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ABSTRACT

Input versus Output Taxation in an Experimental International Economy*

This paper is concerned with a policy oriented macroeconomic experiment involving an 'international' economy with a relatively small 'home' country and a large 'foreign' country. It compares the economic performance of two alternative tax systems as a means to finance unemployment benefits: a sales-tax-cum-labor-subsidy system versus a wage tax system. The two systems are applied to the home country, while the wage tax system always obtains in the foreign country. In stark contrast with expectations of experts the sales tax system clearly outperforms the wage tax system, using standard economic indicators. It is argued that producers' reluctance to incur costs up-front while being uncertain about product prices can explain this outcome. Several pieces of evidence are provided to support this claim. The results strongly suggest that behavioral aspects have to be taken into account also in applied macroeconomic models.

JEL Classification: A10, C90, C91, D21, D80, E62, H20

Keywords: laboratory experiment, wage tax, sales tax, macroeconomic policy, behavioral economics

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1 Introduction

> *Time usually elapses (...) between the incurring of costs by the producer (with the consumer in view) and the purchase of the output by the ultimate consumer. Meanwhile the entrepreneur (...) has to form the best expectations he can as to what the consumers will be prepared to pay when he is ready to supply them (...).*
>
> John Maynard Keynes (1970 [1936], Ch. 5: Expectation as Determining Output and Employment, p. 46)

A major economic issue concerns the effects of taxation on the behavior of individual consumers and producers and the performance of markets. In this context, a longstanding problem in public finance relates to the pros and cons of taxing inputs, e.g. labor and capital, versus the taxation of outputs, like sales or value added. One potentially highly relevant factor in this respect is that production takes time, a fact emphasized by Keynes in the preceding quote. At the time when producers have to make their input decisions, generally, the precise market conditions prevailing at the time consumers buy their products are unknown. Thus, when deciding on labor and capital employment producers, typically, face uncertainty about the real returns from these decisions. A similar problem holds for consumers when they have to allocate time between labor and leisure, because the real return on their labor will depend on the development of consumer prices over the period covered by the wage contract.

Several studies have argued that taking this uncertainty into account is important from a behavioral explanatory and optimal policy point of view. For example, Eaton and Rosen (1980) show that if consumers are uncertain about the real wage, an expected income-compensated increase in the wage tax may induce them to supply more labor. Moreover, lump-sum taxation is no longer necessarily efficient, because the wage tax insures the consumer against random real wage income movements. Regarding producers, a number of theoretical partial equilibrium studies have focused on the effects of output price uncertainty on the input and supply decisions of firms. Results show that output price uncertainty generally reduces factor demand and production level of risk-averse competitive firms (Sandmo 1971, Batra and Ullah 1974, Hartman 1975, 1976, Holthausen 1976, Ghosal 1995).[1]

[1] Loss aversion, as in prospect theory (Kahneman and Tversky 1979), would seem to make this effect

The policy relevance of this topic can be illustrated by referring to "the puzzle of European unemployment" (Blanchard and Katz (1997)). A large piece of this puzzle seems related to the strong reliance on wage taxation in financing the welfare state, and the focus on supply side conditions in employment policies. Indeed, several scholars have pointed at the pernicious effects of wage taxation in this respect, with rising tax rates and unemployment leading to a vicious circle (Snower (2000)). These arguments and the above mentioned research suggests that shifting taxation from inputs to outputs may have a positive effect on production and employment because the government then effectively shares the sales risk faced by producers.

From an optimal taxation and general equilibrium perspective, however, it seems not at all clear whether such a shift in taxation will do any good, in particular in a small open economy. Taxation of outputs implies an implicit tax on the mobile factor capital and the conventional wisdom in the literature on optimal taxation in open economies is that taxing such a factor should be avoided. For example, based on the seminal work of Diamond and Mirrlees (1971), Razin and Sadka (1991) have shown that a small open economy should not tax mobile capital (at the source). More recently, Bovenberg (1994, p. 284) argued that "(...) small and open economies should not tax highly mobile factors (...)".[2]

On the other hand, pure theoretical reasoning does not always provide unambiguous answers, even in a frictionless perfectly competitive world. A well-known result from general equilibrium theory is that, generically, equilibrium predictions are not unique. In case of multiple equilibria, however, no clear forecasts concerning policy reforms can be made. A main motivation of this paper is, therefore, to shed some light on this thorny issue of whether a tax on immobile labor or a sales taxes - implicitly taxing mobile capital - leads to a better economic performance of a small open economy. In fact, in the framework we will be using theoretically multiple equilibria arise.

only stronger. Another strand of literature addresses the impact of (macroeconomic) uncertainty on investment, typically showing a negative effect (Aizenman and Marion 1993, Brunetti and Weder 1998, Guiso and Parigi 1999).

[2]Many relatively small countries nevertheless tax capital implicitly or explicitly. A large body of literature tries to square this empirical fact with the theory of optimal taxation either by discussing legal details (e.g. Gordon 1992), allowing for frictions and market imperfections (e.g. Richter and Schneider 2001, Koskela and Schöb 2002) or taking a global view of capital taxation (Braulke and Corneo 2003).

Another motivation relates to the novelty of the research method. For our investigation we use data from an experimental study pitting a wage tax system against a sales tax system as alternative means to finance unemployment benefits, commissioned by the Dutch Ministry of Social Affairs and Employment.[3] The Minister was requested to do so in a motion carried by the Second Chamber of the Dutch parliament. To our knowledge, it is for the first time that policymakers explicitly asked for laboratory experimentation as a means to advise in macroeconomic policymaking. When doing our investigation we were supervised by a steering committee to which internationally renowned Dutch economists (in the fields of public economics, labor economics, experimental economics and applied general equilibrium modeling) were assigned.[4] Being a policy-oriented study, the experimental design was required to show some parallelism with the Dutch economy. The steering committee had to approve the design of the experiment and assist the project.

Further innovative aspects of our study concern the comparison of different tax systems in a macroeconomic experiment, and the implementation of a relatively small 'home' economy and a large 'foreign' economy in the laboratory.[5] In a sense, doing this study meant exploring the boundaries of the research method of laboratory experimentation. In our view, the results show that also in this area of policy related macroeconomic research experiments are a useful complementary research tool, next to theoretical and field empirical analyses. Compared to field econometric studies an important advantage is that it is possible to empirically analyze the economic consequences of a *complete* implementation of a new tax system. With the additional virtue of being able to do so in a controlled way. Furthermore, an experiment offers the opportunity to generate (and if necessary replicate) the micro-level data of interest and

[3] See van Winden, Riedl, Wit, and van Dijk (1999).

[4] For economically intuitive reasons, backed by the above mentioned theoretical results from optimal taxation theory, the members of the committee had the general opinion that the sales tax system would lead to capital flight, more unemployment, and a substantial welfare loss in a relatively small open economy, like The Netherlands. In addition, it was feared that a shift in economic activity would take place from the relatively capital intensive 'exposed sector' (producing tradeable goods) towards the more labor intensive 'sheltered sector'. The more so, because high tax rates were foreseen due to a labor subsidy that was incorporated in the alternative sales tax system.

[5] Akerlof (2002) discusses some other recent experiments related to macroeconomic issues.

avoids the noise field data are unavoidably exposed to.[6] In addition, no specific behavioral assumptions are needed, nor a restriction to a partial equilibrium framework as in the theoretical studies referred to above. Moreover, since theory generically predicts multiple equilibria, experiments can provide information on their relative attractiveness in practice; an issue that will also prominently show up in our study.

More specifically, the experimental international economy that we will investigate consists of two 'countries', one of which - the home country - is relatively small in terms of potential economic activity. In each country consumers and producers are active. Consumers supply labor and capital to producers on local and global input markets. In both countries, producers are distributed over two production sectors: a sheltered sector producing a relatively labor intensive commodity for a local output market, and an exposed sector producing a relatively capital intensive commodity for a global output market. All production factors and consumption goods are traded through multi-unit double auctions.[7] In the benchmark experimental treatment, in both countries, a wage tax finances the benefits consumers receive for unemployed labor. In the alternative treatment, the wage tax system is substituted by a sales tax system, in the home country only. Under this system, instead of having to pay a tax on labor up-front, a producer is taxed according to the proceeds from sales. Moreover, for each employed unit of labor the producer receives a subsidy equal to the unemployment benefit.

The theoretical general equilibrium predictions turn out to be unique for the wage tax system. For the alternative sales-tax-*cum*-labor-subsidy system, however, we obtain two stable general equilibria implying two quite distinct sets of theoretical predictions concerning the economic performance indicators of this system. One set of predictions supports the economically intuitive hypothesis of capital flight from the small to the large country with very negative effects on factor employment, production, consumption and, hence, welfare in the small country. In the second equilibrium, however, almost no capital flight occurs and labor employment, production, and consumption levels are even higher than under the benchmark system. The experiment allows us to investigate whether economic activities are attracted to one of these equilibria.

[6] In empirical studies of taxation this is a notorious problem which, for example, manifests itself in widely diverging estimates of tax rate elasticities (see e.g. Sørensen (1997)).

[7] Double auctions are typically used for their capability to facilitate the equilibration of supply and demand and the generation of efficient outcomes (see e.g. Davis and Holt (1993)).

To evaluate the performance of the two tax systems relative to each other as well as relative to the theoretical predictions we mainly use the following economic indicators: employment of labor, capital flight, shift towards labor intensive production, real GDP, consumer earnings, and the budget surplus. Our main findings are the following. First, despite of the rather complex experimental environment, we observe a clear tendency towards equilibration of the economic process. Second, it turns out that the wage tax system shows persistent budget deficits, while tax adjustments to balance these deficits have a strong negative impact on the employment of labor and real GDP. Third, shifting taxation from wages to sales and subsidizing labor in the home country has substantial positive budgetary and real economic effects for this country. Moreover, there is no evidence of capital flight nor of a shift in economic activity towards the labor intensive sector. Fourth, under the alternative sales tax system economic behavior tends to coordinate on the equilibrium with the higher activity level or performs even better than this equilibrium predicts. In summary, the alternative sales-tax-*cum*-labor-subsidy system performs significantly better than the wage tax system.

To explain these findings we claim that producers' aversion towards incurring costs up-front, while facing output price uncertainty, plays a crucial role. The sales-tax-*cum*-labor-subsidy system is clearly much more producer and employment friendly in this respect. Instead of having to pay a tax on the input of labor, a subsidy is received, while through the sales tax the government is sharing the risk the producer runs with respect to the return on output. We present theoretical arguments and empirical evidence to support our claim.

Our results point at a hitherto underexposed behavioral regularity, with relevance for economic model building as well as policy advising. Regarding the latter our study fits into a still small but gradually growing stream of 'design' studies which involve the economist as 'engineer' (Roth 2002). In these studies experimental and computational economics are used as research methods filling the gap between theory and design. For the development of theory these studies can be helpful by posing challenges and suggesting some new answers to open questions. However, as Roth notes: "Whether economists will often be in a position to give highly practical advice on design depends in part on whether we report what we learn, and what we do, in sufficient detail to allow scientific knowledge about design to accumulate" (*ibid.*, p. 1342). With our paper we hope to make a contribution to this empirical feedback mechanism.

The organization of the paper is as follows. Section 2 presents the experimental design and procedures, as well as the theoretical predictions. The experimental results are given in Section 3. In Section 4 we propose a behavioral explanation for our main findings, while additional supportive evidence is provided. Section 5 concludes.

2 Experimental design

In the following, the wage tax system is denoted as the *WT-system* and the alternative sales-tax-*cum*-labor-subsidy system as the *STLS-system*.

