative.

This seems an appropriate way to analyse the problem because Game Theory studies the decision making of interacting players and it has applications in economics, political science, finance, international relations, and sociology.

In a typical game, two or more countries make decisions (choose strategies) in a conflicting or competitive situation and receive a payoff, which not only depends on their own decision, but also on those of the other players.

Rogoff's work (1985) shows that cooperation between policy makers can lead to a lower level of welfare than non-cooperative behaviour does. International economic policy focuses on Hamada's work (1976) who, investigating the effect of increasing policy cooperation between countries, concluded that increasing policy cooperation between countries is desirable. The new way of posing the problem was criticised⁵¹, but Kehoe (1989) says that if in Rogoff's model the policy makers "maximize the welfare of their country's residents, the counter example is overturned and cooperation strictly dominates non-cooperation". On the basis of this characteristic the *result is that policy makers' behaviour is against the private sector, which may be worse off than if they do not.*⁵²

Many studies analyse the competitive case between two jurisdictions; sometimes the analysis is extended to more jurisdictions. The typical assumption of this literature is based on the assumption that each country sets its strategy as a player does. Tax rates are the strategic variables of the game. Each country or player sets its optimal tax rate as a reaction to the tax rates applied by another country or other countries. The outcome of this game is an inefficient Nash equilibrium because the players choose an inferior strategy given that they are not co-operating and usually do not trust each other⁵³.

Many studies⁵⁴ represent International Tax Competition as a Prisoner's Dilemma game (DP). This is a traditional metaphor often used in game theory⁵⁵. To be considered as a PD a game must be reducible to singles numeric payoff for each play.

In the Prisoner dilemma game the countries choose a cooperative or a non-cooperative behaviour. In the latter the country will try to maximise his revenue (o gain).

b) The Iterated Prisoner Dilemma and the Evolutionary Theory.

In the traditional Prisoner Dilemma game the countries choose a strategy that can be played either only once (as is analysed in several models of competition) or repeatedly⁵⁶, but with no memory⁵⁷ of former iterations. In each case, the country is seeking to maximise its revenue. In the case of memory and learning of former iterations, we have the Iterated Prisoner Dilemma (IPD) Game.

The most important difference between the static PD and the iterated one is that, in the latter, the structural change brings in an increased insight into the other player's attitudes and patterns of behaviour⁵⁸. The prior level of uncertainty, regarding the opponent's preferences which influences the players' decisions decrease as a result of the knowledge acquired through the process being repeated.

⁵⁰ Following Axelrod only a norms provide a powerful mechanism for regulating conflict in groups, even when there are more than two people and no central authority. Many historical examples of domestic and international norms are used to illustrate the wide variety of mechanisms that can support norms, including dominance, internalisation, deterrence, social proof, reputation and membership in groups.

⁵¹ P. J. Kohoe (1989) point out that The Rogoff's result has been criticised. Canzonieri and Henderson have noted that in the Rogoff model the objective function of each country's policy maker does not coincide with the objective function of its residents.

⁵² J. Hirshleifer says that "Prisoners Dilemma need not to be socially dysfunctional in the larger sense; the cooperation it subverts may be a conspiracy against the public".

⁵³ Similar is the behaviour of the countries when they choose between the free international trade policy or protectionism policy. In this case even if they both gain if they should opt for the free trade both countries will choose the inferior but still dominant protectionism. So in this game they can caught the best result if will be cooperation.

⁵⁴ F. W. Scharpf

⁵⁵ There are many good survey on this topic.

⁵⁶ As in the Coates's work that consider the property tax competition in a repeated game.

⁵⁷ This game, in fact, is characterised by lack of positive feedbacks implying the impossibility by the players to change their strategy during the game. See J. Hirshleifer (1982)

⁵⁸ Paulo Sérgio da Silva Borges

Milner observes that several papers on cooperation have used game theory approaches and she added that the methodological choices are a valid scientific contribution in explaining cooperation among countries. In fact, in the relevant economic literature there are many experimental tests regarding models of cooperation in finitely-repeated prisoner dilemma games; these models suggest that the perception that the other player may adopt the tit-for-tat⁵⁹ strategy or mutual uncertainty with regard to dominant non-cooperative strategies. This can lead to rational cooperation⁶⁰. However, the experimentation implies that only in restricted situations do some types of uncertainty promote cooperation. In this evolutionary process, players cooperate when they are certain of their opponents' payoffs.

