INPUT VERSUS OUTPUT TAXATION IN AN EXPERIMENTAL INTERNATIONAL ECONOMY

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Abstract

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, E21, 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 long-standing problem 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. When input decisions have to be taken, typically, uncertainty exists about the real returns following from these decisions. This is because at the time producers have to decide on the input of labor and capital the precise market conditions that will prevail at the time consumers buy their products are unknown. 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 partial equilibrium studies have focused on the effects of output price uncertainty on the supply and input decisions of firms. Results show that output price uncertainty may reduce the factor demand and production level of risk-averse competitive firms (Sandmo (1971), Batra and Ullah (1974), Hartman (1975, 1976), Holthausen (1976), Ghosal (1995)).[1] This research suggests that shifting taxation from

[1] Loss aversion, as in prospect theory (Kahneman and Tversky (1979)), would seem to make this effect only stronger. Another strand of literature addresses the impact of (macroeconomic) uncertainty

inputs to outputs may have a positive effect on production and employment because the government then effectively shares the risk faced by producers.

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)). However, it is not at all clear whether shifting taxation to outputs would do any better. In fact, since value added taxes or sales taxation would imply an implicit tax on capital, one might expect negative effects on employment due to capital flight. From a more general perspective, the issue regarding the economic effects of shifting taxation from inputs to outputs is much wider, though. It not only involves the employment of labor and capital, but also the budget balance and other economic indicators, like real GDP and consumer welfare in general. To shed light on this ultimately empirical issue motivates this paper.

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.[2] 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.

Because of the implicit tax on capital, the general opinion of policymakers and economic policy advisers was 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.

on investment, typically showing a negative effect (Aizenman and Marion (1993), Brunetti and Weder (1998), Guiso and Parigi (1999)).

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

Being a policy-oriented study, the experimental design was required to show some parallelism with the Dutch economy. A steering committee, to which economists with an international reputation in relevant fields of research (public economics, labor economics, experimental economics and applied general equilibrium modelling) were assigned, had to approve the design and assist the project.

Other 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.[3] In a sense, doing this study meant exploring the boundaries of the research method of laboratory experimentation. 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 avoids the noise field data are unavoidably exposed to.[4] 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 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.[5] In the benchmark experimental treatment, in both countries, a wage

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

[4] 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)).

[5] 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)).

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.

To evaluate the performance of the two tax systems we use the following economic indicators: employment of labor, net capital export, shift towards labor intensive production, real GDP, consumer earnings, and the budget surplus. Our main findings are the following. First, despite of the rather complicated 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. In summary, the alternative sales-tax-*cum*-labor-subsidy system performs significantly better than the wage tax system.

To explain these findings - which took our principals by surprise - 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 that supports 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 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. The experimental results are given in Section 3. In Section 4 we propose a behavioral explanation for our main findings, providing additional supportive evidence. Section 5 concludes.

2 Experimental design

In this section we first describe the economic environment that we investigate in the experiment. Then, we specify its implementation and the choice of parameters, followed by a discussion of the research questions and experimental procedures. For convenience, the wage tax system will be 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 given 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.