2.1 Economic Environment

In view of the desired parallelism with a relatively small open economy, we consider an 'international' economy with consumers and producers in two 'countries', a relatively small country s, the home country, and a large country l, the foreign country. Consumers are endowed with units of capital (K) and labor (L) that they can sell to producers in a capital and a labor market. Consumers derive utility from 'leisure', i.e. unsold units of labor, and the consumption of two private goods: X and Y. In addition to factor payments, the consumption budget is determined by an unemployment benefit for each unsold unit of labor. Commodities X and Y are produced in separate sectors. Producers need capital and labor as inputs, which are transformed to outputs via CES production technologies. The production of good X is relatively capital intensive, while the production of Y is relative labor intensive. Profits are determined by the difference between sales revenue and the costs of inputs. The former may involve sales taxes and the latter wage taxes or labor subsidies, depending on the prevailing tax system. Taxes are paid for the finance of unemployment benefits and/or labor subsidies (see the next subsection). Both the capital market and the market for X are international (exposed), while the markets for labor and good Y are local (sheltered). Consequently, the total number of input and output markets equals six. Figure 1 shows a flow diagram illustrating the economic environment.

Consumers are endowed with $\bar{K}$ units of capital and $\bar{L}$ units of labor. Preferences over leisure ($\bar{L} - L$) and the two consumption goods, X and Y, are induced by a log-

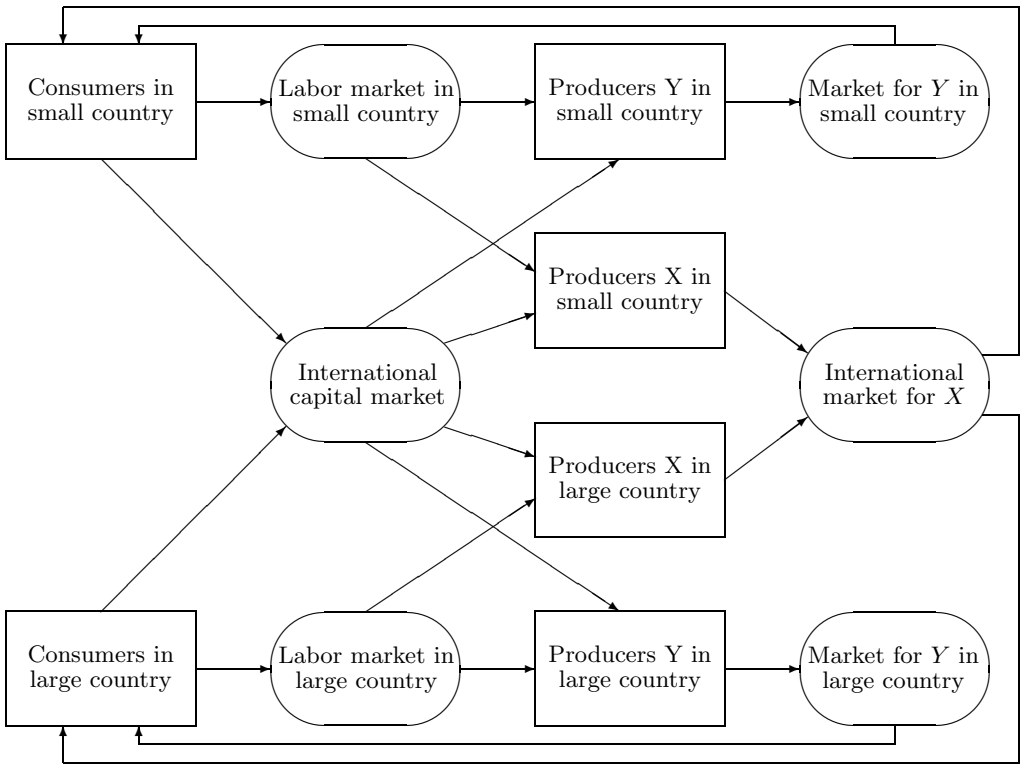


FIGURE 1 – FLOW DIAGRAM OF THE ECONOMIC ENVIRONMENT

linearized Cobb-Douglas type of utility function.[8] Producers are endowed with a CES production technology exhibiting slightly decreasing returns to scale and allowing for different factor intensities and elasticities of substitution in the two production sectors.[9] In the upper part of Table 1 the continuous approximations of the discrete utility (earnings) and output tables used in the experiments are shown. The rest of this table will be discussed below.

All inputs and outputs are traded in computerized multiple units double auction markets as introduced by Plott and Gray (1990). The choice of this market type is guided by its reputation of fast equilibration of supply and demand in experimental

[8]The use of a log-linearized Cobb-Douglas utility function has the advantage that subjects could be provided with a simple sheet of paper showing the marginal and total payoff for each of the three arguments, even though three goods entered the utility function as variables.

[9]The actually implemented factor intensities and substitution elasticities resemble estimates for the Dutch economy. The choice of slightly decreasing returns to scale is motivated by an empirical and a methodological consideration. Firstly, empirical evidence exist supporting this choice (see Basu and Fernald (1997)). Secondly, it allows experimental producers to make strictly positive profits, and hence monetary earnings, in the theoretical general equilibrium discussed below.

Table 1 – Experimental parameters

Preferences and production technologies

Consumers i (utility functions):

$$\left.\begin{array}{l} U_{i_k} = 25\left[\ln X_{i_k} + \ln Y_{i_k} + .25\ln(\bar{L}_{i_k} - L_{i_k})\right], \\ U_{i_k} = 0 \text{ if either } X_{i_k},\ Y_{i_k},\ \text{or } \bar{L}_{i_k} - L_{i_k} \text{ equals zero,} \end{array}\right\} \text{in both tax systems } \ (k = s, l)$$

Quantities L_{i_k}, Y_{i_k} are determined 'locally' (within a country)
Quantities X_{i_k} are determined 'internationally' (one global market)

Producers j (production functions and profit functions):

$$Z_{j_{zk}} = A_k\left[\eta_z^{1-\gamma_z} L_{j_{zk}}^{\gamma_z} + (1-\eta_z)^{1-\gamma_z} K_{j_{zk}}^{\gamma_z}\right]^{\frac{0.9}{\gamma_z}},\ Z = X, Y;\ z = x, y;\ k = s, l$$

Labor intensities : $\eta_x = .5625,\ \eta_y = .675$; Substitution elasticities : $\gamma_x = -2,\ \gamma_y = -6$
Scaling factor: $A_s = 1$ (small country), $A_l = 1.21$ (large country)

$$\left.\begin{array}{l} \Pi_{j_{xk}} = p_x X_{j_{xk}} - (1+\tau_{wk}) w_k L_{j_{xk}} - rK_{j_{xk}}, \\ \Pi_{j_{yk}} = p_{yk} Y_{j_{yk}} - (1+\tau_{wk}) w_k L_{j_{yk}} - rK_{j_{yk}},\ k = s, l \end{array}\right\} \text{in WT-system}$$

$$\left.\begin{array}{l} \Pi_{j_{xs}} = (1-\tau_{xs}) p_x X_{j_{xs}} - (w_s - w_0) L_{j_{xs}} - rK_{j_{xs}}, \\ \Pi_{j_{ys}} = (1-\tau_{ys}) p_{ys} Y_{j_{ys}} - (w_s - w_0) L_{j_{ys}} - rK_{j_{ys}}, \\ \Pi_{j_{xl}} = p_x X_{j_{xl}} - (1+\tau_{wl}) w_l L_{j_{xl}} - rK_{j_{xl}}, \\ \Pi_{j_{yl}} = p_{yl} Y_{j_{yl}} - (1+\tau_{wl}) w_l L_{j_{yl}} - rK_{j_{yl}}, \end{array}\right\} \text{in STLS-system}$$

Prices p_{yk}, w_k, taxes τ_{wk}, τ_{zs}, and quantities $L_{j_{zk}}$, $Y_{j_{yk}}$ are determined 'locally' (within country $k = s, l$)
Prices p_x, r, and quantities $K_{j_{xk}}$, $X_{j_{xk}}$ are determined 'internationally' (one global market)

Endowments (both tax systems)

	Small country	Large country
Consumer	$\bar{L}_i = 15,\ \bar{K}_i = 10,\ Cash_i = 181$	$\bar{L}_i = 105,\ \bar{K}_i = 70,\ Cash_i = 1268$
X-producer	$\bar{L}_j = 0,\ \bar{K}_j = 0,\ Cash_j = 1223$	$\bar{L}_j = 0,\ \bar{K}_j = 0,\ Cash_j = 8557$
Y-producer	$\bar{L}_j = 0,\ \bar{K}_j = 0,\ Cash_j = 815$	$\bar{L}_j = 0,\ \bar{K}_j = 0,\ Cash_j = 5705$

Number of agents

Consumers	3	3
X-Producers	2	2
Y-Producers	3	3

Tax systems

	WT-system	STLS-system	
	Both countries k	Small country s	Large country l
Unemployment benefit (w_0)	70	70	70
Labor subsidy (w_0)	0	70	0
Initial wage tax rate (τ_w^0)	.3777	0	.3777
Wage tax adjustment rule (τ_w^{t+1})	$\tau_{wk}^{t+1} w_k^t L_k^t = w_0(\bar{L}_k - L_k^t)$		$\tau_{wl}^{t+1} w_k^t L_l^t = w_0(\bar{L}_l - L_l^t)$
Initial sales tax rate X (τ_x^0)	0	.6521	0
Initial sales tax rate Y (τ_y^0)	0	.7518	0
Sales taxes adjustment rule ($\tau_x^{t+1}, \tau_y^{t+1}$)		$\tau_{xs}^{t+1} p_x^t X_s^t + \tau_{ys}^{t+1} p_{ys}^t Y_s^t = w_0 \bar{L}_s$; $\tau_{xs}^{t+1}/\tau_{ys}^{t+1} = \tau_{xs}^0/\tau_{ys}^0$	

Note: In the table describing the tax systems, t denotes a trading period, the variables L_k^t, $\bar{L}_k$, X_s, and Y_s denote aggregates in a country, superscripts ^{0} refer to initial values.

market economies. Trading takes place in a number of trading periods. Each trading period is split into a first phase with only the input markets open, and a second phase with only the output markets open.[10] To facilitate trading, both consumers and producers are endowed with some fiat money ($Cash$ in Table 1) at the beginning of the first phase of each period. In addition, consumers receive a transfer (unemployment benefit w_0) for each unit of labor that is unemployed at the end of this phase.[11]

All taxes are levied on the producers. In the baseline treatment of the experiment the WT-system obtains in both countries. In this case a given tax rate ($\tau_{wk},\ k=s,l$) is applied to the wage of each unit of labor that is employed. In the treatment concerning the alternative tax system the WT-system again obtains in the large country, but now the STLS-system prevails in the small (home) country. Instead of paying a wage tax, producers in the small country now receive a fixed subsidy (equal to the unemployment benefit) for each unit of labor they employ, while paying a given tax rate (τ_{xs} in the X-sector and τ_{ys} in the Y-sector) on the sales price of their products.[12]

Experimental subjects participate in a sequence of 16 trading periods. In a given treatment the first eight of these periods are identical with respect to the exogenous parameters. Except for the subjects' earnings nothing carries over from period to period. Consequently, each period can be seen as a repetition of the same static economy.

[10]There are two main reasons for using sequential instead of simultaneous markets. Firstly, in our view sequentiality of input and output markets is much more common in the field than simultaneous markets are. Note also that even simultaneous markets would exhibit some sequentiality, were it alone for the sequentiality that is inherent to the production process (cf. Keynes' view quoted in the beginning). Secondly, the sequentiality considerably reduces the complexity of the market environment for the subjects.

[11]Any unemployment remaining in an equilibrium may be viewed as 'voluntary', theoretically (according to Layard, Nickell, and Jackman (1991, p. 41), however, the question of voluntary versus involuntary unemployment is 'fruitless' for practical and public policy purposes). Rogerson (1997) convincingly argues that any distinction between voluntary and involuntary, frictional and cyclical, equilibrium and disequilibrium unemployment is meaningless because all unemployment consists of all these components. The inclusion of 'frictions', like trade unions or efficiency wages, might have added some realism. However, in view of the novelty of the set-up and the already complicated nature of the economy it was decided to start with a relative simple market structure. Lian and Plott (1998) use a similar setup for their general equilibrium experiment.

