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AN EXPERIMENTAL INVESTIGATION OF WAGE TAXATION AND UNEMPLOYMENT IN CLOSED AND OPEN ECONOMIES*

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Abstract

We investigate experimentally the economic effects of wage taxation to finance unemployment benefits for a closed economy and an international economy. The main findings are the following. (i) There is clear evidence of a vicious circle in the dynamic interaction between the wage tax and unemployment. (ii) In the short run employment is boosted by budget deficits. However, subsequent tax rate adjustments to balance the budget lead to employment levels substantially lower than theoretically predicted. (iii) A sales risk for producers due to price uncertainty on output markets appears to cause a downward pressure on factor employment. For labor the wage tax exacerbates this adverse effect.

JEL Classification Number: C90, D50, E24, F41

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1 Introduction

For more than two decades now unemployment has figured prominently on the political and economic agenda of many industrialized countries. Although by now a great number of theoretical and empirical studies exists and many proposals have been made, there is no consensus yet on how to structurally solve the issue.[1]

Welfare state arrangements and the accompanying tax burdens are generally considered as an important factor fostering unemployment. Using European economies as an example, Snower (2000) points out that these arrangements were established under economic fair-weather conditions. Once the weather started to deteriorate they more and more resembled quicksand. Rising unemployment led to higher social transfers, producing higher taxes on a shrinking tax base, which in turn negatively affected employment: "And so the cycle continues" (ibid., p. 44). Substantial theoretical and empirical evidence indeed exists for a negative feedback effect from a higher tax burden on labor, the tax-wedge, suggesting the possibility of a vicious circle.[2] Thus, it seems that Snower's cycle is an important explanatory factor for persistently high unemployment rates.

Granting the possibility of a vicious circle, the existing literature, unfortunately, is only of limited help in establishing its actual existence and relevance. Theoretical models not only rely on assumptions regarding the behavior of economic agents, they also typically focus on equilibria. Empirical studies, on the other hand, are confronted with the typical problems associated with field data. For instance, lack of control over the data generating process and limited information about preferences and production technologies hamper the estimation of relevant parameters. These problems manifest themselves, for example, in the dramatic differences in estimated tax rate elasticities of pre-tax real wages across studies and countries, resulting in great uncertainty regarding the quantitative impact of taxation on real economic variables (Sørensen (1997, p. 230)).

The goal of this paper is to help improve our understanding of the interaction between wage taxation, budget deficits, and unemployment, including the role played by

[1] See, e.g., Economic Policy (1997, p. 217).

[2] See, e.g., Elmeskov et al. (n.d.), European Commission (1994), Nickell and Layard (1997), Pissarides (1998), Sørensen (1997). For a relatively early theoretical study showing the possibility of a "*crowding-out-effect* with massive unemployment", see van Praag and Halberstadt (1980).

the aforementioned vicious circle. To this end we take the novel approach of laboratory experimentation. This research method offers the opportunity to focus on fundamental issues and mechanisms in a controlled way and will be helpful in generating empirical insights which would otherwise remain undetected.

This study is based on a research project regarding the economic performance of tax systems commissioned by the Dutch Ministry of Social Affairs and Employment, following a motion carried by the Second Chamber of the Dutch parliament.[3] To the best of our knowledge, it is for the first time that policymakers explicitly asked for laboratory experiments to support macro-economic policymaking. Our paper fits into a still relatively small but growing stream of 'design' studies, as Alvin Roth labels them in his Fisher Schultz Lecture (Roth, 2002). From a broader perspective, is is part of an emerging research field showing the usefulness of macro-economic experiments as a complementary research tool next to the more traditional methods of theoretical and field empirical analysis.[4]

Important advantages of laboratory experiments are that, in contrast to field empirical studies, it is possible to control the economic environment and that there is no need for restrictive assumptions about behavior.[5] Additionally, in contrast to most theoretical models, we do not have to restrict the analysis to equilibrium states. By focusing on relatively simple economies - which are real in the basic sense that real people make real choices with real consequences - we can learn more about the interaction between wage taxation and unemployment and about the dynamics and consequences of behavioral adjustment processes that the vicious circle argument refers to.

More specifically, we experimentally investigate the economic performance of economies operating under a wage tax financed unemployment benefit system, as it is

[3]The project was assisted by a steering committee consisting of internationally reputed scientists with expertise in public economics, labor economics, game theory, experimental economics and applied general equilibrium modeling. For more details the interested reader is referred to van Winden et al. (1999).

[4]On taxation issues, see Davis and Swenson (1993), Quirmbach et al. (1996). For other macro-economic experiments, see Bosch-Domènech and Silvestre (1997), Goeree and Holt (1999), Hey and di Cagno (1998), Lian and Plott (1998), Noussair et al. (1995, 1997, 2003).