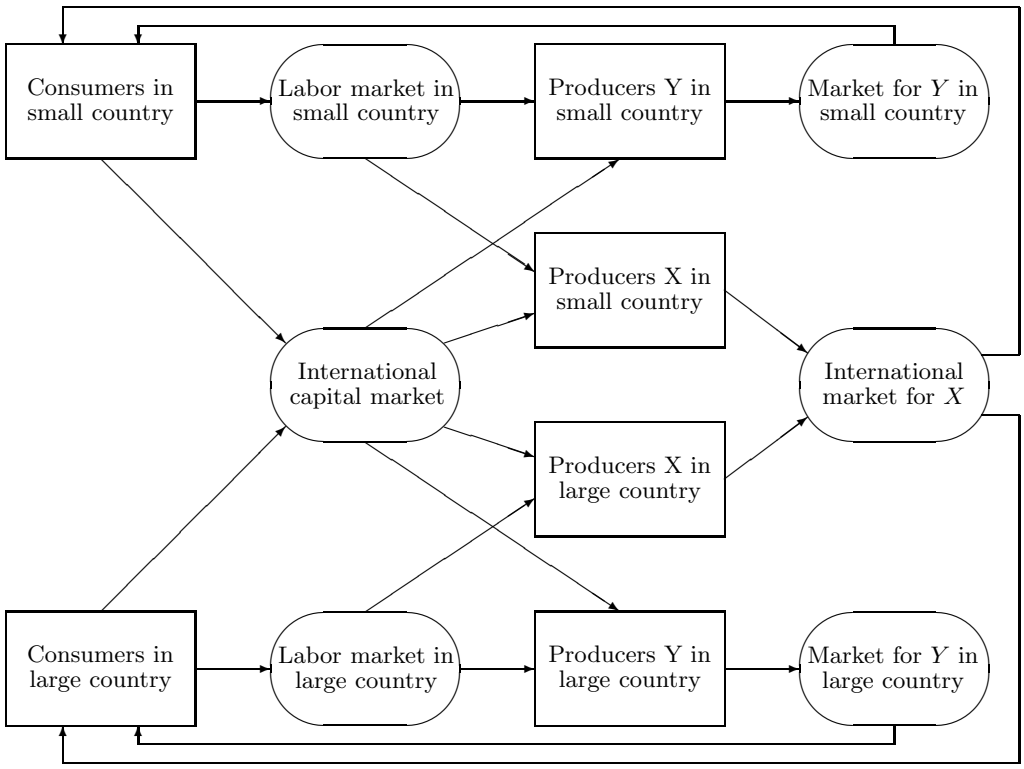


FIGURE 1 – FLOW DIAGRAM OF THE ECONOMIC ENVIRONMENT

2.2 Implementation and Choice of Parameters

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-linearized Cobb-Douglas type of utility function.[6] Producers are endowed with a CES production technology allowing with decreasing returns to scale, different factor intensities, and different elasticities of substitution in the two production sectors.[7] 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 unit double auction markets (see Plott and Gray (1990)). The choice of this market type is guided by its rep-

[6]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.

[7]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 benchmark equilibrium discussed below.

TABLE 1 – EXPERIMENTAL PARAMETERS

Preferences and production technologies

Consumers i (utility functions):

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

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

Producers j (production functions and profit functions):

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

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)

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

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

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.

utation of fast equilibration of supply and demand in experimental 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.[8] To facilitate trading, both consumers and producers are endowed with some fiat money (*cash*) at the beginning of the first phase of each period. In addition, consumers receive a transfer (w_0) for each unit of labor that is unemployed at the end of this phase.[9]

All taxes are paid by 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 regime 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.[10]

Experimental subjects participate in a sequence of 16 trading periods. In the first half of each session these periods are all 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. In the second half of a session (periods 9-16) tax rates are adjusted at the beginning of each new period such that a balanced budget for unemployment benefits would be obtained for the previous period, given the market outcomes of that period. The initial tax rates

[8]The main reason for using sequential instead of simultaneous markets is the considerable reduction of complexity for the subjects. Note, however, 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). Since there is no clear experimental evidence that sequential markets perform worse than simultaneous ones, we are confident that our results are not systematically influenced by our choice (see e.g. Quirmbach, Swenson, and Vines (1996), but also Hey and di Cagno (1998)).

[9]Any unemployment remaining in an equilibrium may be viewed as 'voluntary', theoretically (according to Layard, Nickell, and Jackman (1991, p. 41) the question of voluntary versus involuntary unemployment is 'fruitless' for practical and public policy purposes). The inclusion of 'frictions', like trade unions or efficiency wages, might have added some realism. However, in view of 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.

[10]Because this study does not focus on transitional issues, a between-subjects design was chosen for the tax systems. It also helped to avoid too lengthy sessions.

and the tax adjustment rules are shown in the lower part of Table 1.[11] This procedure guarantees a sufficient number of repetitions with a constant environment for making it possible to examine whether 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 factor (A) in the production functions is adjusted such that, according to the theoretical benchmark model discussed next, in the control treatment supply and demand in the large economy would be seven times as large as in the small economy.[12]

In order to get rationalizable initial tax rates and theoretical benchmark predictions we used the numerical solution of a competitive general equilibrium model equating supply and demand in the various markets under the requirement of a balanced tax-transfer budget. We are thereby following 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 presents the outcomes. Interestingly, there are two quite different equilibria for the STLS-system.[13] Equilibrium 2 shows the serious negative economic consequences - including a substantial capital flight - for the small

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

[12] 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.

[13] Actually, the WT-system also shows two equilibria. Accidently, 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 practical interest, here.

Table 2 – Theoretical benchmark predictions

	WT-system	STLS-system	
		equilibrium 1	equilibrium 2
Small country			
Inputs:			
K_s	30.0	28.0	11.5
L_s	28.2	33.0	18.2
Production:			
X_s	22.2	24.8	13.7
Y_s	18.9	20.9	11.0
Relative prices:*			
r	.0307	.0295	.0289
w_s	.1694	.1971	.1292
p_x	.1882	.1807	.1807
p_{ys}	.2211	.2165	.2727
Tax rates:**			
wage tax τ_{ws}	.3777		
sales tax τ_{xs}		.4889	.7835
sales tax τ_{ys}		.5414	.8677
Large country			
Inputs:			
K_l	210.0	212.0	228.5
L_l	197.4	199.2	213.3
Production:			
X_l	155.1	156.5	167.8
Y_l	132.0	132.9	140.4
Relative prices:*			
r	.0307	.0295	.0289
w_l	.1694	.1640	.1743
p_x	.1882	.1807	.1807
p_{yl}	.2211	.2123	.2121
Tax rates:**			
wage tax τ_{wl}	.3777	.3655	.2769

Note: * Relative prices are obtained through dividing nominal prices by the sum of all (six) nominal prices; ** these tax rates guarantee a balanced budget in equilibrium.

country that were anticipated by policymakers and economic policy advisers. The other equilibrium, however, shows substantial positive employment effects, little capital flight, and an increase in the production of both sectors. These results suggest that, theoretically at least, some beneficial tax shifting is possible by switching from input taxation to output taxation.