[12]Because this study does not focus on transitional issues, a between-subjects design was chosen for the tax systems.

In periods 9-16 tax rates are adjusted at the beginning of each new period such that a balanced budget would be obtained for the previous period, given the market outcomes of that period. The initial tax rates and the precise tax adjustment rules are shown in the lower part of Table 1.[13] This procedure guarantees a sufficient number of repetitions with a constant environment for making it possible to examine whether and at which level economic behavior stabilizes. The adjustment of the tax rates to the budget balance adds an important feature of realism and enables an analysis of the dynamic interaction between taxation, employment and other indicators of economic performance, while keeping everything else constant. It also allows to control for the potentially confounding effect that a relative good performance of a tax system is 'bought' by budget deficits.

Table 1 shows the parameter values chosen for the endowments, utility functions, production functions, and the number of agents. To implement a large country in the laboratory the following solution was chosen. While keeping the number of consumers and producers the same for both countries, consumers in the large country are endowed with seven times as many units of labor and capital as holds for the consumers in the small country (see the different $\bar{L}$ and $\bar{K}$ in the table). Moreover, the scaling factors (A_s and A_l) in the production functions are adjusted such that, theoretically, supply and demand in the large economy are seven times as large as in the small economy, in the baseline treatment with the WT-system (see next subsection).[14]

2.2 Theoretical General Equilibrium Predictions

Given the complex nature of the experimental economy, with several interdependent markets and the double auction trading mechanism, the most natural solution concept is the general equilibrium. We calculated the numerical solution(s) of a competitive general equilibrium model equating supply and demand in the various markets with

[13] An upper bound of 0.90 was maintained for the tax rates because pilot studies showed that tax rates too close to 100% might have a strongly discouraging effect on trading.

[14] The alternative approach of increasing the number of agents instead of endowments would not have been feasible. With the requirement of at least three agents on each side of a market to ensure competitiveness (see Davis and Holt (1993), Huck, Konrad, Müller, and Normann (2001)), the minimal number of subjects per experimental session would have been 64, exceeding by far the capacity of the laboratory.

the additional requirement of a balanced tax-transfer budget. We thereby follow other studies of experimental markets using a similar procedure (see e.g. Noussair, Plott, and Riezman (1995, 1997), Quirmbach, Swenson, and Vines (1996)).

Table 2 shows the predictions concerning quantities, relative prices and taxes separately for the international markets, the small country, and the large country. The most interesting part of these predictions is the fact that there exist two (stable) equilibria for the STLS-system.[15] These two equilibria are quite different, in particular for the small country. Equilibrium 2 shows the serious negative economic consequences - including a substantial capital flight - for the small country that economic intuition and the literature on optimal (capital) taxation in small open economies suggests (see e.g. Diamond and Mirrlees (1971), Bovenberg (1994)). In contrast to the WT-system, where only labor is taxed, the STLS-system implicitly taxes capital thereby reducing the rents from capital in the small country. This induces the capital flight observed in equilibrium 2.

Yet, implicitly taxing capital and labor broadens the tax basis, which has potentially positive efficiency effects. In particular, since the production process exhibits decreasing returns to scale allowing tax shifting to an immobile third factor. This is akin to the tax shifting effect known in the literature on the 'double dividend' of environmental taxes (e.g. de Mooij and Bovenberg (1998). This potentially beneficial tax shifting offers a rationale for equilibrium 1 in the STLS-system. This equilibrium shows substantial positive employment effects, little capital flight, and an increase in the production in both sectors.

The existence of two quite distinct general equilibria for the alternative STLS-system makes the experimental investigation particularly interesting. In addition to the comparison of the two alternative tax-transfer systems we can also investigate whether actual behavior converges to one of the equilibria, if it converges at all. This is of special interest because the multiplicity of equilibria leaves the economies with a coordination problem and the theoretical prediction ambiguous.

[15] Actually, the WT-system also exhibits two (stable) equilibria. Accidentally, however, they are so close to be virtually not distinguishable. Therefore, we report only one here. Although, generically, an odd number of general equilibria exist (Dierker (1972)), instable equilibria are neither likely to be detected - which explains the even number found - nor of particular interest, here.

Table 2 – Theoretical general equilibrium predictions

	WT-system	STLS-system	
		equilibrium 1	equilibrium 2
	International		
K	240	240	240
X	177	181	182
r	0.0307	0.0295	0.0289
p_x	0.1882	0.1807	0.1807
	Small country		
K_s	30	28	11
L_s	28	33	18
X_s^c	22	25	17
X_s^p	22	25	14
Y_s	19	21	11
w_s	0.1694	0.1971	0.1292
p_{ys}	0.2211	0.2165	0.2747
τ_{ws}	0.3777		
τ_{xs}		0.4889	0.7835
τ_{ys}		0.5414	0.8677
	Large country		
K_l	210	212	229
L_l	197	199	213
X_l^c	155	156	165
X_l^p	155	156	168
Y_l	132	133	140
w_l	0.1694	0.1640	0.1743
p_{yl}	0.2211	0.2123	0.2121
τ_{wl}	0.3777	0.3655	0.2769

Note: Equilibrium quantities are rounded to integers. Depicted prices are relative prices that are obtained by dividing nominal prices by the sum of all six nominal prices. The equilibrium tax rates guarantee a balanced budget in equilibrium. Superscript ^{c} (^{p}) indicates consumed (produced) quantities; when this distinction is not made consumed and produced quantities coincide in equilibrium.

In order to avoid a potential bias of the experimental results in favor of the alternative tax system, and because the experiment was also policy oriented, it was decided not to take the initial tax rates for the STLS-system from one of the two equilibria of the theoretical model. Instead, these were determined such that *on impact* the producers of X and Y would have to bear the same tax burden as *empirically* observed (in

the laboratory) under the WT-system.[16] Interestingly, it turned out that these empirically based tax rates (τ_{xs} and τ_{ys}) were in a close neighborhood of the theoretical tax rates in the 'bad' equilibrium 2 prediction. Finally, it is noted that only one currency ('francs', with a fixed conversion rate to Dutch guilders) is used in the lab economy. Since the focus of this study is not on issues of international finance we did not want to complicate the experiment by introducing multiple currencies.

2.3 Research Questions and Experimental Procedures

In the following we empirically analyze the performance of the WT- and the STLS-system in comparison to the theoretical predictions and also compare the two tax systems with each other. We do this on the basis of relative prices and quantities produced and consumed. Additionally, with an eye on the political relevance of our study, we also investigate the behavior of the following more aggregate performance indicators: employment of labor, net capital export, shift towards labor intensive production, real GDP, consumer earnings, and the budget surplus. In light of the implicit taxation of capital under the STLS-system, with capital being mobile and labor immobile between countries, an intuitive hypothesis predicts that serious capital flight with bad economic consequences will be observed. This in turn will have negative consequences on labor employment, real GDP, consumer earnings, and budget surplus. Additionally, an increase in labor intensity of production under the STLS system can be expected. This was in fact the view taken by our naïve principals.

All experimental sessions were run at the CREED-laboratory of the University of Amsterdam. Subjects, recruited through announcements on bulletin boards, were undergraduates of the University and mostly coming from its Faculty of Economics and Econometrics. Because of the relative complexity of the experimental environment we implemented the following procedure. Subjects had to sign up for three meetings: a training session (where participants got acquainted with the trading rules, forms and tables to be used, and how to handle the computer), a 'closed economy' session (for

[16] More precisely, the initial wage tax rate τ_w^0 which *ceteris paribus* balances actual average tax revenue with actual average unemployment expenditure in the periods 6-8 of the WT-system (denoted by A) is derived from: $\tau_w^0 w_s^A L_s^A = w_0(\bar{L}_s - L_s^A)$. The initial tax rates of the STLS-system (τ_x^0 and τ_y^0) then follow from: $\tau_x^0 p_x^A X_s^A - w_0 L_{xs}^A = \tau_w^0 w_s^A L_{xs}^A$ and $\tau_y^0 p_{ys}^A Y_s^A - w_0 L_{ys}^A = \tau_w^0 w_s^A L_{ys}^A$. When the tax rates are adjusted, in periods 9-16, the ratio of the tax rates is kept the same (see the lower part of Table 1).

getting subjects experienced with trading), and the international economy session.[17] Subjects were paid out only at the end of the third meeting. They received a show-up fee of 70 Dutch guilders for the training session. In the closed economy sessions they earned on average 27 guilders, while receiving 40 guilders as a show-up fee. The show-up fee for the international economy session was 10 guilders, while average earnings in this sessions amounted to 120 guilders (at the time of the experiments one Dutch guilder was worth approximately 0.52 U.S. dollar). All meetings lasted about 3.5 hours. At the training session each subject was randomly assigned the role of consumer or producer, which they kept in the subsequent meetings.

At the beginning of an experimental session subjects received instructions consisting of a general part, read aloud by the experimenter, and a role-specific part, which was quietly read by the subjects. They further received personal history forms with all the information that was relevant to them (concerning endowments, markets they were allowed to trade in, any taxes or subsidies, and the conversion rate of 'francs' to guilders).[18] Similar information was provided on the computer screen. By having them fill in their transactions and earnings these forms were also intended to make subjects fully aware of the consequences of their decisions. Quizzes were used to check the understanding of the procedures, the reading of the table with redemption values ('utility') or input-output combinations (production schedule), and the calculation of earnings. A sample copy of the instructions, trading rules, and personal forms used in the experiments can be downloaded from http://www1.fee.uva.nl/creed/pdf files/instr2taxsyscomp.pdf.

Each experimental session started with two unpaid practice rounds, followed by 16 trading periods. During the first eight periods tax rates were kept at their initial values. From trading period 9 on, they adjusted to the budget balance of the previous period. In each period, the input markets phase lasted 4 minutes and 30 seconds. Then, after a short break of 20 seconds, the output markets phase started which lasted 3 minutes

[17] Parameter values of the closed economy were similar but not identical to the ones used in the experiment. Subjects were selected for the international economy session on the basis of their performance (earnings) in the closed economy session; they got informed about this at the first meeting.

[18] In the experiment consumers were labeled 'type-1 traders' and producers 'type-2 traders'. Moreover, labor and capital were denoted as good V and good W, respectively. Markets were labeled as V1(2), W1, X1, Y1(2). The unemployment benefit was denoted as a subsidy for unsold units of V.

Table 3 – Summary of experiments

	Number of subjects	Tax system in small country	Number of periods†	Number of constant tax periods
session 1	16	WT	16 (2)	8
session 2	16	WT	16 (2)	8
session 3	16	WT	16 (2)	8
session 4	16	STLS	16 (2)	8
session 5	16	STLS	16 (2)	8
session 6	16	STLS	16 (2)	8

Note: † number of practice periods in parentheses.

and 30 seconds. This was followed by a 2 minutes break for recording before the next period began.[19]

Two series of experimental sessions were conducted, each consisting of three sessions. One series concerned the treatment where the WT-system obtained in both countries, while the other series dealt with the treatment where the STLS-system was effective in the small country while the WT-system again prevailed in the large country. Table 3 characterizes the sessions.

3 Experimental Results

In presenting our results we will focus first on the trading periods with a constant tax regime (periods 1-8). In the constant tax regime of the WT-system the tax rates are set at the level of the theoretical predictions shown in Table 2. We use the results of these periods for a comparison with these predictions.[20] Yet, the main focus of our analysis will be on the economic indicators showing the relative performance of the two tax systems. Recall that in the large country the wage tax system is effective in both experimental treatments, the WT-system and the STLS-system.