The literature sets some conditions under which cooperation emerges. These hypotheses can be classified as: a) absolute gains, relative gains, and reciprocity; b) propositions about the number of players or actors; c) iteration; d) the relationship between jurisdictions and power asymmetries.

The evolutionary theory focuses not only on optimising behaviour and efficiency solutions⁶¹ but also on non-optimising behaviour which permits the discovery of novelties. The apparently casual fluctuations, mutations and variations of the real world produce new energy for the system. The purpose of the traditional approach is to analyse the results of actions. Instead, the evolutionary approach examines the development of action on a step by step basis. This is because it is thought that a phenomenon is built by the integration of several factors which are casual but become part of the overall trajectory development⁶².

The evolutionary approach takes agents to be imperfectly rational; their imperfection is determined by continuous environment variation, limited capacity to process information, the interaction between more and different players in the same game. More players means the solution is unsettled and unknown⁶³.

The purpose of the evolutionary game is not "a dominant strategy" but the research of the mechanisms that may lead to co-operation, coalition and agreement. These are the determining elements of this theory. Pure competition does not exist because the agents are encouraged to co-operate⁶⁴ in order to achieve better long-term results which are in contrast with the elements of traditional game theory which has a short-term outlook. In fact, even if classical game theory tries to incorporate conflict, heterogeneity⁶⁵ and plurality in the decision process, its result is a strict derivation of neo-classical equilibrium. The game solution which permits each player to obtain the best pay-off is unique. The game outcome, even though the game takes place in uncertain or unstable conditions, provides the equilibrium solution which combines the divergent interests that have generated the game, in a given *distribution of winning and losing*⁶⁶.

Although game theory considers elements such as uncertainty and variety, it is a theory of *complication* and not a theory of *complexity*⁶⁷. This implies it does not find any applicability in the analysis of open systems. The alternative strategies and the procedures of optimisation are known by the agent, and the game outcome is predetermined and linked to each strategy.

The game preferences and purposes are given and are invariant. Therefore, the game theory considers the individuals attained rationally self-interest against others self-interest individuals.

⁵⁹ If all players adopt the TFT strategy, the Iterated Prisoner's Dilemma has a Nash equilibrium, and in this case TFT is called a *collectively stable strategy*, which means that it cannot be *invaded* by any other rule if every member of the population uses it.

⁶⁰ See Kahn, Lawrence M. and J. Keith Murnighan (1993).

⁶¹ J. Hirshleifer (1982) point out that to achieve an ideal state of efficiency, property rights in all resources would have to be preassigned and perfectly respected. Absent these conditions there will be excessive efforts to acquire assets .. such efforts include unlawful activities like theft.

⁶² See E. Laszlo, C. Laszlo (1994), p.161.

⁶³ M. M. Waldrop (1994)

⁶⁴ Even if "competition and cooperation may seem antithetical, but at some very deep level they are two sides of the same coin" M. M. Waldrop (1994).

⁶⁵ This concept take account the different characteristic of each player.

⁶⁶ See B. Giacomini (1982).

⁶⁷ The term complication indicates something (system, machine o phenomena) that we can understand the structure and the running principle, complex means the impossibility to understand the details the observed object, so that in this case we can have only a global perception, see, P. Albani (1990)

4. An interpretative model: The state of art

Kabur and Keen (KK) demonstrated that for two countries which differ in size tax competition implies a Nash equilibrium in which the smaller country has a predominant gain⁶⁸. The authors started from the simplified hypothesis of fixed transport costs, equal consumer preferences and open borders. Each consumer will shop in the country where the *international equal price* plus the transport cost and tax is minimum. This happens under conditions whereby the amount of goods bought by each consumer will not change regardless of the weighted average tax level, known as a "zero sum" game⁶⁹. The authors' deductions were that the reaction function of the small country differed from the larger one because the latter could only lose from the opening of its national borders. In fact, the population size which the two countries may gain and/or lose in tax competition is different. The importance of this model is based on the fact that it could be considered the most affirmed model for interpreting tax competition in open border situations as in the case of the EU or other countries operating a system of fiscal federalism.