In order to avoid a potential bias of the experimental results in favor of the alternative tax system, and because of the policy orientation of the experiment, 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.[14] 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

The main research question of this study concerns the economic performance of the STLS-system in comparison with the WT-system in the small country. In light of the implicit taxation of capital under the STLS-system, with capital being mobile and labor immobile between countries, the general expectation of our principals was that a serious capital flight with bad economic consequences would show up. To evaluate the performance of the two tax systems the following economic indicators were selected, with the expected effect of the STLS-system between parentheses: employment of labor $(-)$, net capital export $(+)$, shift towards labor intensive production $(+)$, real GDP $(-)$, consumer earnings $(-)$, and the budget surplus $(-)$.

All experimental sessions were run at the CREED-laboratory of the University of Amsterdam in the Fall and Winter of 1998. Subjects, recruited through announcements on bulletin boards, were undergraduates of the University and mostly coming from its Faculty of Economics and Econometrics. Because the experimental environment is rather complex, subjects had to 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 getting subjects experienced with trading), and the international economy session.[15] Subjects were paid out at the

[14] 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).

[15] 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.

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).[16] 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://www.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 and 30 seconds. This was followed by a 2 minutes break for recording before the next period began.[17]

[16] 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.

[17] 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.

Two series of experimental sessions were conducted, each consisting of three sessions. One series concerned the 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.

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.

3 Experimental Results

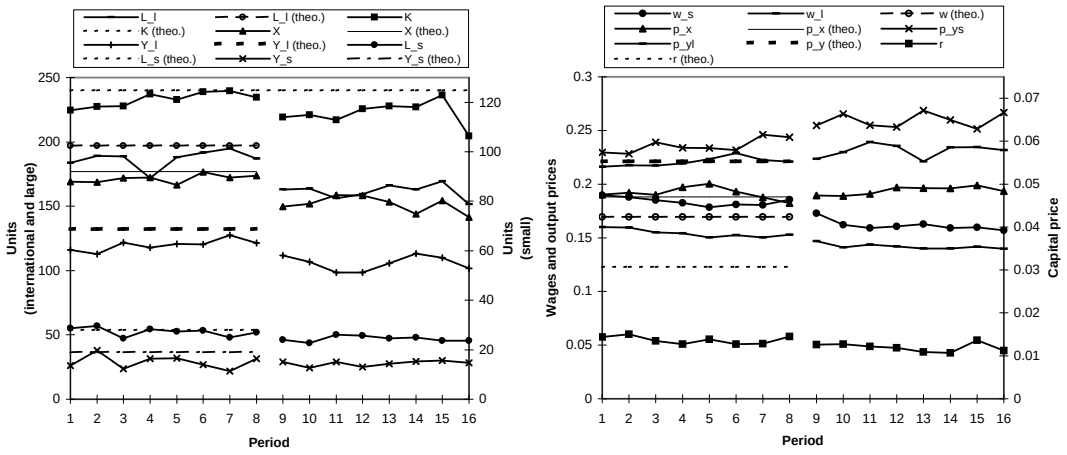
In presenting our results we will focus first on the trading periods with a constant tax regime (periods 1-8). Since the wage tax rates in the constant tax regime of the WT-system are at the level of the theoretical benchmark predictions shown in Table 2, we use the results of these periods for a comparison with these benchmark predictions.[18] However, the main focus 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.

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

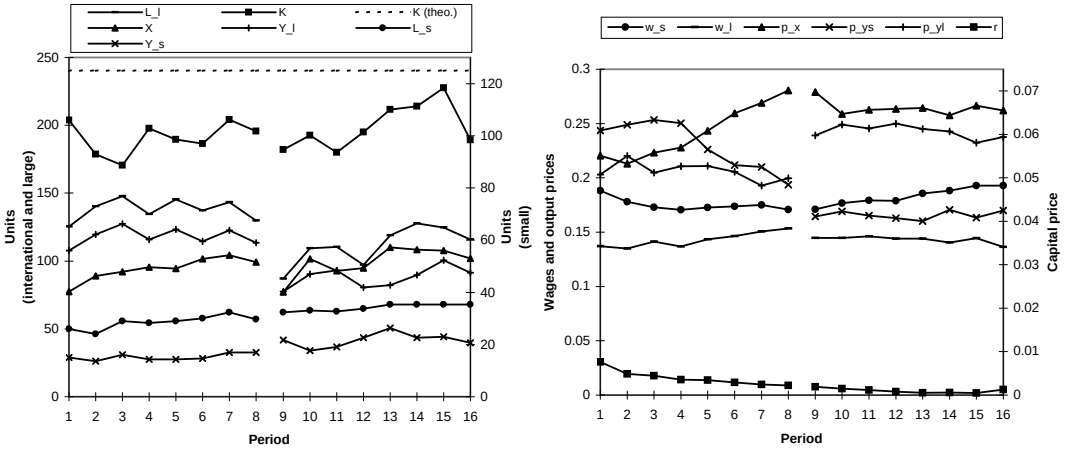
[18]Recall that the initial tax rates in the STLS-system are determined by using the outcomes of the constant tax regime of the WT-system.

markets experiments. More interesting are the following observations. Notice from Figure 2 (a) that, with only one exception, all quantities start below the equilibrium levels of the theoretical benchmark model. Most of these variables, however, seem to 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 clearly start (and seem to stay) below the theoretically predicted levels.