[19]Standing bids and asks were presented as 'market prices' (excluding any taxes or subsidies) and as 'inclusive prices' (including taxes or subsidies). After the closing of the factor markets consumers were informed about the transfers received for unsold units of labor, while producers were informed about the number of goods produced with the inputs they bought. In addition, some market statistics were provided concerning trades, average prices, and the average price subjects received (paid) for the inputs they sold (bought). Similar market statistics were provided after the closing of the product markets.

[20]Recall that the initial tax rates in the STLS-system are determined by using the outcomes of the constant tax regime of the WT-system.

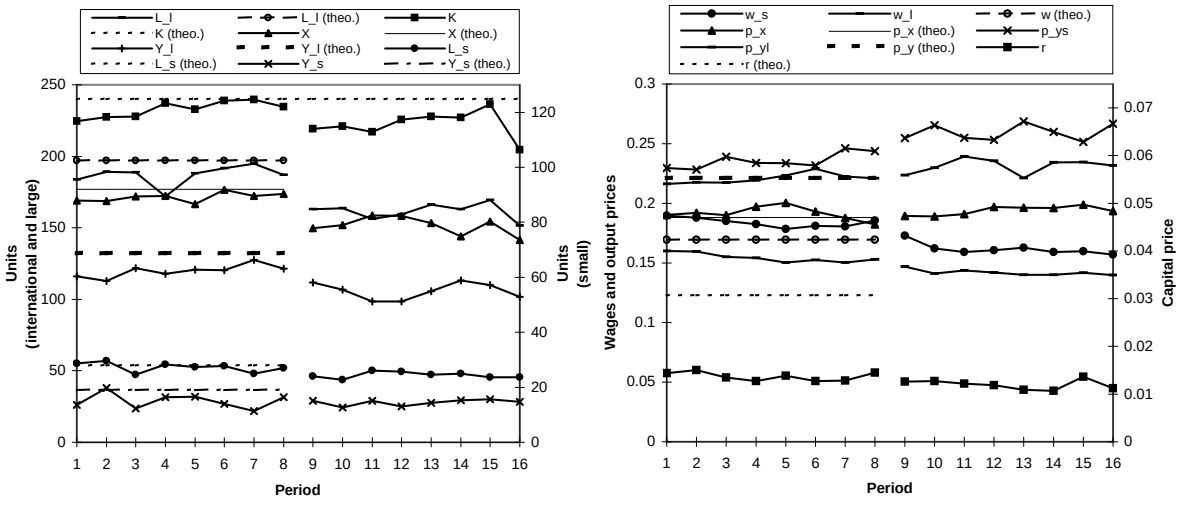
3.1 Constant Tax Regime

Figures 2 and 3 illustrate the development of quantities (panels (a)) and relative prices (panels (b)), averaged over sessions, for the WT-system and the STLS-system. In this subsection we restrict our discussion to the left-hand part of each figure (the first 8 periods). The figures show an orderly development, as is also observed in other multiple markets experiments. Of particular interest are the following observations. Figure 2 (a) shows that, with only one exception, all quantities start below the equilibrium levels of the general equilibrium prediction (straight lines in the figures). Most of these variables, however, exhibit some converge towards these levels. Regarding the development of prices, panel (b) of Figure 2 exhibits no clear picture concerning the starting levels of the output prices, but shows that two of the three input prices (r and w_l) clearly start (and seem to stay) below the theoretically predicted levels.

This general impression is confirmed by a convergence analysis based on the following estimation model (see Noussair, Plott, and Riezman (1995)):

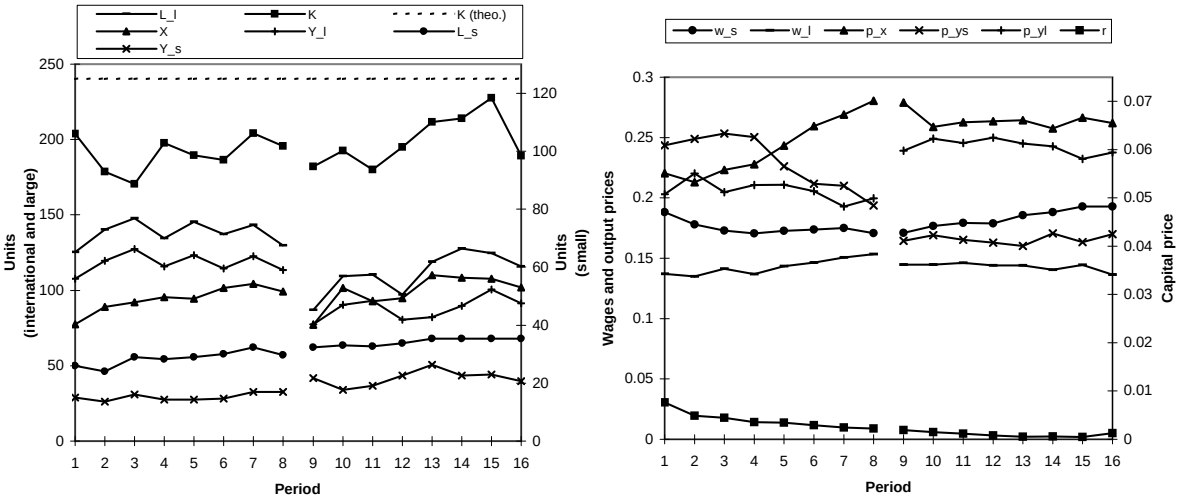
$$y_{it} = a_{11}D_{A1}(1/t) + a_{12}D_{A2}(1/t) + a_{13}D_{A3}(1/t) + a_2 D_A(t-1)/t + u_{it}$$

where y stands for the particular outcome focused at (quantity, price; with average outcomes per period and session as units of observation), i denotes the experimental



(a) Quantities (b) Relative prices

Figure 2 – Development of quantities and prices under the WT-system



(a) Quantities (b) Relative prices

Figure 3 – Development of quantities and prices under the STLS-system

session, t the trading period in the session, D_{Ai} a dummy variable for session i of the WT-system which is equal to 1 for i and 0 otherwise, and u the error term. Note that the coefficients a_{1i} indicate session specific starting values and a_2 the asymptotic value of y in the WT-system ($D_A = 1$ when the WT-system is effective). Strong convergence is said to hold if the estimated asymptotic value (a_2) is not significantly different from the theoretically predicted level. We will speak of weak convergence if the majority of the starting values (a_{1i}) are further apart from the theoretical level than the estimated asymptotic value.

The regression results are presented in Table 4. They show that strong convergence has to be rejected for a majority of the 18 investigated variables. Only the behavior of employed capital K, employed labor in the small country L_s, and the relative price p_{yl} satisfy the strong convergence criterion. However, most variables (10 out of 18) converge in the weak sense. Furthermore, though most asymptotic values are statistically significantly different from the predicted levels, the differences are mostly small in economic terms. Given the complexity of the laboratory economy and the fact that the theoretical general equilibrium model is a very stylized representation of the economy we find this a quite remarkable result. In line with the visual impression from Figure 2, we find that the asymptotic value of all aggregate quantity variables is lower than the respective theoretical level, with the exception of capital employment and the produc-

TABLE 4 – CONVERGENCE REGRESSIONS FOR CONSTANT WAGE TAX REGIME
COMPARISON WITH THEORETICAL BENCHMARK MODEL

Variable	a_{11}	a_{12}	a_{13}	a_2	prediction	p-value[a]	Wald's χ^2
				International			
K	231.5	209.2	230.7	236.1	240	.204	18131.7
	(8.92)	(5.99)	(4.32)	(3.04)			
X	171.9	129.0	183.6	164.7	177	.000	5561.2
	(5.97)	(8.22)	(14.59)	(3.43)			
r	.0141	.0164	.0201	.0169	.0307	.000	375.4
	(.0021)	(.0011)	(.0030)	(.0013)			
p_x	.1764	.2283	.1869	.2001	.1882	.038	5628.6
	(.0144)	(.0039)	(.0082)	(.0057)			
				Small country			
K_s	17.7	29.5	42.5	35.9	30	.000	2192.7
	(4.21)	(3.98)	(2.55)	(1.35)			
L_s	28.2	24.9	31.8	25.5	28	.084	811.7
	(2.48)	(3.51)	(4.58)	(1.43)			
X_s^c	22.7	20.7	26.1	25.5	22	.000	6512.8
	(4.32)	(1.12)	(2.79)	(.70)			
X_s^p	16.3	13.3	27.7	25.0	22	.005	1418.4
	(2.71)	(1.65)	(1.92)	(1.05)			
Y_s	15.4	14.1	18.9	14.8	19	.000	1135.4
	(2.82)	(2.98)	(1.72)	(.87)			
w_s	.1903	.2010	.1748	.1825	.1694	.001	4962.4
	(.0110)	(.0050)	(.0033)	(.0039)			
p_{ys}	.2277	.2177	.2500	.2390	.2211	.009	2016.5
	(.0171)	(.0110)	(.0120)	(.0068)			
				Large country			
K_l	212.3	178.9	187.3	202.5	210	.020	11899.6
	(11.52)	(6.92)	(5.72)	(3.2)			
L_l	167.0	175.5	204.6	186.2	197	.041	2700.0
	(12.13)	(11.26)	(14.19)	(5.27)			
X_l^c	147.9	108.3	159.1	142.2	155	.000	4360.2
	(6.24)	(9.26)	(12.37)	(3.44)			
X_l^p	157.1	114.4	159.3	143.3	155	.000	5710.5
	(3.69)	(8.98)	(10.92)	(2.97)			
Y_l	89.9	137.1	113.7	120.3	132	.000	11468.0
	(12.22)	(10.97)	(3.38)	(2.43)			
w_l	.1796	.1426	.1547	.1501	.1694	.000	5419.4
	(.0053)	(.0048)	(.0067)	(.0029)			
p_{yl}	.2107	.2059	.2446	.2211	.2211	.985	30222.6
	(.0181)	(.0102)	(.0037)	(.0024)			

Note: [a] tests the hypothesis that the asymptotic value a_2 is equal to the theoretical prediction; two-sided Wald tests. For X superscript c (p) indicates units consumed (produced); for Y quantities produced are used as units of observation. Standard errors in parentheses; corrected for session specific heteroskedasticity and AR(1).

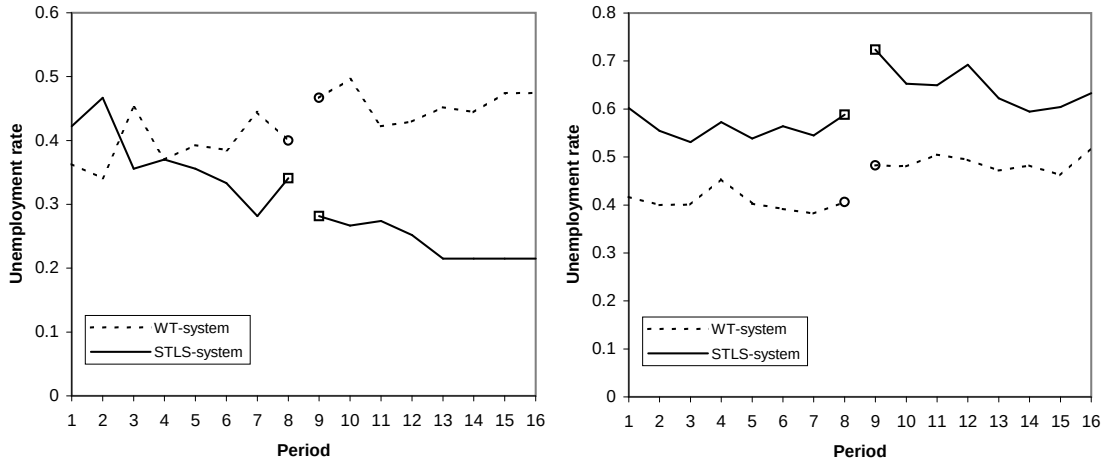
tion and consumption of the capital intensive commodity in the small country. Also two of the three input price variables are too low, while for two of the three output price variables the asymptote is higher than the theoretical value. This leads to our first result.