We will demonstrate that their model only represents a special case of "*tax competition when countries differ in size*". In fact, when only two countries are involved their model is correct. When more than two countries are involved in an open border situation, a more general model is needed. This model implies the obvious consideration that (starting from their same hypothesis), an open borders situation may result in no country having a reaction function of the kind that they consider valid for larger countries. In fact, it could be that a large country may not exist at all. In this case the main conclusions that it will be possible to reach are substantially different from those reached by KK model extension. On this base of this more general model, the main conclusions that are possible to reach seem to be quite different from the consequence resulting from extension of the KK model (for an open border market with more than two countries⁷⁰).

"Last but not least", in order to take specific account of a globalisation scenario we cannot accept a hypothesis of fixed transport cost for unity of distance. This was true in a pre-globalisation scenario. At present a condition of equal costs for different distances is the minimum requirement of reality. It would be best to consider different travel costs according to the chosen means of transport⁷¹. This is connected with the centrality or the marginality of the areas and not with distance or information costs. For the sake of brevity, we will not go into the analytical details of this generalisation but propose only an "intuitive" presentation. What's more in this case the conclusions are different from those in the KK model.

68 Kanbur, R. and Keen, M. (1993).

69 For "zero sum games" and tax competition see Shannon that highlight that " Until quite recently, students of public policy have generally taken a rather dim view of intergovernmental tax competition dismissing it as a "zero sum game" or a "beggar thy neighbor" activity. In addition, they usually were quite quick to downplay the significance of intergovernmental tax differentials in influencing the decision of plant locators".

70 It seems possible also to generalise and render the model a more realistic one in many other ways. The most important way seems that to eliminate the zero sum hypothesis. This is in accordance with one of the main postulates of public finance: the relations between tax and demand. Perhaps, the consequences of such a modification could be considered marginal if we are interested in the industrial trade but are central if we wish to have technical suggestions, or forecasting, about the optimal governmental behaviour for revenue maximisation. This modification is necessary not only for realism sake but also for coherence. The total revenue modification will be stronger in the case of many countries federal community compared with equal population two countries tax competition.

71 The effect of tax competition on total tax revenue. Many Authors consider the invariance of total tax revenue in the case of two countries tax competition or they highlight that its variance could not be very meaningful. So they simplify to a "zero sum game". Vice versa, others (See for an example Wildasin (1991), that consider the capital tax competition in duopoly and in the N-countries case) highlight that the total tax revenues depends from the tax level. This seems correct from two points of view: realism and coherence. It is obvious that, in any case, the weighted average of the tax rate will changes the total demand and then also the total revenue will change. Of course, in the case of transport costs dependent on the distances this phenomena could be of little significance as it affects only a very small parts of the population. Vice versa, in the case of constant transport costs it could affect a larger part of the population. This means that the change of the total final demand and revenues are relevant.

A development of this model may be found in work which considers explicitly the implications of the abolition of border controls for the design of commodity taxes in a general equilibrium environment⁷².

5. The model

When there are only 2 countries, with transport costs depending on distance, there are two different reaction functions⁷³; that of the small country and that of the larger one. The main difference between a large and small country, (which causes the difference in the reaction functions), is that by reducing its prices (internal tax), a small country may gain by attracting foreign shoppers while (following such a strategy), the larger country will lose. In this case a Nash equilibrium is found at a point such as E in fig.1. The two intersecting lines represent, the reaction functions of the small and large country respectively. Defining h and H as the population of the small and the larger country respectively, $\theta = h/H$ and δ the transport cost.