(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

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 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 the 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 theoretical benchmark level, while weak convergence holds if, instead, 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 can be rejected for only 1 of the 12 variables. Moreover, weak convergence holds for the not strongly converging relative price of capital. In our view this finding is quite remarkable since the theoretical benchmark model is an extremely stylized representation of the experimental economy. Note, that the asymptotic value of all the quantity variables is lower than the respective theoretical level. This is also the case for two of the three input price variables, 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 *Almost all variables strongly convergence towards the equilibrium levels of the theoretical benchmark model. The quantity and input price variables are typically converging from below, while the output prices are typically converging from above.*

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 is affected, while its product price exhibits a clear upward thrust. 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 the theoretical benchmark model but determined in a way that *on impact* the producers of X and Y would have to bear the same tax burden as observed

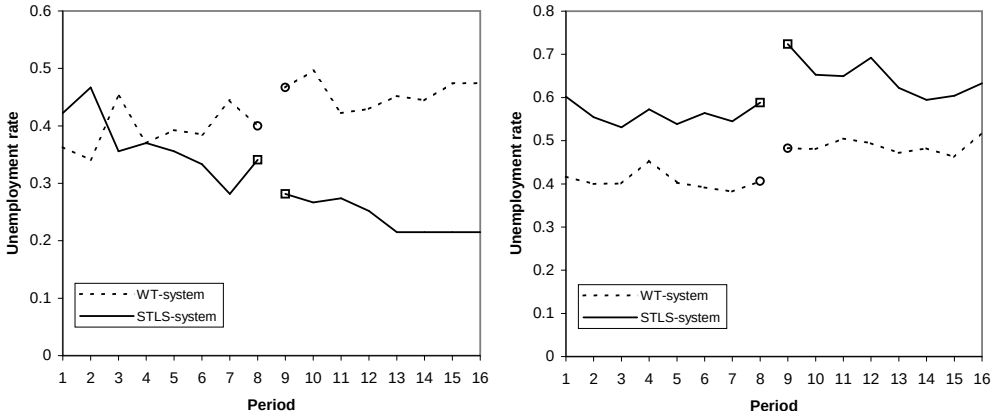
TABLE 4 – CONVERGENCE REGRESSIONS FOR CONSTANT WAGE TAX REGIME
COMPARISON WITH THEORETICAL BENCHMARK MODEL

Variable	a_{11}	a_{12}	a_{13}	a_2	prediction	p-value[b]	R^2
			International				
K	231.05	208.67	229.36	237.88	240	0.6660	0.42
	(78.56)[a]	(70.96)	(77.99)	(56.35)			
X	199.03	139.54	173.34	172.16	177	0.8216	0.77
	(12.08)	(8.47)	(10.52)	(9.11)			
r	0.0091	0.0142	0.0204	0.0148	0.0307	0.0122	0.24
	(0.29)	(0.45)	(0.64)	(0.45)			
p_x	0.1722	0.2171	0.1721	0.1887	0.1882	0.9597	0.88
	(27.83)	(35.08)	(27.81)	(19.82)			
			Small country				
L_s	27.892	26.297	30.608	26.893	28	0.8006	0.58
	(217.10)	(204.69)	(238.24)	(6.99)			
Y_s	15.952	14.066	19.010	14.420	19	0.1605	0.38
	(7.63)	(6.73)	(9.09)	(6.88)			
w_s	0.1931	0.1997	0.1743	0.1835	0.1694	0.1041	0.96
	(68.99)	(71.36)	(62.26)	(37.15)			
p_{ys}	0.2361	0.2115	0.2528	0.2388	0.2211	0.2641	0.89
	(41.00)	(36.73)	(43.90)	(20.71)			
			Large country				
L_l	181.19	175.96	190.61	188.96	197	0.6679	0.79
	(31.14)	(30.24)	(32.76)	(11.70)			
Y_l	106.89	130.74	118.68	119.33	132	0.3470	0.77
	(17.28)	(21.14)	(19.19)	(11.48)			
w_l	0.1743	0.1511	0.1492	0.1538	0.1694	0.2145	0.93
	(23.64)	(20.48)	(20.23)	(17.65)			
p_{yl}	0.2066	0.2170	0.2280	0.2208	0.2211	0.9864	0.81
	(16.69)	(17.53)	(18.42)	(15.59)			

Note: Prais-Winsten regressions that are corrected for first-order serially-correlated residuals and robust standard errors, allowing for dependent observations within sessions. [a] t-values in parentheses, [b] F-test testing the value of a_2 against the theoretical prediction; all tests two-sided. For X, Y_s, and Y_l the units consumed are used as unit of observation.