Result 1 *A majority of the variables exhibits weak convergence towards the theoretical general equilibrium levels. The quantity and input price variables are typically converging from below, while the output prices are typically converging from above.*

We have also run convergence regressions for the economic performance indicators unemployment rate, real GDP, consumer earnings, net capital export, and labor intensity in the Y-sector. The results of these regressions corroborate the above findings. In both countries, all five performance indicators are weakly converging to the theoretically predicted equilibrium values. In both countries the unemployment rate exhibits even strong convergence (from above) as does real GDP (from below) in the small country and the Y-production intensity in the large country. There is, however, a caveat to this result. As will be demonstrated below, this rather positive result does not come for free, but is associated with relatively large budget deficits.

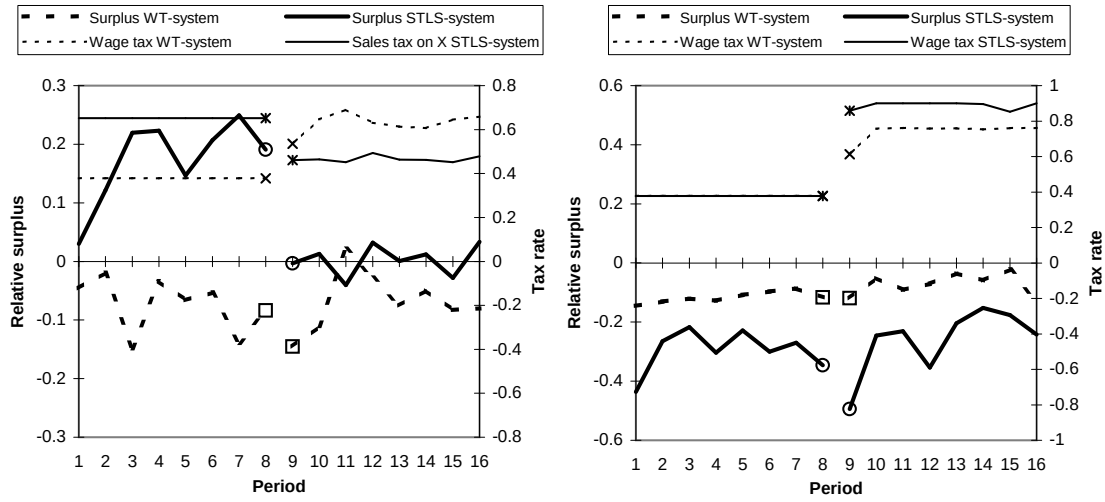
We now turn to a comparison of the two tax systems in the constant tax regime. Comparing Figure 2(a) with Figure 3(a) shows that economic activity starts at a lower level in the experimental sessions with the STLS-system. This holds for the employment of both input factors, and is accompanied by lower input prices. In particular, output of the exposed sector X is affected, while its product price p_x exhibits a clear upward thrust. To put this outcome into perspective, one has to recognize that in these periods the small country is facing substantial sales taxes, with a tax rate of 65% and 75% on the price of X and Y (see Table 1). Recall that these tax rates are not taken from a theoretical model but determined such that *on impact* the producers of X and Y would have to bear the same tax burden as observed under the WT-system. Thus, the initial economic circumstances are not particularly favorable for a comparatively good performance of the alternative tax system.

Our primary research questions concern the small country. Therefore, in the following we mainly, but not exclusively, focus on the economic performance regarding the small country under the two different tax regimes. Figures 4-6 illustrate the development of the unemployment rate, the budget surplus, and real GDP, for both tax



(a) Small country (b) Large country

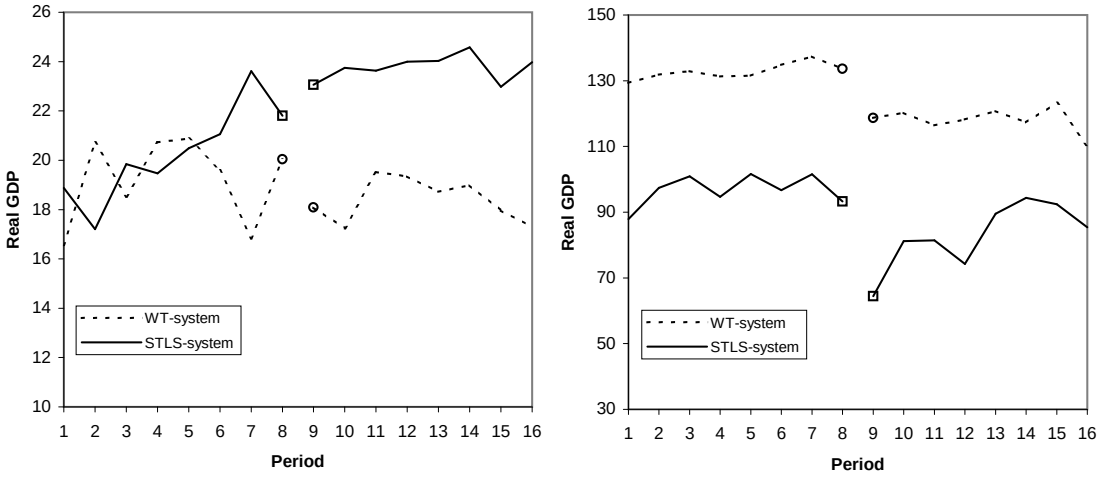
Figure 4 – Development of unemployment rates under the two tax systems



(a) Small country (b) Large country

Figure 5 – Development of budget surplus and tax rates under the two tax systems

systems (and both countries). Initially, the unemployment rate in the small country is at a higher level in case of the STLS-system. However, in spite of the high sales tax rates, there is a clear tendency for this rate to decline over time (Figure 4). This stays in clear contrast to the development of the unemployment rate under the WT-system (and the development in the large country, where a wage tax is applied in both



(a) Small country (b) Large country

Figure 6 – Development of real GDP under the two tax systems

treatments). Under the STLS-system this appears to have a beneficial effect on the budget surplus of the small country, which substantially increases over the periods (see Figure 5). Wage taxes, on the other hand, are systematically accompanied by budget deficits; this holds for the baseline treatment (WT-system, small and large country) as well as the alternative treatment (large country with wage tax system). A similar picture emerges from the development of real GDP (see Figure 6). Whereas economic activity strongly increases in the small country when the sales tax applies, it shows no clear development, neither in the small country nor in the large country, when the wage tax system is effective.

These observations are corroborated by a convergence analysis using an extension of the estimation model presented above.[21] Table 5 gives the results. Whereas the asymptotic estimates for the large country (b_2 versus a_2) still show the negative effects of the relatively adverse start in economic activity in these sessions, the outcomes for the small country are quite different. Compared to the WT-system, we observe a clear

[21] The estimation model now becomes

$$\begin{aligned} y_{it} &= a_{11}D_{A1}(1/t) + a_{12}D_{A2}(1/t) + a_{13}D_{A3}(1/t) + a_2 D_A(t-1)/t + \\ &\quad b_{11}D_{B1}(1/t) + b_{12}D_{B2}(1/t) + b_{13}D_{B3}(1/t) + b_2 D_B(t-1)/t + u_{it} \end{aligned}$$

where D_{Bi} is a dummy variable representing session i of the STLS-system (equal to 1 for i, 0 otherwise); $D_B = 1$ for sessions where the STLS-system applies in the small country, zero otherwise. The coefficients b_{1i} denote the session specific starting values and b_2 the asymptotic value of y in the STLS-system.

Table 5 – Convergence regressions for constant tax regime
Economic performance indicators compared between the tax systems

Variable	a_{11}	a_{12}	a_{13}	b_{11}	b_{12}	b_{13}	a_2	b_2	p-value[a]	Wald's χ^2
					Small country					
Unemployment rate	.3738 (.0552)	.4479 (.0779)	.2927 (.1017)	.5547 (.0371)	.6151 (.0357)	.2683 (.0373)	.4326 (.0317)	.3134 (.0135)	.001	2667.5
Budget surplus	−.0927 (.0676)	−.0895 (.0804)	−.0070 (.1129)	.0266 (.0538)	−.0566 (.0923)	.1056 (.0428)	−.1409 (.0345)	.2069 (.0251)	.000	124.3
Real GDP	13.6 (2.02)	14.1 (1.99)	25.1 (1.54)	15.3 (1.44)	14.2 (1.84)	22.3 (1.22)	20.0 (.68)	21.8 (.56)	.039	6392.5
Consumer earnings 1	84.0 (7.48)	88.0 (11.97)	107.1 (3.60)	67.4 (6.03)	18.7 (9.66)	104.6 (4.78)	98.4 (2.75)	87.3 (3.52)	.013	17157.8
Consumer earnings 2	−13.9 (80.25)	−36.2 (119.38)	172.7 (167.24)	108.4 (147.67)	−25.4 (350.22)	331.5 (120.64)	−59.0 (48.00)	549.7 (76.94)	.000	81.35
Net capital export	8.9 (6.43)	1.3 (4.75)	−16.8 (2.85)	2.8 (4.38)	.4 (7.21)	−.9 (3.42)	−8.1 (2.36)	−9.9 (2.15)	.560	86.5
Y-production intensity	.5018 (.0541)	.5133 (.0527)	.4011 (.0438)	.5607 (.0510)	.5293 (.0763)	.4975 (.0522)	.3625 (.0188)	.3347 (.0231)	.351	2061.5
					Large country					
Unemployment rate	.4699 (.0385)	.4429 (.0357)	.3506 (.0451)	.6928 (.0257)	.6579 (.0905)	.3653 (.0672)	.4088 (.0167)	.5206 (.0151)	.000	6001.3
Budget surplus	−.2724 (.0467)	−.1578 (.0154)	−.0425 (.0539)	−.5536 (.0470)	−.6708 (.1587)	−.0388 (.0714)	−.1174 (.0108)	−.2175 (.0258)	.000	1339.8
Real GDP	120.7 (8.16)	127.2 (2.31)	139.1 (6.01)	71.3 (5.25)	79.5 (18.67)	132.4 (10.87)	134.8 (1.64)	108.6 (3.26)	.000	30313.3
Consumer earnings 1	197.3 (2.41)	207.6 (1.93)	214.6 (2.63)	176.9 (6.06)	177.4 (11.93)	197.8 (5.65)	208.9 (.95)	197.2 (3.49)	.001	136271.6
Consumer earnings 2	−1489.6 (428.87)	−1369.3 (122.11)	−219.5 (492.82)	−3865.3 (253.75)	−3344.2 (940.85)	−379.0 (665.68)	−843.3 (84.61)	−1926.2 (150.48)	.000	1814.1
Net capital export	−8.9 (6.43)	−1.3 (4.75)	16.8 (2.85)	−2.8 (4.38)	−.4 (7.21)	.9 (3.42)	8.1 (2.36)	9.9 (2.15)	.560	86.54
Y-production intensity	.3606 (.0257)	.5322 (.0352)	.4025 (.0230)	.5437 (.0493)	.7096 (.0379)	.6178 (.0371)	.4416 (.0157)	.6612 (.0178)	.000	4060.7

Note: [a] tests the hypothesis that the asymptotic values a_2 and b_2 are equal; two-sided Wald tests. Superscript c (p) indicates units consumed (produced). Standard errors in parentheses; corrected for session specific heteroskedasticity and AR(1). 'Unemployment rate' is defined as the amount of unemployed units of labor relative to the total labor force (endowment) in the respective country; 'Budget surplus' denotes the nominal budget surplus relative to nominal GDP (defined as the total nominal value of the produced goods) in the respective country; the base 'year' for calculating 'Real GDP' is the first trading period in each session; 'Consumer earnings 1' denotes average earnings of a consumer in points ('utility'); 'Consumer earnings 2' are 'Consumer earnings 1' with the per capita budget surplus added; 'Net capital export' is the difference between total capital sold to the other country and total capital bought from the other country; 'Y-production intensity' denotes the total amount of goods produced in the Y-sector relative to the total amount of goods produced in the respective country.

decrease in the unemployment rate and a substantial improvement in the budget balance. Also real GDP and consumer earnings net of budget surplus show a statistically significant better outcome under the STLS- than under the WT-system. Whereas for the former the better performance is economically not large it is dramatically different for the latter. When not correcting for budget deficits consumer earnings are statistically significantly larger under the WT-system. Economically, however, the difference is not large in that case. The remaining two variables are not significantly different for the two tax systems. There is no shift in production between the sectors (measured by 'Y-production intensity'), while net capital export decreases, but not significantly. These observations lead to our next result.