Assuming $v = V = +\infty$ where v and V are the reservation price of the two types of consumers there exists a unique Nash equilibrium. The equilibrium taxes are:

$$t^N = \delta \left[\frac{1}{3} + \left(\frac{2}{3} \right) \theta \right]$$

$$T^N = \delta \left[\frac{2}{3} + \left(\frac{1}{3} \right) \theta \right]$$

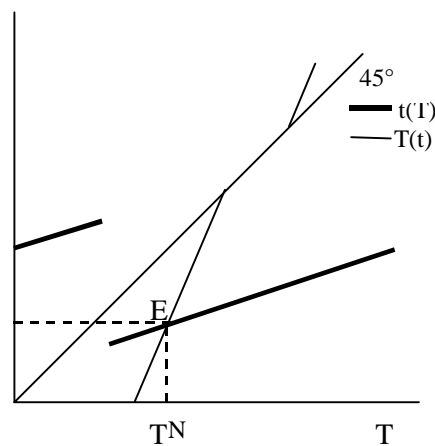


Fig. 1

The KK model is inadequate to deal with the case when there are many countries in an open border economic community (as in EU or federalist regions)⁷⁴. This is because in some cases, each and every country is small compared to the complete set of all the other countries. Therefore, the total community population, for which the countries compete, is larger than the population that the largest

72 Lockwood, Ben (1990): Border Controls and Tax Competition in a Customs Union, Birkbeck College Discussion Paper in Economics: 20/90, July 1990, pages 32; This paper considers the implications of the abolition of border controls for the design of commodity taxes in a general equilibrium environment where the terms of trade adjust to ensure a trade balance. It is assumed that cross-border shopping by consumers is costly and governments choose taxes non cooperatively. It is shown that abolition introduces a negative spillover effect from taxes which tends to bias equilibrium taxes upwards, in contrast to the conventional wisdom that "tax competition" reduces taxes. This result holds both for inter- and intra-industry trade. It is also possible that abolition of controls can raise consumer welfare. The effect of abolition on the gains from cooperation between governments over tax policy is also considered: it is shown that while in the case with controls, these gains depend crucially on the existence of countries possessing "monopoly power" over the terms of trade, this is not the case without controls - there may be large gains to cooperation even when countries have only a negligible effect on the terms of trade.

73 See Kabur and Keen (op.cit)

74 Vice versa, Kabur and Keen consider (p. 879) that as their model presents "no tax adjustments on purchases made in either country by resident of the other" it is applicable to a context in which it exists "unlimited allowances for duty-paid goods intended for personal use" like as been the case in the EU (taxation origin principle).

country could lose. It may follow that no reaction function of the "large country type" exists at all. All countries are small compared to the total community population.

This will happen when the weight of population of each country N_i is such that:

$$p_i \leq \sum p_j \quad \forall j \neq i \quad (1)$$

In this case it is easy to understand that there is no large country. In fact, each single country could gain by attracting shoppers from all the other countries. Thus, the real competition is between countries all having the same kind of reaction function.

Nevertheless, from a quantitative point of view, the reaction functions are different according to the relative magnitude of each country with respect to the aggregate of community countries.

Each country, then, will present an equilibrium tax rate for each of the community's countries which will differ according to the level of transport costs for that country and the level of its population.

Simply put, we could start by considering equal unitary transport costs as KK does.

Of course, condition (1) will be realised whenever $p_i \leq \sum p_j / 2 \quad \forall j \leq N$.

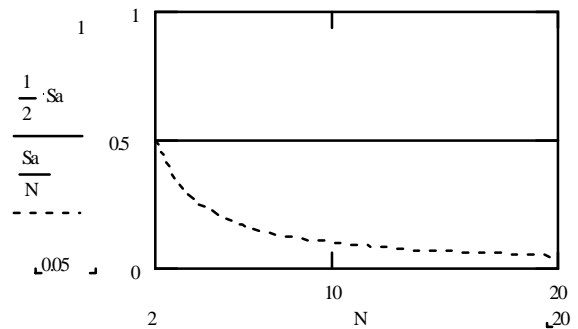


Fig. 2

The area $[0.5, .. 1]$ is the area of validity of the KK model. This area plus the area below the dotted line is the area in which the equilibrium will be reached in the upper part of fig. 3 (see Fig 3.a). The area below the dotted line is that in which the equilibrium will be reached in the lower part of fig 3 (see fig. 3.b)