[5]Natural experiments that allow for good control in outside-lab environments are rare events. An example is the case where Washington State was forced to adopt a new tax system in 1985. Anderson and Meyer (2000) use this case to investigate the tax incidence of a payroll tax.

common in many developed countries. Two different economic environments are investigated: a closed economy, and an international economy with a relatively small 'home country' and a large 'foreign country'. The latter allows us to study a large and a small open economy simultaneously. In both cases there are input markets for capital and labor, and output markets for the goods produced by two production sectors. In the open economies environment, there are international markets for capital and one commodity. In each environment two tax regimes are imposed in sequence. During the first part of each experimental session the wage tax rate is held constant. This allows us to investigate whether the economies stabilize and, if so, at what level of the different economic variables. To analyze the dynamic interaction between the wage tax and unemployment as well as other indicators of economic performance, in the second part of each session, the tax rate is adjusted to the previous period's budget deficit.

In this paper, we are mainly interested in investigating whether wage tax financed unemployment benefits may produce a vicious circle boosting unemployment and deteriorating the performance of an economy as a whole. We therefore abstract in this first approach from other factors conducive to unemployment, like efficiency wages or institutions fostering insider-outsider effects. Furthermore, we will not distinguish between voluntary and involuntary unemployment because, for the empirical questions at hand, this distinction is "fruitless" (Layard et al., 1991, p.91).[6] Moreover, from a budgetary point of view it does not really matter much whether in the end the benefits have to be paid for voluntarily or involuntarily unemployed units of labor.

To facilitate equilibriation and efficiency we implement competitive double auctions for all markets. This trading mechanism has been shown to be very effective in fostering trade and equilibriation in experimental markets (see e.g. Davis and Holt (1993)). In this way, we give the theory of competitive markets, that we will use as benchmark, its best chance to perform well. Moreover, finding a vicious circle in such a competitive environment would only strengthen the significance of the result.[7]

[6]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.

[7]According to Snower (1994, p. 65), unemployment benefit systems typically augment common labor-market failures, particularly those highlighted by efficiency wage, insider-outsider, and union theories.

Our main findings are the following. First, for all economies we find clear evidence of a vicious circle in the dynamic interaction between the wage tax and unemployment. Second, in the short run employment seems to be boosted by budget deficits. However, subsequent tax rate adjustments in order to balance the budget lead to employment levels that substantially fall short of the predictions obtained from the general equilibrium benchmark model. Third, and related to the previous point, there appears to be a downward pressure on the employment of production factors caused by a (disequilibrium) sales risk for producers. Due to uncertainty about output prices, and hence revenues, producers are reluctant to employ inputs. For labor this downward pressure on employment is exacerbated by the wage tax. Our results provide support for the hypothesis of a 'risk-compensated price mechanism' where the reluctance of producers to employ inputs is accompanied by (in comparison with the equilibrium predictions) too low input prices and too high output prices. This mechanism is not accounted for in general equilibrium models. Reliance on such models in policymaking would therefore lead to unexpected unemployment and disappointing economic performance. This may also help explain why one seems to have been taken by surprise by the vicious circle of wage taxation and unemployment.

The organization of the remainder of the paper is as follows. Section 2 presents the experimental design and theoretical predictions. Results are given and discussed in section 3. Section 4 concludes.

2 Experimental design and theoretical predictions

2.1 Experimental environment

We consider two types of economies, a closed economy and an international economy. The latter involves two 'countries', a relatively small 'home country' (h) and a relatively large 'foreign country' (f). In both economies there are consumers and producers participating in computerized multiple unit double auction markets.[8] Consumers are endowed with $\bar{K}$ units of capital and $\bar{L}$ units of labor that they can sell to the producers as inputs (K and L) on a capital and a labor market, respectively. Consumers

[8]For a description of the multiple unit double auction, see Plott and Gray (1990).

derive utility (money earnings in the experiment) from 'leisure', the unsold units of labor $\bar{L} - L$, and the consumption of two commodities, X and Y. In addition to their proceeds from sales, they obtain an unemployment benefit for each unsold unit of labor that can be used for the purchase of consumption goods on the output markets. Goods X and Y are produced in two separate sectors. The producers in these sectors need capital and labor as inputs, which are transformed to outputs via given production technologies. The technologies for the two goods differ in the sense that the production of good X is relatively capital-intensive whereas the production of good Y is relatively labor-intensive. Producers derive experimental earnings from profits, determined by the difference between their proceeds from sales in their respective output market and the costs of inputs. The cost of labor includes a proportional wage tax.

In total, there are four markets in the closed economy: two factor markets (for K and L) and two output markets (for X and Y). In the international economy, both the capital market and the market for X are 'international' ('exposed'), whereas the markets for labor and good Y are 'local' ('sheltered'). Consequently, the total number of markets in this economy equals six. To implement a large foreign economy in the lab - making the home country similar to a 'small' open economy - we choose the following design.