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 of 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 systems (and both countries). Whereas, initially, the unemployment rate in the small country is at a higher level in case of the STLS-system, Figure 4 shows that there is a clear tendency for this rate to decline, in contrast to the development of the unemploy-



(a) Small country (b) Large country

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

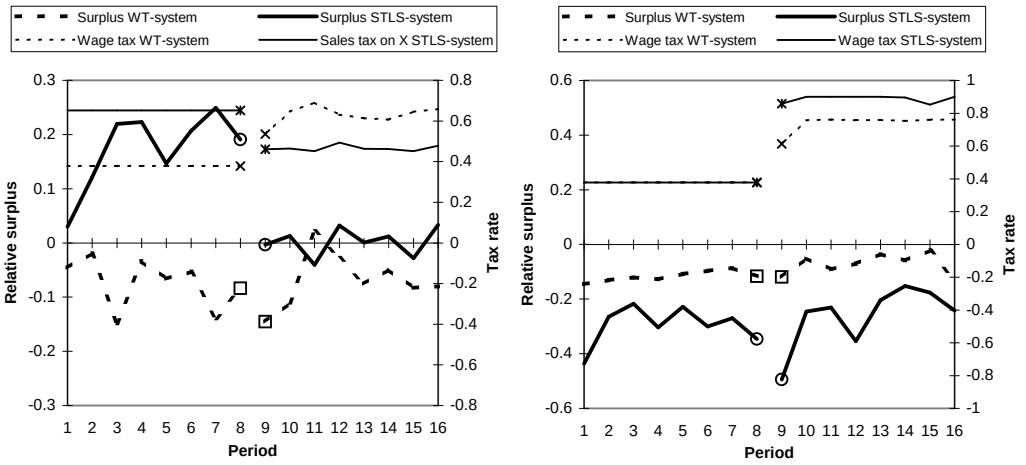
ment rate under the WT-system (and the development in the large country, where a wage tax is applied in both treatments). This appears to have a beneficial effect on the budget surplus of the small country, which substantially increases over the periods (see Figure 5). Wage taxes, on the other hand, 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.[19] Table 5 gives the results. Whereas the asymptotic estimates for the large country (b_2 versus a_2) still show the negative consequences 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 de-

[19]The estimation model now becomes

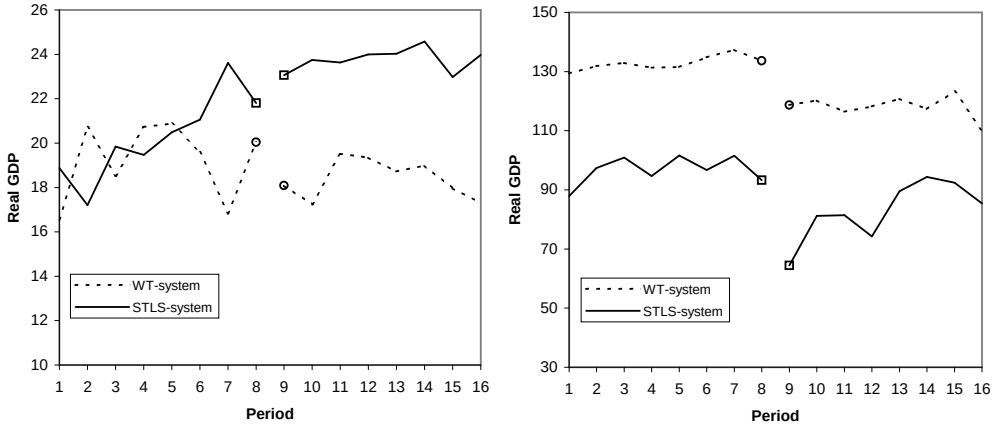
$$\begin{aligned} y_{it} &= a_{11}D_{A1}(1/t) + a_{12}D_{A2}(1/t) + a_{13}D_{A3}(1/t) + a_2 D_A(t-1)/t + \\ &\quad b_{11}D_{B1}(1/t) + b_{12}D_{B2}(1/t) + b_{13}D_{B3}(1/t) + b_2 D_B(t-1)/t + u_{it} \end{aligned}$$

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.



(a) Small country (b) Large country

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



(a) Small country (b) Large country

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

crease in the unemployment rate and a substantial improvement in the budget balance, while the remaining variables are not significantly different for the two tax regimes. There is no shift in production between the sectors (measured by 'Y-production intensity'), while real GDP increases and net capital export decreases, though not significantly. Furthermore, although consumer earnings are somewhat smaller, this outcome reverses into a large increase when adjusted for the budget surplus (consumer earnings 2). Both outcomes are only weakly significant, however. These observations lead to our next result.