In the case of only two countries existing, one is small and the other is the larger (or they are both equal) with respect to the total. With 3 or more countries, only if $p_i \geq \sum p_j$ (for j different from i) the country i will have a reaction function of the "larger country type". In this case the KK model holds true. Instead, if the disequation is not verified, every country will always present a reaction function of the "smaller country type". Here there is no country that presents a comparative exchange disadvantage in accordance with its relative magnitude. Every country would gain more than it would lose. This will happen even if $p_i > \sum p_j / N \quad j \in [2, N]$. But, in this case the country in question is larger than the medium one. If an equilibrium exists it will be obtained in the upper part (to the left of the 45° line) (Fig. 3a). Potentially, in this case we will have many different levels of equilibrium, one for each country. But, only the lowest one will be chosen – total competition.

Instead, when the country is smaller than the medium it presents comparative advantages in competition. In this case, if an equilibrium exists, it will be on the lower part of the graph (Fig. 3b). It will have a unique level for all the other countries.

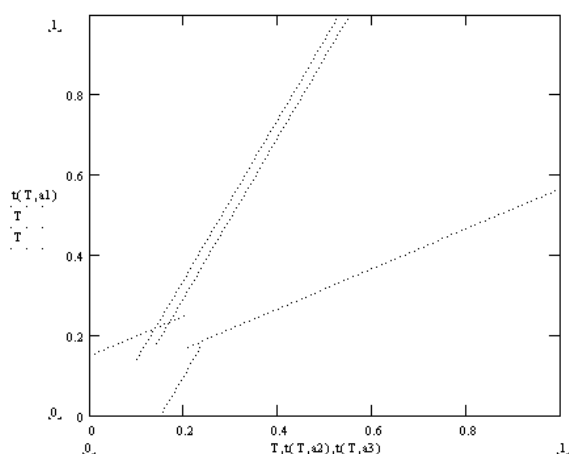


Fig 3-a

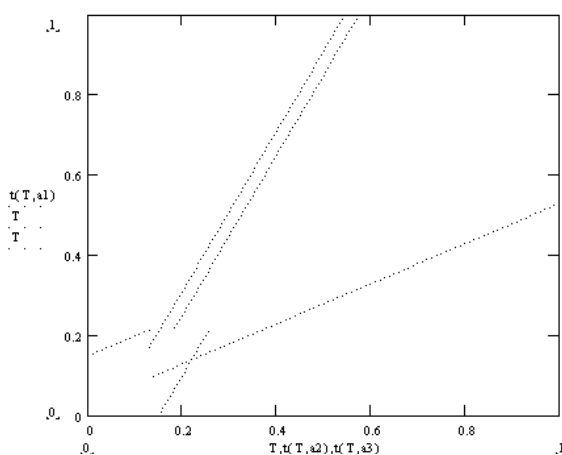


Fig 3-b

The effect of globalisation on tax competition via the cost of transport

There are many definitions of globalisation. From these, it seems possible to extrapolate the most important characteristics of tax competition. These seem to be the economic possibility to easily obtain price information and the fact that only a very [small – equal transportation cost] are incurred in order to operate in any market. Of course, such a hypothesis is much more realistic when a stronger relationship exists between the different regions considered. If this is true for federalist countries operating in an open border market, for example, the EU, it would appear logical to assume that the maximum effect of globalisation is reached. Therefore, in the case of such communities we have to consider that transport costs are equal irrespective of distance. An example of such uniformity is UPS's prices which for Europe, are fixed according to area and not always dependent on distance. Another example is the postal freight tariff which is generally invariant in relation to distance.

The immediate consequence of such a hypothesis is that when we are in a multi-country context with open borders, if one country has a lower tax rate than its counterpart, we lose “internal shoppers”. To gain external shoppers we must have the lowest tax rate, otherwise all the potential mobile population will be attracted to the country with the lowest tax rate. The potential number of mobile shoppers is the whole community population. Of course, information is not free which mitigates such an effect.