While keeping the number of consumers and producers the same for both countries in the international economy, we endow the consumers in the foreign country with seven times as many units of labor and capital as the consumers in the home country. Moreover, a scaling factor in the production functions of foreign producers is adjusted such that theoretically supply and demand in the foreign economy are seven times as high as in the home economy. Table 1 shows the parameters of the experimental economies, including continuous approximations of the earnings functions (utility and profit functions) of consumers and producers, and the production technology of producers.[9]

[9]In addition to the endowment of capital and labor for consumers both consumers and producers are endowed with some cash. Note, furthermore, that with the requirement of at least three agents on each side of a market (as e.g. in Quirmbach et al. (1996)), which seems to be the smallest number of agents ensuring that the markets approximate competitiveness (see also Davis and Holt (1993, p.150)), the minimal number of subjects would have been 64, in case of the alternative approach of increasing numbers of agents instead of endowments. Apart from potential control problems with that many

Table 1: Experimental parameters

Preferences

Consumers: $U_i = 25\left[\ln X_i + \ln Y_i + .25\ln(\bar{L}_i - L_i)\right]$
$U_i = 0$ if either X_i, Y_i, or $\bar{L}_i - L_i$ equals zero

Producers: $\Pi_j = p_z Z_j - (1+\tau)wL_j - rK_j,\ Z = X, Y$
In international economy: p_y, Y, τ, w, and L are determined 'locally' (within a country)
p_x, X, r, K are determined 'internationally' (one market)

Parameters:

	Endowments and francs/Dutch cents conversion rates		
	Closed economy	International economy	
		Home country	Foreign country
Consumers	$\bar{L} = 60,\ \bar{K} = 40,$ $Cash = 725$ $Conversion\ rate = 1.2$	$\bar{L} = 15,\ \bar{K} = 10$ $Cash = 181$ $Conversion\ rate = 3.6$	$\bar{L} = 105,\ \bar{K} = 70$ $Cash = 1268$ $Conversion\ rate = 1.8$
Producers X	$\bar{L} = 0,\ \bar{K} = 0,$ $Cash = 4890$ $Conversion\ rate = 0.4$	$\bar{L} = 0,\ \bar{K} = 0$ $Cash = 1223$ $Conversion\ rate = 2.8$	$\bar{L} = 0,\ \bar{K} = 0$ $Cash = 8557$ $Conversion\ rate = 0.4$
Producers Y	$\bar{L} = 0,\ \bar{K} = 0,$ $Cash = 3260$ $Conversion\ rate = 0.6$	$\bar{L} = 0,\ \bar{K} = 0$ $Cash = 815$ $Conversion\ rate = 4.2$	$\bar{L} = 0,\ \bar{K} = 0$ $Cash = 5705$ $Conversion\ rate = 0.6$
Number of agents:			
Consumers	6	3	3
Producers X	4	2	2
Producers Y	6	3	3

Production:

Production function: $Z = A\left[\eta_z^{1-\gamma_z} L^{\gamma_z} + (1-\eta_z)^{1-\gamma_z} K^{\gamma_z}\right]^{\frac{0.9}{\gamma_z}}$
Labor intensity: $\eta_x = .5625,\ \eta_y = .675$
Substitution elasticity: $\gamma_x = -2,\ \gamma_y = -6$
Scaling factor A: 1.15 in closed economy
1 for home country in international economy
1.21 for foreign country in international economy

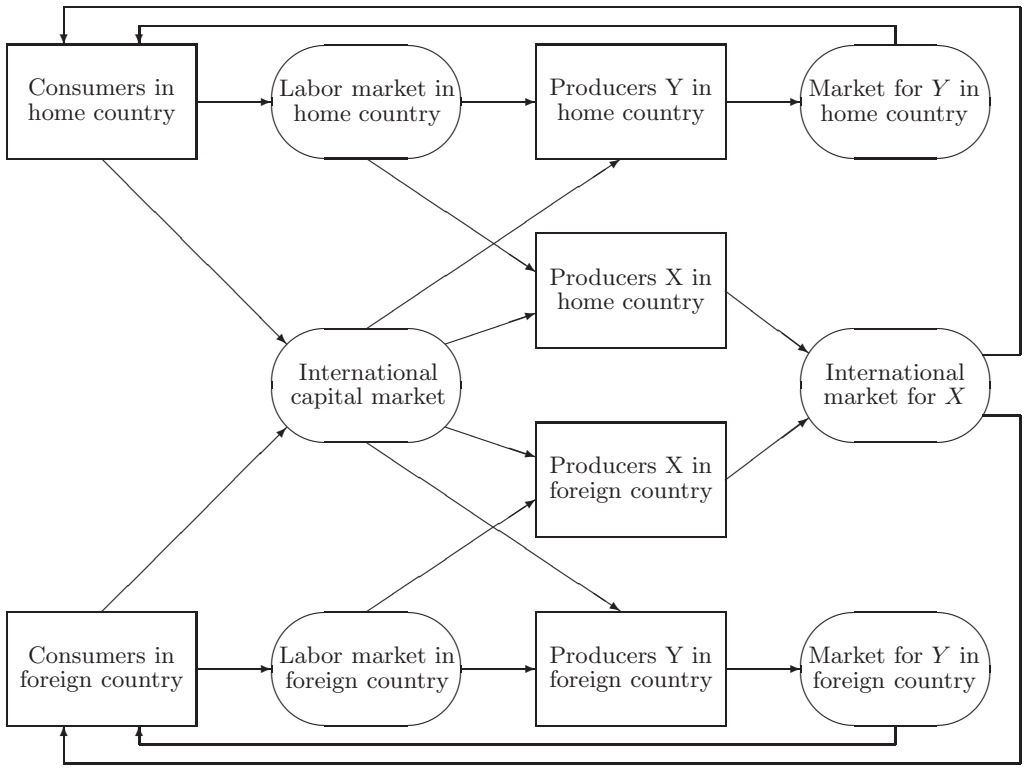
'Government':