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[b]	R^2
	Small country									
Unemployment rate	0.3845 (28.37)[a]	0.4709 (6.80)	0.2116 (2.24)	0.5270 (10.10)	0.5521 (7.03)	0.2667 (15.61)	0.4130 (21.70)	0.3227 (15.57)	0.0453	0.40
Budget surplus	-0.1165 (-8.56)	-0.0789 (-1.77)	0.0406 (1.36)	0.0159 (0.81)	-0.0224 (-0.58)	0.1045 (6.64)	-0.0843 (-1.38)	0.2404 (5.65)	0.0085	0.45
Real GDP	14.881 (9.54)	13.857 (12.19)	24.068 (9.56)	15.336 (6.14)	14.349 (5.99)	22.327 (30.84)	20.092 (22.33)	21.783 (25.79)	0.3541	0.58
Consumer earnings 1	82.397 (5.51)	88.398 (8.89)	106.08 (24.7)	73.432 (11.25)	15.027 (1.52)	106.54 (28.82)	98.383 (34.28)	89.675 (43.36)	0.0511	0.78
Consumer earnings 2	-28.441 (-1.18)	44.929 (1.8)	76.194 (0.73)	139.25 (2.79)	-7.5958 (-0.12)	410.16 (5.4)	6.971 (0.06)	639.74 (3.56)	0.0598	0.28
Net capital export	7.7293 (1.30)	0.5997 (0.60)	-17.552 (-8.34)	3.8651 (0.79)	-1.5065 (-0.20)	-1.7854 (-1.22)	-6.7038 (-4.05)	-8.6318 (-4.26)	0.4029	0.30
Y-production intensity	0.4494 (3.10)	0.5101 (8.81)	0.3953 (9.04)	0.5212 (7.11)	0.6063 (8.38)	0.4631 (10.80)	0.3667 (14.63)	0.3607 (28.16)	0.8328	0.23
	Large country									
Unemployment rate	0.3897 (6.29)	0.4396 (24.19)	0.4343 (6.26)	0.7527 (17.3)	0.6380 (10.44)	0.4877 (5.03)	0.3994 (8.11)	0.5468 (10.41)	0.0037	0.64
Budget surplus	-0.1624 (-1.85)	-0.1734 (-14.20)	-0.0940 (-1.30)	-0.6607 (-9.39)	-0.6718 (-15.68)	-0.1203 (-1.56)	-0.1079 (-5.81)	-0.2279 (-2.35)	0.2287	0.59
Real GDP	139.395 (15.19)	121.514 (28.86)	127.353 (19.05)	54.584 (5.71)	86.164 (9.71)	110.274 (7.48)	134.281 (38.12)	100.287 (9.87)	0.0075	0.69
Consumer earnings 1	209.25 (27.76)	204.03 (42.23)	214.42 (115.76)	160.44 (12.8)	197.75 (12.73)	188.80 (29.86)	208.67 (53.86)	195.18 (33.09)	0.1288	0.96
Consumer earnings 2	-604.52 (-1.07)	-1363.38 (-8.84)	-1180.43 (-1.77)	-4484.74 (-9.16)	-3140.44 (-6.31)	-1728.07 (-1.89)	-785.02 (-3.89)	-2185.56 (-3.41)	0.0355	0.40
Net capital export	-7.7293 (-1.30)	-0.5997 (-0.60)	17.5523 (8.34)	-3.8651 (-0.79)	1.5065 (0.20)	1.7854 (1.22)	6.7038 (4.05)	8.6318 (4.26)	0.4029	0.30
Y-production intensity	0.3902 (19.08)	0.5258 (19.41)	0.4023 (25.33)	0.5673 (18.89)	0.6441 (12.04)	0.5770 (14.54)	0.4514 (20.7)	0.6512 (15.87)	0.0006	0.85

Note: Prais-Winsten regressions that are corrected for first-order serially-correlated residuals and robust standard errors, allowing for dependent observations within sessions. [a] t-values in parentheses, [b] F-test testing the value of a_2 against the value of b_2; all tests two-sided. '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.

Result 2 *By the end of the constant tax regime, all the economic performance indicators, except for consumer earnings unadjusted for the budget surplus, show a mostly significant improvement for the small country under the STLS-system compared to the WT-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 expected effects of the STLS-system presented at the beginning of the previous section. We turn now to 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 and, more specifically, the economic impact of changes in the different taxes.

3.2 Variable Tax Regime

When the exogenous tax rates start to get adjusted 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 all traded quantities in both countries decrease from period 8 to period 9, under the WT-system. Under the STLS-system the quantities traded internationally and in the large country also decrease, but now the amount of local goods in the small country increases, when the tax rates begin to adjust (Figure 3).

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 the economic performance indicators in Figures 4 and 6, this triggers a clearly observable negative economic shock, with increasing unemployment rates and decreasing real GDP, in the economies with wage taxation (i.e. both countries under the WT-system, and only the large country under the STLS-system). 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 higher level, which has a negative effect on outputs, as manifested by the development of real GDP in Figure 6.[20]