Result 2 *By the end of the constant tax regime, most economic performance indicators show a significant improvement for the small country under the STLS-system compared to the WT-system. Only consumer earnings unadjusted for the budget surplus are significantly lower under the STLS-system. In the large country, where in both treatments the wage tax is applied to finance unemployment benefits, no such development is observed.*

Note that these outcomes clearly contradict the intuitive hypothesis concerning the STLS-system presented at the beginning of the previous section. For constant taxes, the STLS-system does even better than the WT-system. This holds despite the fact that the exogenously fixed sales tax rates are in the neighborhood of the unfavorable general equilibrium.

In the following section we present the results of the trading periods where the tax rates adjusted to the budget surplus in the previous period: the variable tax regime. This enables us to investigate the robustness of our findings. Especially, we can examine the economic impact of changes of tax rates in the different tax systems. Additionally, it also allows us to test for possible convergence of economic activity in the STLS-system and, hence, to explore whether economic activity coordinates on one of the two theoretical general equilibria.

3.2 Variable Tax Regime

When the tax rates start to adjust to the budget surplus in the previous trading period an economic shock occurs. This can be observed from the development of the quantity

variables shown in the panels (a) of Figures 2 and 3. From the former it can be seen that, under the WT-system, all traded quantities in both countries decrease from period 8 to period 9. Under the STLS-system, the quantities traded internationally and in the large country also decrease, but now the the traded quantities of local goods in the small country (L_s and Y_s) increase when the tax rates begin to adjust (Figure 3 (a)).

In the last constant tax period all economies with wage taxation are confronted with substantial budget deficits, whereas large surpluses are generated under the sales tax system in the small country. Therefore, tax rates increase in the former and decrease in the latter case (see Figure 5). As illustrated by two economic performance indicators in Figures 4 and 6, in the economies with wage taxation, this triggers a clearly observable negative economic shock, with increasing unemployment rates and decreasing real GDP. Because of this shock, the budget balance does not improve in the transition period 9 (see Figure 5). Thereafter, these economies seem to improve somewhat, showing some convergence towards a balanced budget and a full utilization of capital (see Figure 3). However, unemployment stays at a high level, which has a negative effect on outputs, as manifested by the development of real GDP in Figure 6.[22]

These developments in the economies where the wage tax system applies are in stark contrast to the economic development in the small country under the alternative tax system. First of all, the initial decline in the sales tax rates in period 9 produces positive economic effects. This is witnessed by the development of the economic performance indicators in Figures 4 and 6. The unemployment rate drops significantly and real GDP clearly increases. Note, furthermore, the positive effect on the wage rate (w_s), and the negative effect on the price of the labor intensive good Y (p_{ys}), in contrast to the development under wage taxation (see Figures 2 (b) and 3 (b)). This development is due to the replacement of the wage tax by a labor subsidy. Remarkably, under the STLS-system the budget immediately balances, and stays that way over the remaining periods, with only small deviations. As Figures 4 (a) and 6 (a) indicate, the unemployment rate and real GDP further improve in later periods, and show convergence towards a level that is substantially different from the level reached under the WT-system.

[22]Note, furthermore, that the gap between the values of the economic performance indicators in the large country narrows over the periods with variable tax rates. We will return to this when presenting the convergence analysis for the variable tax regime.

Table 6 – Convergence regressions for variable tax regime
Economic performance indicators compared between the tax systems

Variable	a_{11}	a_{12}	a_{13}	b_{11}	b_{12}	b_{13}	a_2	b_2	p-value[b]	Wald's χ^2
					Small country					
Unemployment rate	.6647 (.0790)	.5279 (.0155)	.2076 (.0845)	.3200 (.0592)	.2726 (.0270)	.2974 (.0411)	.4807 (.0279)	.2417 (.0151)	.000	2818.1
Budget surplus	−.3990 (.0940)	−.0357 (.0349)	−.0155 (.0450)	.0151 (.0119)	−.0295 (.0261)	.0061 (.0177)	−.0259 (.0227)	.0038 (.0067)	.210	30.1
Real GDP	15.1 (3.43)	16.1 (.25)	26.1 (2.46)	21.3 (1.76)	24.1 (1.29)	22.4 (1.11)	18.9 (.91)	22.8 (.56)	.000	8526.7
Consumer earnings 1	83.4 (4.41)	86.3 (5.00)	70.7 (10.25)	82.3 (8.10)	76.8 (11.90)	104.8 (10.82)	91.8 (2.32)	89.3 (4.83)	.640	5030.7
Consumer earnings 2	−353.9 (108.24)	49.6 (47.05)	64.7 (73.52)	122.8 (22.09)	−1.1 (64.71)	114.0 (34.69)	64.2 (30.73)	104.6 (13.86)	.230	447.5
Net capital export	2.0 (7.48)	5.0 (1.48)	−22.0 (7.16)	.1 (6.47)	.7 (3.80)	−23.9 (3.05)	−5.9 (1.04)	−20.1 (1.57)	.000	550.9
Y-production intensity	.3046 (.0471)	.4229 (.0111)	.4113 (.0296)	.4361 (.0654)	.5061 (.0970)	.4846 (.0586)	.4091 (.0107)	.4204 (.0283)	.709	11007.1
					Large country					
Unemployment rate	.6007 (.0174)	.5046 (.0676)	.4126 (.0609)	.6807 (.0706)	.8258 (.0842)	.6193 (.0222)	.5244 (.0203)	.5838 (.0213)	.043	9030.9
Budget surplus	−.3274 (.0435)	−.0705 (.0705)	−.0126 (.0609)	−.3562 (.1140)	−.7059 4(.1534)	−.3281 (.0470)	−.1249 (.0344)	−.1216 (.0339)	.945	283.4
Real GDP	96.3 (3.93)	117.6 (11.53)	133.3 (12.01)	73.5 (15.34)	48.3 (18.14)	85.1 (4.99)	110.5 (3.91)	98.8 (4.61)	.053	5736.4
Consumer earnings 1	196.7 (2.16)	202.4 (6.74)	211.1 (3.35)	188.7 (3.19)	169.5 (8.90)	192.4 (3.88)	203.9 (1.51)	197.5 (1.91)	.008	101716.7
Consumer earnings 2	−2343.8 (366.52)	−550.1 (579.34)	93.3 (481.54)	−2155.2 (948.01)	−4374.2 (1154.18)	−1830.1 (323.99)	−750.2 (282.92)	−935.9 (264.15)	.631	222.7
Net capital export	−2.0 (7.48)	−5.0 (1.48)	22.0 (7.16)	−.1 (6.47)	−.7 (3.80)	23.9 (3.05)	5.9 (1.04)	20.1 (1.574)	.000	550.9
Y-production intensity	.4409 (.0122)	.4735 (.0528)	.4671 (.0107)	.6344 (.0409)	.6051 (.0860)	.5444 (.0539)	.4484 (.0071)	.5411 (.0289)	.002	32879.1

Note: [a] tests the hypothesis that the asymptotic values a_2 and b_2 are equal; two-sided Wald tests. Superscript c (p) indicates units consumed (produced). Standard errors in parentheses; corrected for session specific heteroskedasticity and AR(1). 'Unemployment rate' is defined as the amount of unemployed units of labor relative to the total labor force (endowment) in the respective country; 'Budget surplus' denotes the nominal budget surplus relative to nominal GDP (defined as the total nominal value of the produced goods) in the respective country; the base 'year' for calculating 'Real GDP' is the first trading period in each session; 'Consumer earnings 1' denotes average earnings of a consumer in points ('utility'); 'Consumer earnings 2' are 'Consumer earnings 1' with the per capita budget surplus added; 'Net capital export' is the difference between total capital sold to the other country and total capital bought from the other country; 'Y-production intensity' denotes the total amount of goods produced in the Y-sector relative to the total amount of goods produced in the respective country.

Table 6 presents the results of the convergence analysis comparing the performance of the two tax systems for the variable tax regime. These estimation results corroborate the above observations.

Comparing the estimated asymptotic values a_2 and b_2, for the small country under the STLS-system, a significant decrease in the unemployment rate and net capital export together with a significant increase in real GDP show up. For the budget surplus, the labor intensity of production, and both of the consumer earnings measures, no statistically significant differences are found. Observe, however, that the amount of consumer earnings adjusted for the budget surplus shows a considerable improvement, too. The outcome of no significant difference in the development of the budget surplus is due to the convergence towards a balanced budget under both tax systems when tax rates adjust. Notice, however, that the convergence happens from a negative balance under the WT-system whereas it convergences from a surplus under the STLS-system.

Not surprisingly, for the large country, the outcomes are worse for the STLS-system sessions, because of the bad start. Note, however, that the asymptotic values a_2 and b_2, which are statistically significantly different for unemployment and consumer earnings uncorrected for the budget surplus, clearly show a movement towards each other. For both indicators the starting values are much further apart than the asymptotic values. Furthermore, the differences seem economically not significant. This pattern is in line with the observation from the figures indicating that the gap between the values of the economic performance indicators for this country narrows over the periods with variable tax rates. The budget surplus is clearly negative and virtually the same under both systems as are the consumer earnings net of the budget surplus. The significant difference in net capital export mirrors the result for the small country. The following result summarizes.

Result 3 *Under the variable tax regime, the positive view of the STLS-system as observed for constant taxes is corroborated and enhanced. The economic performance of the country where the STLS-system is applied further improves and shows a substantially lower unemployment rate and net capital export, as well as a higher real GDP, compared to its performance under the WT-system. With respect to the other economic indicators - the budget surplus, consumer earnings, and labor intensity of production - there are no significant differences in performance.*

An important further issue concerns the economic effect of *changes* in the different tax rates under the two tax systems. Table 7 shows the results of a regression analysis with respect to the economic performance indicators: unemployment rate, capital employment, real GDP, consumer earnings, net capital flight, and Y-production intensity. In addition to the tax rates the number of the trading period is also included as an explanatory variable, to control for a time trend.

Several observations are in order. First of all, the signs of all tax effects are completely in line with economic intuition. For both the wage tax and the sales tax it appears that tax hikes have a negative impact on economic activity and consumer earnings of the country directly involved. Higher taxes also encourage capital flight. Furthermore, changes of tax rates in the small country have no spill-over effects on the large country (the only exception being the effect of a wage tax change on capital flight, which is due to definition of this variable). An increase of the wage tax in the large country, however, has a statistically significantly negative effect on consumer earnings in the small country. The only obscure result concerns the effect of the sales tax on labor intensity of production.

The regression results clearly show that a wage tax increase has strong adverse effects on the economic performance in the respective country. This is witnessed by the statistically and economically highly significant coefficients of the wage taxes τ_{ws} in the small country and τ_{wl} in the large country, in most regressions. Increasing the wage tax rate in a country substantially increases unemployment and capital flight and decreases real GDP and capital employment.