Unemployment benefit: $w_0 = 70$

Wage tax rate: $\tau = .3777$ in 'constant tax periods'
$\tau_{t+1} = \frac{w_0}{w_t}\frac{\bar{L}-L_t}{L_t}$ in 'variable tax periods'
with an upper bound of 0.9*

Note: * This upper limit was set given the experience with another tax system investigated in van Winden et al. (1999). Pilot studies showed that tax rates too close or even above 100 percent might have a strong discouraging effect on trading.

Figure 1: Flow diagram of the international economy (a) and sequence of events (b)



(a)

Input markets open	Production	Output markets open	Calculation of gains
Phase 1	Recording time	Phase 2	Recording time

(b)

Panel (a) of Figure 1 presents a flow diagram of for all goods for the more complex international economy. In case of the closed economy, the total number of consumers and producers is the same as in the international economy. However, in that case there is only one market for labor and one market for good Y, instead of two. Furthermore, consumers are endowed with four times as many units of capital and labor as the consumers in the home country of the international economy. The scaling factor in the production function of the producers is adjusted such that theoretically supply and demand will be four times as large as in the home country of the international economy.

In both economies 'francs' are used as the experimental currency unit, implying that only one currency exits in the open economies.[10] The rates at which earnings in

subjects, lab size restrictions urged us to choose the design of this study.

[10]Since we are not focusing on issues of international finance, we do not want to complicate the

francs were converted into Dutch guilders (*conversion rate*) can be found in Table 1. This table also shows the two ways in which the wage tax is implemented. During the first seven (closed economy) or eight (international economy) trading periods into which the experimental sessions are divided (see below) the tax rate is kept constant, while it adjusts to the previous period's budget deficit (that is, outlays on unemployment benefits minus tax revenues) in the later periods. The reason for choosing this procedure is that, on the one hand, we need a sufficient number of repetitions with a constant environment - keeping conditions *exactly* the same in each period - to see whether economic behavior stabilizes, and, if so, at what level.[11] On the other hand, we want to analyze the dynamic interaction between the wage tax and unemployment, as well as other indicators of economic performance, if the wage tax adjusts to deficits or surpluses, as occurs in reality, while keeping the other conditions constant. Note, however, that we do not impose an intertemporal budget constraint forcing it to balance the budget across all periods. Our main goal is here to examine how the markets react to the introduction of some fiscal discipline, while keeping all other parameters the same.

2.2 Procedures

In total seven experiments were conducted: four concerning the closed economy, and three involving the international economy.[12] Table 2 provides some data characterizing these sessions. All experiments were run at the CREED-laboratory of the University of Amsterdam. Subjects, undergraduates at the University and mostly coming from its Faculty of Economics and Econometrics, participated in three meetings. At the first meeting they got thoroughly acquainted with the trading rules, forms and tables to be used, and the software of the double auction markets. Producers and consumers

experiments by introducing multiple currencies. Generally, the use of an artificial experimental currency is common practice in experimental market economies (see, e.g. Noussair et al., 1995 and Quirmbach et al., 1996). In our experiment the use of such a currency has the advantage that it allows us to equalize the expected earnings of subjects in different roles, based on the theoretical model.

[11] In less complex experimental competitive environments behavior usually stabilizes - in the neighborhood of the theoretical predictions - within the first few periods (Davis and Holt, 1993).

[12] For comparison, in the only other experiment that we are aware of addressing tax issues in a general equilibrium framework, three experimental sessions per treatment are run, as in our open economies experiments (see Quirmbach et al., 1996).

Table 2: Summary of experiments

Date	Economy	Number of subjects	Experience	Number of periods*	Number of constant tax periods
05/10/98	Closed	16	Training	14 (3)	7
05/10/98	Closed	16	Training	13 (3)	7
06/10/98	Closed	16	Training	12 (3)	7
06/10/98	Closed	16	Training	14 (3)	7
08/10/98	International	16	Closed economy	16 (2)	8
08/10/98	International	16	Closed economy	16 (2)	8
09/10/98	International	16	Closed economy	16 (2)	8

Note: * Number of practice periods in parentheses.

were separately trained.[13] Then, at the second meeting, subjects participated, in their respective role, in the closed economy experiment. Again after a few days, this was followed by the third meeting concerning the international economy experiment. Each meeting lasted about 3.5 hours. Thorough training is common for more complex market experiments. In this case, because of the complexity of the international economy (with one of the novel aspects being the many units to be traded by subjects in the foreign economy), it was also decided to use only experienced subjects for this experimental environment. The closed economy experiment, with its intermediately sized endowments, enabled subjects to gain experience with a similar (but not identical) environment.[14]

At the beginning of the experiments subjects received the instructions, consisting of a general part which was read aloud and a specific part to be read by themselves. The specific part only presented instructions that were relevant to the subject in its

[13]To avoid experimenter-induced effects, the bids and asks of the experimenters who acted as counterparts in the markets for training were randomly varied within a considerable range, which was the same for all training sessions.