[20]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]	R^2
	Small country									
Unemploy-ment rate	0.5972 (9.61)[a]	0.5522 (12.73)	0.2282 (7.49)	0.3066 (16.20)	0.2378 (8.39)	0.2551 (5.86)	0.4729 (7.24)	0.2264 (8.09)	0.0165	0.63
Budget surplus	-0.3972 (-12.37)	-0.0002 (0.00)	-0.0011 (-0.02)	0.0186 (1.92)	-0.0253 (-0.85)	-0.0078 (-0.39)	-0.0356 (-1.71)	0.0062 (0.41)	0.1698	0.62
Real GDP	14.381 (8.93)	14.989 (9.96)	24.932 (21.12)	21.979 (24.45)	23.231 (10.96)	23.753 (11.69)	17.699 (8.57)	24.177 (22.38)	0.0310	0.72
Consumer earnings 1	81.931 (16.94)	84.767 (23.39)	76.938 (8.01)	87.830 (13.10)	80.752 (9.37)	103.334 (18.30)	95.376 (30.43)	93.540 (21.56)	0.7569	0.35
Consumer earnings 2	-367.71 (-7.45)	101.96 (1.39)	76.035 (0.94)	128.23 (9.12)	7.3062 (0.09)	99.196 (2.98)	50.433 (2.28)	105.19 (4.10)	0.1829	0.56
Net capital export	5.5644 (1.80)	2.8271 (1.49)	-21.841 (-6.77)	0.3272 (0.09)	-1.0861 (-0.23)	-22.535 (-8.23)	-4.4474 (-4.52)	-20.716 (-15.84)	0.0000	0.64
Y-production intensity	0.3060 (32.13)	0.4423 (61.07)	0.4588 (12.93)	0.4050 (27.96)	0.5061 (10.44)	0.5757 (11.36)	0.4018 (15.85)	0.4195 (5.92)	0.7812	0.58
	Large country									
Unemploy-ment rate	0.5543 (10.60)	0.4549 (11.96)	0.4663 (6.15)	0.7538 (13.61)	0.7381 (8.51)	0.7003 (11.16)	0.5015 (12.33)	0.6080 (10.78)	0.0903	0.70
Budget surplus	-0.2185 (-7.26)	-0.1219 (-2.37)	-0.0106 (-0.32)	-0.3717 (-5.66)	-0.7370 (-8.51)	- 0.3696 (-10.61)	- 0.0572 (-1.57)	-0.1493 (-2.71)	0.1090	0.57
Real GDP	104.29 (10.08)	122.62 (17.90)	120.97 (7.84)	59.061 (4.93)	60.058 (3.21)	69.244 (5.07)	115.43 (13.16)	91.732 (8.11)	0.0716	0.55
Consumer earnings 1	200.40 (38.52)	208.51 (50.08)	207.74 (43.37)	181.82 (28.73)	174.60 (24.25)	181.04 (22.98)	203.45 (63.08)	194.39 (33.09)	0.0854	0.96
Consumer earnings 2	-1680.7 (-17.79)	-777.71 (-2.33)	-156.14 (-1.48)	-2534.6 (-9.12)	-4356.0 (-17.53)	-2380.6 (-8.89)	-273.96 (-0.71)	-1208.2 (-2.38)	0.0934	0.42
Net capital export	-5.5644 (-1.80)	-2.8271 (-1.49)	21.842 (6.77)	-0.3272 (-0.09)	1.0861 (0.23)	22.535 (8.23)	4.4474 (4.52)	20.716 (15.84)	0.0000	0.64
Y-production intensity	0.4345 (121.68)	0.5071 (27.23)	0.4618 (60.96)	0.6358 (85.21)	0.6080 (42.98)	0.5591 (36.81)	0.4453 (17.28)	0.5549 (17.63)	0.0554	0.77

Note: Prais-Winsten regressions that are corrected for first-order serially-correlated residuals and robust standard errors, allowing for dependent observations within sessions. [a] t-values in parentheses, [b] F-test testing the value of a_2 against the value of b_2; all tests two-sided. '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.

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, and the negative effect on the price of the labor intensive good Y, in contrast to the development under wage taxation (see Figures 2 and 3). The labor subsidy clearly seems to play a role here. Remarkably, the budget immediately balances, and stays that way, with only small deviations. As Figures 4 and 6 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.

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

Comparing the estimated asymptotic values a_2 and b_2, for the small country, a significant decrease in the unemployment rate and net capital export together with a significant increase in real GDP show up under the STLS-system. For the budget surplus, the labor intensity of production, and both of the consumer earnings measures, no significant differences are found. Observe, however, that consumer earnings adjusted for the budget surplus show 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.

Not surprisingly, for the large country, the outcomes are worse for the STLS-system sessions, because of the bad start. Note, however, that none of the differences between the asymptotic values a_2 and b_2 are significant at the 5 percent level, with the only exception of net capital export that mirrors the result for the small country. 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 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.

Another way of looking at the economic impact of the tax systems is to investigate the effects of changes in the different tax rates. Table 7 shows the results of regressions concerning some real economic variables of interest: unemployment rate, capital employment, real GDP, consumer welfare in terms of earnings, net capital export, and Y-production intensity. In addition to the tax rates the number of the trading period is included as independent variable to control for a linear trend.

Several observations are in order. First of all, the signs of all tax effects are quite intuitive. For both the wage tax and the sales tax it appears that tax hikes have a negative impact on the economic activity and consumer earnings of the country directly involved. Higher taxes also encourages capital flight. The only ambiguous effect concerns the labor intensity of production. Furthermore, a wage tax generally has adverse effects on the economic variables in the respective country. This is witnessed by the highly significant coefficients of the wage taxes τ_{ws} in the small country and τ_{wl} in the large country, in most regressions. Interestingly, this is not the case for the sales tax. Only the negative effect on capital employment is significant at the 5 percent level. Note, however, that the size of this adverse effect is much smaller for the sales tax than for the wage tax. Interestingly, neither the unemployment rate nor real GDP is significantly affected by an increase in the sales tax. The next result summarizes.

Result 4 *Compared to wage tax changes, increases in the sales tax appear to have a much smaller adverse economic impact. Whereas an increase in the wage tax shows a clearly detrimental effect on the employment of labor and real GDP, no significant effect is observed for the sales tax. Moreover, the negative effect of the sales tax on capital is much weaker than that of the wage tax, while no effect on the labor intensity of production is observed.*

All in all, compared to the WT-system, the performance of the STLS-system turns out to be remarkably good. None of the expectations regarding the economic indicators, presented at the beginning of the previous section, find support in the experimental data. Incidentally, the results are even better than the ones suggested by the 'favorable' equilibrium of the theoretical benchmark model. For example, instead of the dreaded capital flight, in fact capital import is observed (see Tables 5 and 6). In the next section we offer a tentative explanation for this major finding, using some further evidence.