An increase of the sales tax rate in the small country also adversely affects unemployment and real GDP in a statistically significant way. What is striking, though, is that the magnitude of these effects is substantially smaller than the effects of a wage tax rate increase. For unemployment the coefficient is .4420 for the the wage tax but only .1831 for the sales tax. Similarly, real GDP decreases by only 6.85 when the sales tax increases whereas the marginal decrease of this measure amounts to 11.95 for the wage tax. For capital employment, consumer earnings, net capital flight, and labor intensity of production, a change in the sales tax is not even significantly different from zero. The next result summarizes the most important findings.

Table 7 – The effect of taxes on the performance of real economic variables

Variable	Unemployment rate	Capital employment	Real GDP	Consumer earnings 1	Net capital flight	Y-production intensity
	Small country					
τ_{ws}	$.4420^{***}$	-27.95^{***}	-11.95^{***}	-2.89	24.42^{***}	$-.0879$
	(.0554)	(6.02)	(1.92)	(8.18)	(5.58)	(.0521)
τ_{xs}	$.1831^{*}$	-8.87	-6.85^{***}	-3.38	13.96	$-.0639$
	(.0728)	(7.10)	(2.03)	(13.22)	(7.95)	(.0750)
τ_{wl}	$-.0342$	3.82	$-.25$	-22.21^{*}	-2.55	.0308
	(.0425)	(5.70)	(1.32)	(9.74)	(5.95)	(.0604)
period	$-.01$	1.11	$-.03$	1.15^{*}	-1.44^{***}	.0018
	(.05)	$(.54)^{*}$	(.14)	(.56)	(.38)	(.0038)
constant	$.26^{***}$	31.30^{***}	26.72^{***}	95.90^{***}	$-.25$	$.4136^{***}$
	(.06)	(6.24)	(1.78)	(6.44)	(4.37)	(.0430)
N	54	54	54	54	54	54
Wald's χ^2	106.2	25.5	42.1	16.6	48.0	5.1
	Large country					
τ_{ws}	.0041	32.95	5.69	6.30	-24.42^{***}	$-.0357$
	(.0528)	(18.29)	(11.31)	(5.00)	(5.58)	(.0628)
τ_{xs}	.1450	-26.03	-27.46	-8.61	-13.96	$.1964^{***}$
	(.0808)	(25.40)	(17.35)	(8.40)	(7.95)	(.0627)
τ_{wl}	$.2793^{***}$	-49.81^{*}	-54.71^{***}	-25.61^{***}	2.55	.0238
	(.0583)	(20.27)	(12.76)	(5.39)	(5.95)	(.0472)
period	$-.0032$	.4667	.4183	.6010	1.44^{***}	.0005
	(.0043)	(1.18)	(1.00)	(.4271)	(.38)	(.0032)
constant	$.3371^{***}$	203.58^{***}	147.29^{***}	210.60^{***}	.25	$.4485^{***}$
	(.0487)	(13.06)	(11.39)	(38.46)	(4.37)	(.0367)
N	54	54	54	54	54	54
Wald's χ^2	38.2	54.1	27.4	24.6	48.0	19.0

Note: *** significant at .1 percent, ** significant at 1 percent, and * significant at 5 percent. Standard errors in parentheses; corrected for session specific heteroskedasticity and AR(1). All estimates are based on periods 8 to 16. 'Unemployment rate' is defined as the amount of unemployed units of labor relative to the total labor force (endowment) in the respective country; 'Capital employment' denotes the total amount of capital employed in the respective country; 'Real GDP' is total value of produced goods in the respective country with the first trading period in each session as the base 'year'; 'Consumer earnings 1' denotes the average earning of a consumer in points ('utility'); 'Net capital flight' is the difference between total capital sold to the other country and total capital bought from the other country; 'Y-production intensity' denotes the total amount of goods produced in the Y-sector relative to the total amount of goods produced in the respective country. Only one sales tax rate appears in the regressions because of the fixed ratio of the tax rates for the two production sectors (see Table 1).

Result 4 *In the small country, compared to the wage tax, an increase in the sales tax appears to have a much smaller adverse economic impact. The detrimental effect of a rise in the sales tax on the employment of labor and real GDP is only about half the effect of an increase in the wage tax. Moreover, whereas there is a significantly negative effect of an increase in the wage tax on capital, no such effect is found for the sales tax.*

All in all, compared to the WT-system, the performance of the STLS-system turns out to be remarkably good.

What remains to be discussed is whether under the STLS-system economic activities tend to coordinate on one of the two theoretical general equilibria presented in Table 2. To this end we performed a convergence analysis for the periods 9 to 16 and compared the outcomes with the theoretical predictions. Table 8 presents the results. In the table, column "equil. 1" shows the predictions of the 'favorable' general equilibrium and the column labeled "equil. 2" those of the 'unfavorable' one. For the international variables, which are mainly influenced by the large country, it holds that too little capital is employed and (accordingly) too little X produced. Both variables, however, exhibit weak convergence towards the equilibrium values which are virtually identical in the two general equilibria. On the other hand, the price of capital is too low and the price of commodity X appears to be too high. All this suggests that the equilibration process did not yet settle down on the international markets. A similar picture can be observed for the development of variables in the large country. There, capital and labor employment as well as the production and consumption of X weakly converge towards the equilibrium values from below. Concerning the local prices of labor and Y it can be observed that the former is too low and the latter to high compared to any of the equilibrium predictions. The budget surplus is weakly balancing from below but the tax rate τ_{wl} is much too high and far removed from any equilibrium value.

We turn now to the most interesting case, the small country in which the alternative STLS-system applies. Here the results are remarkably different. Three of the five real variables converge at least weakly to the favorable equilibrium (L_s, X_s^c, and Y_s). Capital K and the production level of the capital intensive commodity, X_s^p, do not converge but do *better* than predicted in the favorable equilibrium. The budget balance strongly converges to zero, while the sales taxes (weakly) converge to the tax rates predicted by the favorable general equilibrium. Also the wage rate converges from below to the value predicted in the favorable equilibrium. Only the price of the local good Y does

TABLE 8 – CONVERGENCE REGRESSIONS FOR VARIABLE STLS REGIME
COMPARISON WITH THEORETICAL EQUILIBRIUM PREDICTIONS

Variable	b_{11}	b_{12}	b_{13}	b_2	equil. 1	p-value[a]	equil. 2	p-value[a]	Wald's χ^2
				International					
K	188.4 (23.73)	131.6 (10.39)	201.7 (12.37)	209.3 (4.73)	240	.000	240	.000	5050.2
X	82.0 (21.0)	91.7 (21.4)	95.0 (12.3)	132.1 (7.86)	181	.000	182	.000	473.7
r	.0036 (.0003)	.0010 (.0003)	.0011 (.0006)	.0006 (.0002)	.0295	.000	.0289	.000	250.2
p_x	.2313 (0.35)	.3450 (0.97)	.2191 (0.44)	.2427 (0.32)	.1807	.000	.1807	.000	2624.9
				Small country					
K_s	29.8 (7.69)	36.6 (7.17)	50.4 (4.32)	51.1 (3.63)	28	.000	11	.000	451.1
L_s	30.6 (2.67)	32.7 (1, 21)	31.6 (1.85)	34.1 (.68)	33	.098	18	.000	5719.6
X_s^c	11.9 (2.76)	9.6 (5.42)	19.0 (4.30)	18.9 (1.63)	25	.000	17	.235	260.7
X_s^p	27.5 (4.03)	23.8 (5.55)	22.4 (2.21)	30.0 (1.44)	25	.001	14	.000	1038.2
Y_s	20.5 (4.13)	23.6 (4.01)	21.4 (3.32)	21.2 (1.60)	21	.917	11	.000	370.6
w_s	.1566 (.0144)	.1099 (.0178)	.1998 (.0235)	.1647 (.0128)	.1971	.011	.1292	.005	237.0
p_{ys}	.2074 (.0048)	.0979 (.0309)	.1950 (.0329)	.1704 (.0043)	.2165	.000	.2747	.000	13928.1
τ_{pxs}	.5442 (.0143)	.2985 (.0286)	.5239 (.0264)	.4681 (.0099)	.4889	.035	.7835	.000	8102.9
sur_s	.0151 (.0119)	−.0295 (.0261)	.0061 (.0177)	.0038 (.0067)	0	.568	0	.568	8086.3
				Large country					
K_l	160.3 (17.84)	105.5 (13.77)	148.3 (17.14)	168.6 (5.96)	212	.000	229	.000	1809.9
L_l	100.6 (22.24)	54.9 (26.53)	119.9 (7.00)	131.1 (6.70)	199	.000	213	.000	1749.2
X_l^c	69.5 (14.26)	82.1 (18.60)	75.6 (10.86)	111.5 (6.42)	156	.000	165	.000	488.2
X_l^p	54.2 (19.98)	61.6 (18.53)	74.5 (11.68)	100.4 (7.51)	156	.000	168	.000	300.5
Y_l	100.4 (10.24)	32.9 (9.57)	99.7 (6.97)	92.3 (3.49)	133	.000	140	.000	1832.8
w_l	.1451 (.0037)	.1533 (.0052)	.1538 (.0065)	.1446 (.0032)	.1640	.000	.1743	.000	4289.4
p_{yl}	.2380 (.0069)	.3103 (.0217)	.2313 (.0183)	.2512 (.0111)	.2123	.000	.2121	.000	1934.6
τ_{wl}	.8762 (.0418)	.8982 (.0067)	.8258 (.0228)	.8958 (.0156)	.3655	.000	.2769	.000	141093.6
sur_l	−.3562 (.1140)	−.7059 (.1534)	−.3281 (.0470)	−.1216 (.0339)	0	.000	0	.000	207.5

Note: [a] tests the hypothesis that the asymptotic value a_2 is equal to the theoretical prediction; two-sided Wald tests. For X superscript c (p) indicates units consumed (produced); for Y quantities produced are used as units of observation. Standard errors in parentheses; corrected for session specific heteroskedasticity and AR(1). Only the sales tax rate τ_{pxs} appears because of the exogenously fixed ratio of the tax rates for the two production sectors.

not show a clear pattern in the small country. The following result summarizes the main observations.

Result 5 *Under the variable tax regime, when the STLS-system obtains in the small country and the WT-system obtains in the large country, the international real variables and the real variables related to the large country mostly weakly converge towards to the equilibrium predictions, from below. The input prices turn out to be too low and the output prices too high compared to both theoretical equilibria. In contrast, in the small country the real variables are either converging towards the favorable equilibrium or do even better than this equilibrium predicts. The wage rate also converges towards the prediction of the favorable equilibrium. Only the output price for the labor intensive commodity Y stays too low compared to any of the equilibrium predictions.*

Hence, the alternative STLS-system performs better than the WT-system by coordinating economic activity in the direction of the favorable general equilibrium or does even better than that. In the next section we offer a tentative explanation for this finding, using theoretical arguments and some further evidence.

4 A behavioral explanation and empirical support

Our experimental results clearly suggest that financing unemployment benefits via sales taxes, in combination with a subsidy for employment, leads to much better economic outcomes than using a wage tax, even in a relatively small open economy. Though disadvantaged at the beginning, due to high tax rates stemming from persistent budget deficits under the wage tax system and the requirement of equivalent tax burdens on impact, the STLS-system manifests its beneficial effects immediately. Its better performance regarding the economic indicators is even further improved when tax rates start to adjust to the budget balance. Also, it appears that changes in sales taxes have a much weaker negative economic effect than changes in wage taxes.

Compared to the theoretical predictions of the standard general equilibrium model the wage tax system has a tendency to do worse. For the STLS-system the theoretical prediction is ambiguous in the sense that two stable equilibria exist. It turns out that under this alternative system economic behavior exhibits a tendency to coordinate on the 'favorable' equilibrium or to perform even better than the theoretical model predicts. In the following we offer theoretical arguments and empirical support for the following claim, which can explain these observations.