[14]Furthermore, subjects were selected for the international economy experiment on the basis of their performance (earnings) in the closed economy experiment. All subjects got informed about this during the first meeting. Subjects received a show-up fee of 70 guilders for the training. They got a show-up fee of 40 guilders and earned on average 27 guilders in the closed economy session. For the international economy session these figures were, respectively, 10 and 67 guilders. All money was paid out privately at the end of the third meeting.

specific role of consumer or producer.[15] Apart from similar information provided on the computer screen, subjects received personal history forms containing all the information that was relevant to the subject (endowments, markets they were allowed to trade in, any taxes or subsidies, and the conversion rate of francs into guilders).[16] By having them fill in their purchases or sales of goods as well as their earnings these forms were also intended to make subjects fully aware of the consequences of their actions. Quizzes were used to check the understanding of the procedures, the reading of the redemption values and production schedules, and the calculation of earnings.[17]

Each experiment consisted of a number of trading periods, with a couple of practice periods at the beginning in which no money was earned (see Table 2). Except for the adjustment of the wage tax in later periods, all periods were identical in terms of endowments and parameter values. Apart from subjects' earnings, nothing carried over from one period to the next. Each period was divided into two phases. In the first phase the factor markets for capital and labor were open, while in the second phase the product markets were open. Including some recording time and time to look up information, each phase took about five minutes.[18] Panel (b) of Figure 1 shows - from the left to the right - the sequence of events.

Standing bids and asks in the labor market were presented as 'market prices' (exclusive of the wage tax) and as 'inclusive prices' (including the tax), where for consumers the former and for producers the latter was highlighted on the computer screen. After the closing of the factor markets consumers were informed about the unemployment benefits received due to unsold labor units, while producers were informed about the number of goods produced with the inputs they bought. In addition, some market statistics were provided concerning the amounts of capital and labor traded, average prices, and the average price subjects received (paid) for the inputs they sold (bought).

[15] In the experiment consumers were labeled 'type-I traders' and producers 'type-II traders'. Moreover, labor and capital were denoted as good V and good W, respectively.

[16] Markets were labeled as V1(2), W1, X1, and Y1(2); the unemployment benefit was denoted as a subsidy for unsold units of V.

[17] A sample copy of the instructions, trading rules, and personal forms used in the experiments is available at http://www.fee.uva.nl/creed/pdffiles/WTInstr(separate).pdf.

[18] Two pilot experiments had shown that this timing was sufficient to allow subjects to trade all the units they wanted to trade, and to fill in the personal history forms.

Table 3: Theoretical predictions

	Closed economy	International economy	
Variable		Home country	Foreign country
Production:			
X	177	177	
Y	151	19	132
Inputs:			
K	240	240	
L	226	28	197
Unemployment rate*	37%	37%	37%
Relative prices:**			
p_x	.3088	.1882	
p_y	.3628	.2211	.2211
r	.0504	.0307	
w	.2780	.1694	.1694
'Government':			
Budget balance	0	0	0
Wage tax rate	.3777	.3777	.3777

Note: * For convenience, the unemployment rate is calculated with respect to total initial endowment of labor units, i.e. the potential labor force. ** Relative prices are defined by dividing nominal prices with the sum of all nominal prices. The relative prices in the international economy differ from those in the closed economy, since there are two local markets for labor and the labor intensive product Y, respectively. Treating each of them as just one market would give the same relative prices in the closed economy and the international economy.

After the closing of the product markets similar market statistics were provided on the computer screen.

2.3 Theoretical predictions

As theoretical benchmark we use the predictions obtained from the numerical solution of a general competitive equilibrium model including the requirement of a balanced budget. In this model we neglect the double auction character as well as the sequential

structure of the experimental markets, assuming price taking behavior. We are forced to do so since theoretical models able to capture the complexity of the experimental economies are lacking. Similar benchmark modeling is used in other studies of experimental markets (e.g. Noussair et al. (1995, 1997) and Quirmbach et al. (1996)). The main results concerning production levels, quantities of traded inputs, 'government' variables, and relative prices are shown in Table 3.

3 Empirical analysis

In this section we present our main experimental results and observations. We first concentrate on the functioning of the economies in a more general way and their performance relative to the theoretical benchmark predictions under the constant tax regime. Then, we will zoom in on the issue whether indeed a vicious circle in the dynamic interaction between wage taxation and unemployment can be observed. In this context we will also look at the - short run - impact of budget deficits on employment. Finally, we present and provide evidence for a behavioral explanation of the observed divergence between the empirical results and the theoretical predictions.