Moreover, it also seems possible to refine this idea taking into account that different transportation costs are valid for different places, irrespective of distances between places. Instead, it depends on the different means of transport that a consumer is obliged to choose from, taking into consideration the means of transport available in the individual place of residence when s/he lives in different places. For a better understanding of this point, we can consider the diversity of transportation costs incurred by consumers living in the main centres of each region and those incurred by those people living in areas that are not served by main transportation services. (they could be fast internet lines like in Milan or international airports like those existing in every main city). Analogously, the effect of costly information could be introduced in the fragmentation in social classes. This will highlight the existence of an increasing return effect.

From an aggregate point of view, the hypothesis that different transport costs exist is not very different from that concerning distance. In fact, it means simply that we have to aggregate similar places or social groups (main towns, marginal places and so on). Instead, from a microeconomic point of view they differ greatly. In fact, this means that the effect of transport costs is not linear but it is a step-by-steps process. This could result in small changes implying large variations. There is a vast amount of literature to illustrate that such a function can imply chaotic behaviour. In this case, it would no longer seem possible to talk of stable equilibrium.

6. The Iterated Prisoner Dilemma and the "evolutionary" scenario

The 'Prisoner's Dilemma' is used as the standard metaphor to conceptualise the conflict between mutual support and selfish exploitation⁷⁵. When transport costs are fixed or indeed are non-existent there is only one possible strategy: defect or cooperate, as in the Prisoner Dilemma case. In this case, if the agents compete with each other, they gain the full amount. Alternatively, if they collaborate they can share the gain (often a larger one). This implies that the PD metaphor is easily applicable in such a case.

When transport costs exist, as in the original KK model, if we accept the fact that there are no "large" countries, we can consider the problem as one of classical duopoly. In this case, we can apply the prisoner dilemma metaphor. In fact, Wildasin has shown that this game could be analysed as a two phase prisoner dilemma.

If, however, we are concerned with tax competition, then it is difficult to consider it as one shot game. In fact, governments will confront each other on the market every day. Therefore, it would more realistic to consider an Iterated Prisoner Dilemma (IPD). In this context an "evolutionary" approach, which assumes agents will learn from past experience, would be of interest.

The IPD is widely regarded as a standard model for the evolution of cooperation. In a one shot game defection is the primeval state and the only evolutionary stable strategy (Maynard Smith 1982). Hence, it seems cannot rise cooperation from a non-cooperative state. Vice versa, if there is learning and chance to meet previous interactant⁷⁶ it not possible to exclude any possibility that cooperation⁷⁷ will take place. In fact, as showed by Bouyd and Lorberbaum, in the IPD "no strategy is evolutionary stable"⁷⁸.

This is explained by Axelrod, who points out that depending on the payoff matrix the winning evolutionary strategy will change⁷⁹.

As regard with evolution results of a game we can try to find the conditions under which the observed behaviour is evolutionarily stable. In this context, the question of stability can be analysed at several levels: there are: 1) qualitative results (which is the winning strategy after iterations and what is the ESS strategy); 1.a) The stability of single strategies (Lorberbaum 1994); 2) quantitative results (frequencies measurement). The existing literature was more interested in the former; 2.b) The stability of relative frequencies in an ensemble of strategies (Axelrod 1986, Feldmann and Thomas 1987); Many simulation comparing possible strategies like: TFT, ALLD, Pavlov, GTFT, Grim, etc. are reported in the literature⁸⁰; c) The stability of oscillations in these frequencies (Nowak and Sigmund (1992, 1993a and 1993b), Novak and May (1992)); They pointed out that posing different strategies in competition we can obtain both a frequential and a spatial chaos.

According to Brembs (1996), Nowak and Sigmund highlighted the fact that the equation of frequency exhibits complex dynamics in the sense that frequencies may oscillate periodically or display violently chaotic orbits⁸¹. Vice versa (Instead), Nowak and May (1992) analysing the

⁷⁵ Björn Brembs: Chaos, cheating and cooperation: potential solutions to the Prisoner's Dilemma; <http://brembs.net/ipd/ipd.html>

⁷⁶ In this case a strategy would be a rule, modifying the behaviour.