Claim 1 *Uncertainty about product prices makes producers reluctant to incur production costs. This can explain the good economic performance of the sales-tax-cum-labor-subsidy system in comparison with the wage tax system. Instead of being confronted with a tax burden up-front on the input of labor, producers under the former system receive a labor subsidy and only have to pay taxes in proportion to their sales revenues, which effectively means risk sharing by the government.*

To substantiate this claim we offer four pieces of evidence. *First*, recall from Result 1 that under the constant wage tax regime quantity and input price variables typically converge from below, whereas output prices seem to converge from above towards the competitive equilibrium levels of the theoretical general equilibrium model. Although this theoretical model does not capture all details of our complex lab economy, the result is suggestive of some downward pressure on the demand for inputs. Also, because these outcomes are accompanied by a budget deficit. A *second* piece of evidence in this respect is obtained by comparing the (after tax) marginal revenue product of labor and capital with the respective net (i.e. after tax or subsidy) input price. Table 9 shows the number of cases in which producers' marginal revenue product *exceeds* the input price, using average current prices.[23] Assuming random errors, profit maximization would be consistent with a fraction of 50%. The observed fractions are remarkably different from this benchmark, however. Our next result summarizes the evidence.

Result 6 *Averaging over periods and tax systems, for about* 70 *percent of the cases producers' marginal revenue product of capital* (74%) *and labor* (65%) *exceeds the input price. Taken over all periods, with only one exception in each system, the excess is always significant. Moreover, comparing the second half of the trading periods with the first half, there is no systematic decrease in the excess.*

This result provides further support for the view that, under both tax systems, producers are reluctant to buy inputs.[24] Interestingly, Noussair, Plott, and Riezman (1995) observe a similar phenomenon in an experiment concerning international trade.[25] These

[23]Similar results are obtained when the average product price of the previous period is used.

[24]In particular, because we have no evidence of a shortage of capital or labor. On the contrary, comparing actual labor supply with theoretical labor supply - using the benchmark model and actual prices - we find excess supply for a fraction of consumers that is significantly larger than 50% (on average, 94% for the WT-system and 73% for the STLS-system). Concerning capital, the relatively low capital price also points into the direction of an excess supply (see Figures 2 and 3).

[25]Noussair, Plott, and Riezman (1995) use simultaneous (double auction) input and output markets. Thus, our results do not seem to be due to the use of sequential markets. Hey and di Cagno (1998), investigating experimentally two sequential double auction markets, also observe a shortage of trade, compared to the competitive equilibrium predictions (see also Goeree and Holt 1999).

Table 9 – Fraction of cases where producers' marginal revenue product exceeds net input price

		WT-system		STLS-system	
		Labor	Capital	Labor	Capital
		Small country			
	1 to 8	0.4583	0.6250	0.6250	0.9583
		(0.7646)	(0.0557)	(0.0557)	(0.0000)
X-sector	9 to 16	0.5000	0.6667	0.8750	0.9583
		(0.5573)	(0.0147)	(0.0000)	(0.0000)
	all	0.4792	0.6458	0.7500	0.9583
		(0.6950)	(0.0028)	(0.0000)	(0.0000)
	1 to 8	0.5694	0.6944	0.4722	0.6528
		(0.1444)	(0.0007)	(0.7220)	(0.0064)
Y-sector	9 to 16	0.5833	0.8472	0.9167	0.6944
		(0.0973)	(0.0000)	(0.0000)	(0.0007)
	all	0.5764	0.7708	0.6944	0.6736
		(0.0399)	(0.0000)	(0.0000)	(0.0000)
		Large country			
	1 to 8	0.6042	0.8333	0.9583	0.9583
		(0.0967)	(0.0000)	(0.0000)	(0.0000)
X-sector	9 to 16	0.6250	0.7708	0.7708	1.0000
		(0.0557)	(0.0001)	(0.0001)	(0.0000)
	all	0.6146	0.8021	0.8646	0.9792
		(0.0158)	(0.0000)	(0.0000)	(0.0000)
	1 to 8	0.6250	0.6528	0.7361	0.5694
		(0.0222)	(0.0064)	(0.0000)	(0.1444)
Y-sector	9 to 16	0.6111	0.5972	0.5556	0.6944
		(0.0382)	(0.0625)	(0.2048)	(0.0007)
	all	0.6181	0.6250	0.6458	0.6319
		(0.0029)	(0.0017)	(0.0003)	(0.6319)

Note: Based on average current period input and output prices and all periods; within parentheses the probability of obtaining values as least as extreme as observed when $p = 0.5$; binomial test, one-sided; $n = 48$ for periods 1 to 8 and 9 to 16, $n = 96$ for all periods.

authors conjecture that producers may require a compensation for the market risk they run, since they may not be able to sell outputs. A likely underlying reason for this behavior is some form of aversion towards risk or losses. Indeed, theoretical partial equilibrium models exist indicating that product price uncertainty reduces the factor demand of risk-averse competitive firms (see the literature mentioned in the Introduc-

Table 10 – Correlation of factor employment and output price uncertainty

	St.dev. output price			St.dev. output price	
	WT-system	STLS-system		WT-system	STLS-system
L_{ys}	-0.0868	-0.3490	K_{ys}	-0.0056	-0.3390
	(0.5709)	(0.0188)		(0.9711)	(0.0227)
L_{yl}	-0.3198	-0.4796	K_{yl}	-0.3251	0.2455
	(0.0322)	(0.0009)		(0.0293)	(0.1041)
L_{xs}	-0.3195	-0.5016	K_{xs}	-0.3004	-0.6194
	(0.0324)	(0.0004)		(0.0450)	(0.0000)
L_{xl}	-0.2721	-0.6669	K_{xl}	0.0737	-0.5833
	(0.0706)	(0.0000)		(0.6304)	(0.0000)
L_x	-0.2828	-0.6565	K_x	-0.0523	-0.6567
	(0.0598)	(0.0000)		(0.7331)	(0.0000)

Note: Entries show Spearman's ρ between employment of the mentioned factor in period t and the standard deviation of the relevant nominal output price in period $t-1$; p-values in parentheses, two-sided tests.

tion), and risk-averse behavior of firms appears to be a realistic assumption.[26] Yet, empirical microeconomic studies of the consequences of market uncertainty for factor demand are scarce (see Ghosal (1995)).[27] Important exceptions are Leahy and Whited (1996) and Guiso and Parigi (1999). Both of these studies find that investment is negatively affected by uncertainty.

Taking the standard deviation of transaction prices in the previous period as measure of expected price uncertainty in the current period, we examine the correlation of this measure with the employment of capital and labor. Table 10 presents the outcomes. In line with our conjecture and as suggested by field studies, a mostly significantly negative correlation shows up. The next result summarizes this *third* piece of evidence for our claim.

Result 7 *The demand for capital and labor is mostly significantly negatively correlated with output price uncertainty.*

What causes risk averse behavior is not completely clear yet. Recent studies on the economic significance of emotions suggest that anxiety may play a role, because of the

[26] According to Stiglitz (1999, p. 254): "There is by now a large body of literature arguing that normally firms act in a risk averse manner (...)". Zhang (1998, p. 1753) notes: "Investors of all types generally exhibit aversion to risk". For an empirical study showing risk-aversion by firms, see Gunjal and Legault (1995).

[27] The situation is different for studies focusing on the impact of macroeconomic uncertainty, as captured by inflation, for instance. These studies typically show a negative effect on private investment (see Aizenman and Marion 1993, Brunetti and Weder 1998).

time lag between inputs and outputs (cf. the motto of our paper). For example, Caplin and Leahy (2001) argue that by ignoring anxiety conventional measures of risk aversion underestimate the effects of uncertainty on asset prices. The reason is that because anxiety is aversive it requires compensation by a higher rate of return. Consequently, an anxious decision maker may appear more risk averse.[28] Another relevant finding in this context is that the possibility rather than the probability of a negative outcome appears to be important (Loewenstein, Hsee, Weber, and Welch (2001)), which manifests itself in overreaction to small probability events (see Harless and Camerer 1994). In the context of sequential markets it is also interesting that people also seem to treat delayed outcomes as being uncertain (see Keren and Roelofsma (1995)). These results do not only provide additional support for our result of a negative effect of price uncertainty on factor demand, they also indicate that little perceived uncertainty may already have substantial effects. Thus, it need not be surprising if we do not observe rapid convergence to competitive equilibrium levels in complex market environments. To improve theoretical predictions it seems important to take the so far neglected dynamic *behavioral* aspects of such market economies into account. A research direction which is strongly advocated by Akerlof (2002).

Importantly, the overall output price uncertainty turns out to be similar under both tax systems. In fact, our measure of uncertainty shows some tendency to be larger under the STLS-system. Together with the above result and the relatively good performance of the economy under this system this corroborates the view that producers perceive the uncertainty differently under the WT- and the STLS-system. The fact that under the latter system the risk can be shared with the government seems to play an important role here.

For our *fourth* and final piece of evidence for our claim we return to Table 7. This table shows that increases in the sales tax have much weaker adverse economic effects than increases in the wage tax. This finding fits the view that producers are relatively more concerned with incurring certain costs up-front than with some uncertain costs, that can be shared with the government, in the future.

All in all, the theoretical arguments and the empirical support for our claim seem substantial. The evidence presented makes it quite intuitive why the sales tax system

[28] Experimental evidence of a negative impact of anxiety on risk taking is presented in Bosman and van Winden (2002).

performs so much better than the wage tax system. It also provides a rationale for why under the STLS-system economic activity is attracted by the favorable equilibrium or does even better than that. With any aversion to risk or losses, having the government sharing in the sales revenue risk, instead of having to bear a tax burden up-front, certainly seems to be the more producer and employment friendly scheme. The more so when a labor subsidy is included.

5 Conclusion

In this paper we present an experimental comparison of a wage tax system and an alternative sales-tax-*cum*-labor-subsidy system as a means of financing unemployment benefits. Our experimental results are strongly in favor of the alternative system. Under the alternative system, economic activity is directed towards the theoretical equilibrium without capital flight and with the better economic performance. In particular, employment and GDP do not decline but sharply increase. Instead of capital flight, even capital import is observed and the balance of the budget does not deteriorate but strongly improves.

In our view, producers' reluctance to incur production costs up-front when facing product price uncertainty plays a crucial role. We present four pieces of experimental evidence in support of this claim. First, a convergence analysis using the results of the theoretical benchmark model appears to be suggestive of a downward pressure on the demand for inputs. Quantity and input price variables typically converge from below, and output price variables from above the theoretically predicted levels. Second, for most producers the estimated marginal revenue product of capital and labor persistently exceeds the respective input price. Third, the demand for capital and labor turns out to be mostly negatively correlated with the variance of output transaction prices in the previous trading period. Finally, we find that increases in sales tax rates have much weaker adverse economic effects than increases in wage tax rates. This evidence makes it understandable that the alternative tax system performs much better than the wage tax system. Instead of having to pay an input tax up-front, producers receive a labor subsidy while they only have to pay taxes in proportion to whatever the sales revenues turn out to be. The latter effectively means risk sharing by the government.

Furthermore, our claim finds support from some theoretical partial equilibrium models showing that risk-averse firms indeed employ fewer inputs.

Although, as yet, relatively few macroeconomic experiments have been carried out, we think that the experience that is now accumulating is of interest from a scientific as well as policy perspective. For example, our experimental findings are in agreement with Akerlof's view that macroeconomics should be behavioral, in the spirit of Keynes (see Akerlof (2002, p. 428)). An aversion on the side of producers to input taxation relative to output taxation, due to the elapse of time, is a behavioral factor that seems to have been neglected in theory. In fact, this finding may have a wider bearing on the theoretical modeling of how economic agents behave in complex dynamic market environments. As noted by Plott (2001): "as it turns out, the classical theories of price adjustment are incomplete" (p. 3), and "experiments teach us about theory and it is theory that we use when addressing complex and new problems. The progress builds in slow and in unexpected ways" (p. 27).

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