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 export	Y-production intensity
	Small country					
τ_{ws}	0.3950***	-24.081**	-10.030**	-4.8863	26.529***	-0.1014*
	(5.49)	(-3.19)	(-3.75)	(-0.95)	(4.56)	(-2.14)
τ_{xs}	0.0898	-9.7006**	-2.0667	-0.1446	12.000*	-0.0681
	(1.23)	(-2.79)	(-0.94)	(-0.03)	(2.35)	(-1.10)
τ_{wl}	-0.0444	1.5124	0.5829	-20.119***	-5.0507	0.0338
	(-0.71)	(0.13)	(0.28)	(-4.51)	(-0.53)	(1.01)
period	-0.0071	0.8163	0.0878	1.1852**	-1.1439	0.0025
	(-1.65)	(1.30)	(0.90)	(2.93)	(-1.74)	(0.53)
constant	0.3326**	34.626***	22.936***	94.801***	-2.7821	0.4157***
	(3.06)	(10.80)	(8.15)	(18.48)	(-0.59)	(8.68)
N	54	54	54	54	54	54
R^2	0.69	0.36	0.75	0.28	0.51	0.34
	Large country					
τ_{ws}	-0.0349	31.317***	13.021	7.0651	-26.529***	-0.0682
	(-0.95)	(8.78)	(1.52)	(1.22)	(-4.56)	(-1.56)
τ_{xs}	0.1835	-18.511	-35.903	-13.395	-12.000*	0.1625***
	(1.33)	(-0.91)	(-1.31)	(-1.75)	(-2.35)	(5.04)
τ_{wl}	0.3082***	-51.831***	-63.023***	-27.147***	5.0507	0.0225
	(8.18)	(-4.88)	(-7.80)	(-5.08)	(0.53)	(0.60)
period	-0.0058	1.3556	1.1607	0.7079	1.1439	-0.0001
	(-1.18)	(0.82)	(0.99)	(1.66)	(1.74)	(-0.05)
constant	0.3664***	192.53***	139.15***	209.91***	2.7821	0.4795***
	(5.97)	(10.98)	(11.12)	(38.46)	(0.59)	(12.57)
N	54	54	54	54	54	54
R^2	0.61	0.51	0.69	0.96	0.51	0.75

Note: Prais-Winsten regressions that are corrected for first-order serially-correlated residuals and robust standard errors, allowing for dependent observations within sessions; regressions are based on periods 8 to 16; *** significant at 1 percent, ** significant at 5 percent, and * significant at 10 percent; [a] t-values in parentheses, two-sided tests; '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; the base 'year' for calculating 'Real GDP' is the first trading period in each session; 'Consumer earnings 1' denotes average earning of a consumer in points ('utility'); '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. 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).

4 A behavioral explanation and empirical support

Our results 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. Since this result seems also to be at odds with the prediction of the standard general equilibrium model, this requires an explanation. Although, of course, the robustness of our results should be checked in future experiments, theoretical and empirical support can be offered for the following claim.

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 benchmark model. Although this general equilibrium model does not capture the full complexity of the 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 8 shows the number of cases in which producers' marginal revenue product *exceeds* the input price, using average current prices.[21] Assuming random errors, profit maximization would be consistent with a fraction of 50%. The observed fractions are remarkably different, however. Our next result summarizes the evidence.

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

TABLE 8 – 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.

Result 5 *Averaging over periods and tax systems, for about 70 percent of the cases producers' marginal revenue product of capital and labor 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.[22] Interestingly, Noussair, Plott, and Riezman (1995)

[22]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

observe a similar phenomenon in an experiment concerning international trade.[23] They conjecture that producers may require a compensation for the market risk they run, since they may not be able to sell outputs. The underlying reason may be some form of aversion towards risk or losses. Indeed, partial equilibrium models exist indicating that product price uncertainty reduces the factor demand of risk-averse competitive firms (see the literature mentioned in the Introduction). And risk-averse behavior of firms appears to be a realistic assumption.[24] Empirical microeconomic studies of the consequences of market uncertainty for factor demand are scarce, though (see Ghosal (1995)).[25] Important exceptions are Leahy and Whited (1996) and Guiso and Parigi (1999). Both of these studies find that investment is negatively affected by uncertainty. Guiso and Parigi note that field empirical research in this area is plagued by the absence of data and measurement problems. Experiments like ours may be helpful in this respect.

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 9 presents the outcomes. In line with the field studies, a mostly significant negative correlation shows up. The next result summarizes this *third* piece of evidence for our claim.

Result 6 *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 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

prices - we find excess supply for a fraction of the 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).

[23]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.

[24]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).

[25]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).

Table 9 – 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.

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.[26] 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).

For our *fourth* and final piece of evidence 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

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

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 and empirical support for our claim seems substantial. The evidence presented makes it quite intuitive why the sales tax system performs so much better than the wage tax system. With any aversion to risk or losses, having the government share 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. None of the worries and expectations that were ventilated by policymakers and economic policy advisers regarding the alternative tax system find support. Employment and GDP does not decline but sharply increased. Instead of capital flight, capital import is observed. The balance of the budget does not deteriorate but strongly improves, and no shift towards labor-intensive production occurs.

This calls for an explanation. 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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