⁷⁷ Björn Brembs highlight this for homogenous population.

⁷⁸ Obviously, unconditional defection is still an ESS against single cooperating mutants. Björn Brembs p. 15

⁷⁹ See Axelrod (1986), p. 17.

⁸⁰ Axelrod (1986). For a larger list of strategies and their definitions see Axelrod (1997). Surprisingly, a very simple strategy did outstandingly well: cooperate on the first move and then copy your opponent's last move for all subsequent moves. This strategy was called 'Tit-for-tat' (TFT). But, as Boyd and Lorberbaum (1987) and Lorberbaum (1994) showed, even if, in the long run, TFT out-competed its rivals and went to fixation (Axelrod and Hamilton 1981) in the IPD no deterministic (pure) strategy is evolutionarily stable.

⁸¹ For example, around $u = 0.0004$, S_4 , S_6 , S_7 and S_{12} almost perish, while the other strategies oscillate vigorously. Only TFT persists at comparatively high frequency, whereas the other oscillating strategies come very close to $f_i=0$. But whenever f_{10} (TFT) is high, it is outcompeted by a more generous strategy S_{11} (1, 0, 1, 1) and S_9 (Pavlov), which in turn are invaded by the parasitic S_1 (0, 0, 0, D). S_1 is then sacked by ALLD-like (S_0) and Grim-like (S_8) rules which, as expected, can easily be overrun by TFT (S_{10}).

simulation of the spatial distribution of unconditional defectors (ALLD) and unconditional cooperators (ALLC) found spatial chaos⁸².

The possible existence of both frequential and spatial chaos seems to imply that in the case of evolution there is not a single determined winning strategy⁸³. So, to correctly analyse the question of T.C. in the evolutionistic context it would seem necessary to use a chaotic methodology.

7. Conclusion

We considered tax competition regarding commodities in a globalised scenario with open borders.

It was shown that the KK model is a special case that occurs only under certain conditions. Larger countries may not exist when the open border is $n > 2$.

In a globalised scenario, it is not possible to speak of constant transport costs per unit of distance. In actual fact, they are almost constant regardless of distance. This means that tax competition can be dealt with using the metaphor of the Prisoner Dilemma. It justifies competition rather than cooperation.

A generalisation of the model implies that transport cost are considered dependent both on distance and on means of transport. This introduces some discontinuities in to the cost function. In comparison to these discontinuities, it would seem possible to gather the open border area in zones that present similar transport costs. The modification in taxes will not now have any effect until a threshold level is reached. This threshold is determined by transport cost existing in the area in question. Therefore, the effects will proceed in jumps. The relevant information has a cost. On one hand, this determines increasing output for the country that succeeds in exploiting the competitive advantage; on the other, it weakens the threshold effect.

It is evident that its intrinsic characteristics, tax competition must be dealt with by adopting a model of the "repeated prisoner dilemma" type. This, in turn gives origin to an evolutionary model, if the agents learn from the past experience. This introduces non stable solutions.

Finally, it was pointed out, that for the analysis of tax competition in an evolutionary scenario, it is necessary to take into account the possible strong dependence on the initial conditions. In fact, the no stability of the evolutionary solutions seems correlated to the existence of chaos in the model.

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⁸² They considered 'territories' in a population of players distributed on the squares of a chess board. Each player interacts only with its immediate neighbours. In the next generation, the square is inhabited by the player who scored the highest total, i.e. neighbour or previous owner. Their analysis of this simple deterministic model revealed spatial chaos "unpredictably ever-changing spatial patterns of ALLD and ALLC neither vanishing"⁸². What is more, for certain parameters the frequencies of cooperators (f_C) and defectors ($f_D = 1 - f_C$) are converging towards asymptotic fractions

⁸³ However, large e favours the domination of defective strategies and the oscillations disappear.

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