3.1 General performance of the economies

The first result concerns the functioning of the experimental economies.

Result 1 *The development of prices in both the closed and the international economy shows a clear structure, with generally most variation during the initial periods. Furthermore, both the ratio of employed inputs and the ratio of outputs are inversely related to the respective price ratio, in line with the theoretical prediction.*

SUPPORT. Figure 2 presents a typical time series. For one of the sessions, the figure shows on the vertical axes the nominal prices of the transactions on the labor market, with the time of the transaction (in real time, starting from zero) indicated on the horizontal axes. The vertical lines separate subsequent trading periods. Focusing first on the initial seven periods where the tax rate is fixed the variation in transaction prices appears to get smaller over time. This visual expression is corroborated by

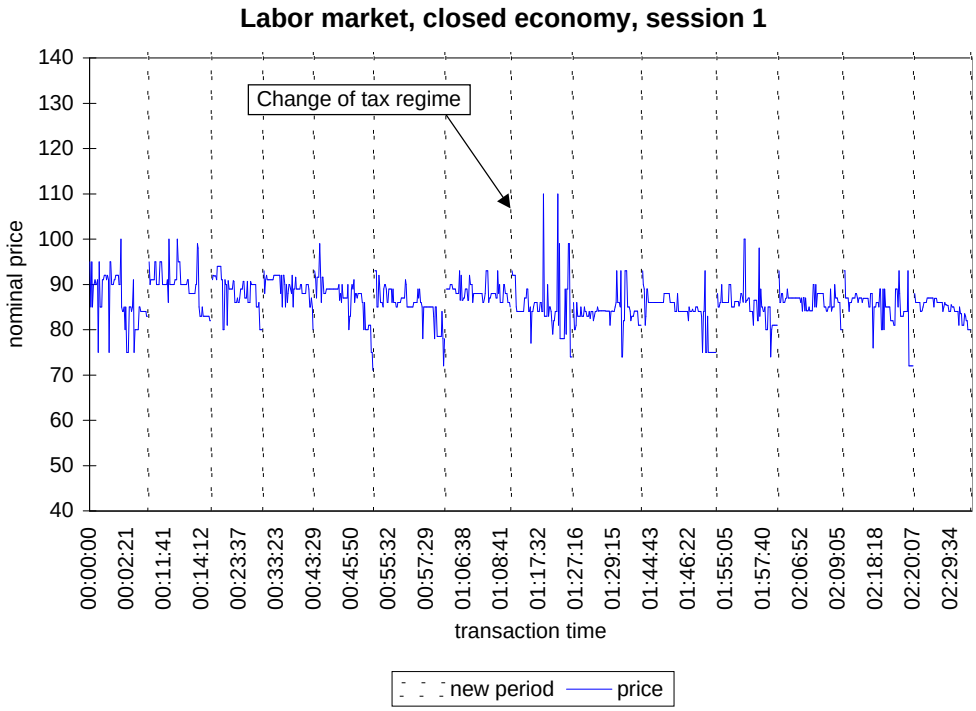


Figure 2: Transaction prices on the labor market of a closed economy session

the finding that the average standard deviation of transaction prices in the first two periods is larger than in the last two periods of the constant tax regime. This holds for the closed as well as the international economy and for all markets, except one. The figure suggests that a similar pattern obtains after period eight, when the tax rate adjusts to the previous period budget deficit. However, this cannot be confirmed for all other markets. We attribute this to the changing tax rates in this tax regime, which seems to induce larger price variations and thus uncertainty into the economies. (We discuss the behavior of the tax rates, prices, and quantities under the variable tax regime in more detail below.) Within periods prices show some tendency to decline towards the end, where also the number of transactions is generally smaller. This pattern also holds for other markets in the experimental sessions.[19] Regarding the input markets generally a (mostly significant) positive relationship between the capital-labor employment ratio and the inverse input price ratio is observed. A similar picture concerning the relationship between the X-Y consumption ratio and the inverse of the

[19]Time series of transaction prices of all markets and experimental sessions can be found at http://www.fee.uva.nl/creed/pdffiles/WTTimeseries(separate).pdf.

output price ratio is obtained for the output markets.[20]

Figures 3 and 4 illustrate the development of the quantity and price variables over the periods. The straight horizontal lines indicate the theoretical predictions. Figure 3 shows the evolution of sales of inputs and outputs (averaged across sessions). Perhaps the most striking result is the decrease in economic activity once the tax rates start to adjust to the previous period budget deficit or surplus, which happens in period 8 in the closed economy and in period 9 in the international economy. We will come back to this below. Here we will mainly focus on the constant tax periods. Notice, that with only one exception (L_h in the international economy) all quantities start too low in comparison with the theoretical levels. However, in many cases there also seems to be some convergence to the theoretical predictions.

Figure 4 shows the evolution of relative prices. The figure indicates that, with the exception of p_{yf}, all output prices start at a higher level than predicted. Concerning the input prices it shows that wages in the closed economy and in the foreign country of the international economy are clearly too low, whereas the wage rate in the home country is too high. Interestingly, in the international economy, the capital price is far too low without showing any tendency to increase, whereas the capital price in the closed economy starts too high but steadily decreases over time. Note, that the relatively high capital price in the closed economy is accompanied by too little capital

[20]We tested these relationships by using cross-sectional time series FGLS regressions (allowing for heteroscedasticity between panels and AR(1) within panels; we also allowed for different intercepts per session by using session dummies.). The units of observation for the input market regressions are the ratio of employed capital and employed labor (as dependent variable) and the ratio of the average nominal inclusive wage and the average nominal capital price (as independent variable), per session and period. For the output market regressions, the dependent variable is the ratio of X-consumption and Y-consumption, and the independent variable the ratio of the average nominal price of Y and the average nominal price of X. With respect to the input markets the coefficient of the price ratio shows the 'right' positive sign for all sectors, except the Y-sector in the home country where it is insignificantly negative. For the X-sectors in the closed economy and the foreign country in the international economy, as well as sector Y in the foreign country the coefficient is significantly positive at least at the 5 percent level. For the X-sector in the home country and the Y-sector in the closed economy the coefficient of the price ratio is positive but not significant. With respect to the output markets we find, for both countries in the international economy, the expected positive coefficient for the price ratio, which is significant at the 10 percent level in both cases. For the closed economy the coefficient is negative but not significant.

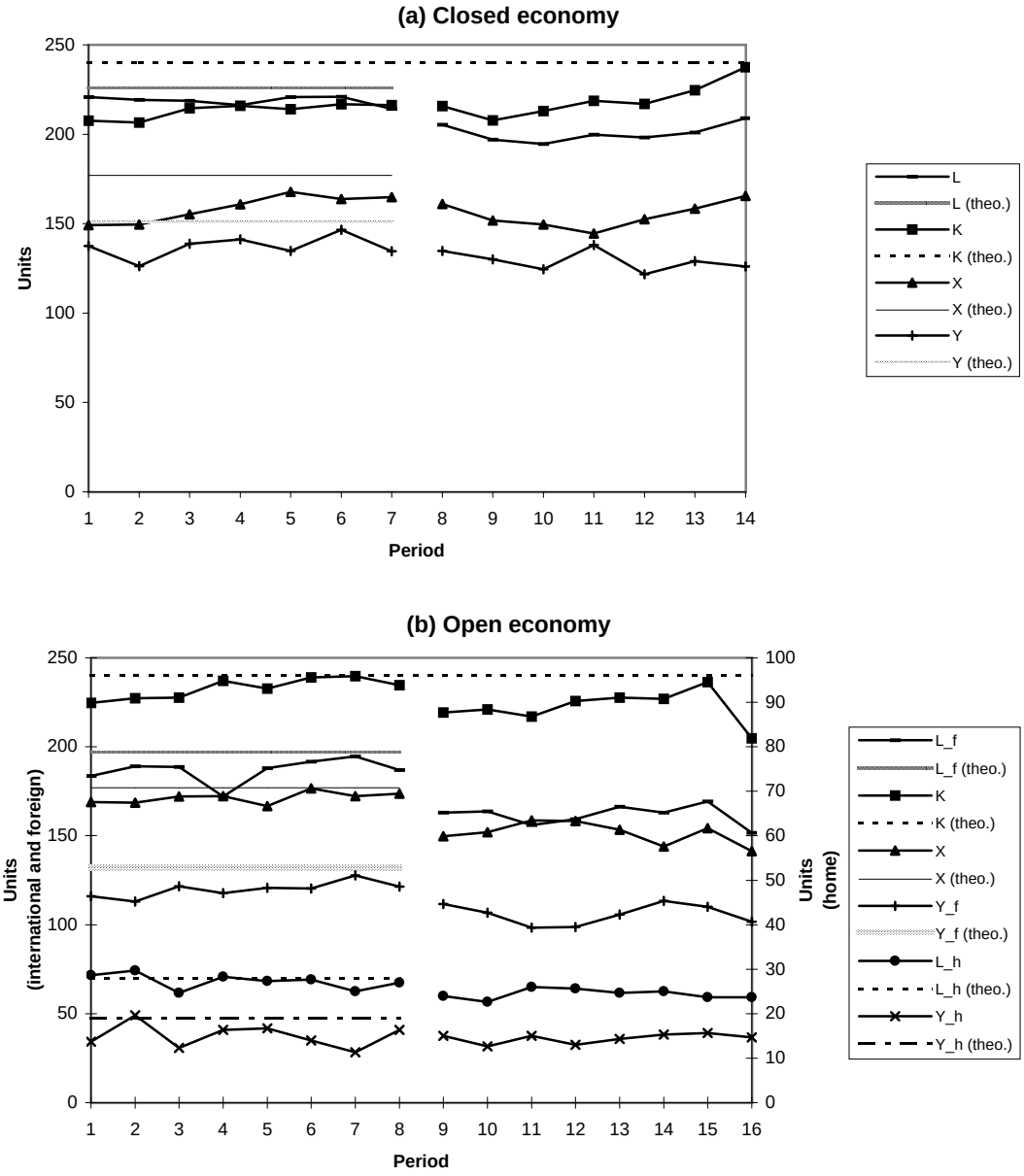


Figure 3: Development of transacted quantities over periods (averages across sessions)

employment. As the capital price decreases employment of capital slowly converges to the full employment level (see panels (a) in Figures 3 and 4). In the international economy, with its low capital price over all periods, capital employment already starts nearby full employment and also converges quickly to it (see panels (b) in Figures 3 and 4).[21]

[21]Since subjects in the open economies already had experience with the closed economy these differences between the closed and international economy may be due to experience effects.

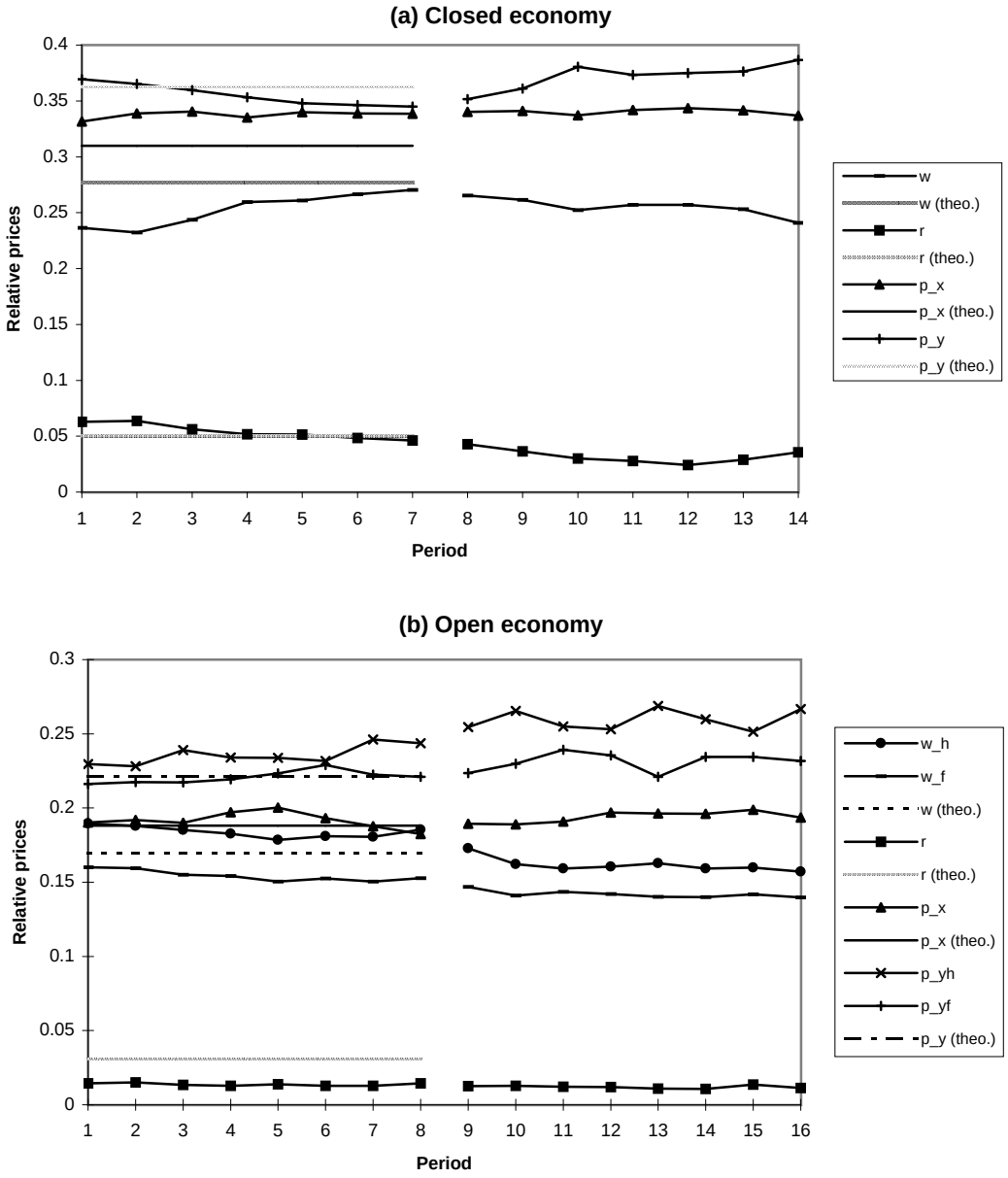


Figure 4: Development of relative prices over periods (averages across sessions)

Constant tax regime. We will now investigate more thoroughly whether the economic process shows a tendency to converge towards the equilibrium predictions during the constant tax periods. Figures 2, 3, and 4 already illustrate that some deviations are to be expected. Nevertheless, because of the good performance of the competitive model in simpler market experiments, it is interesting to investigate its predictive power in this more complicated environment. Table 4 presents the results of a convergence analysis for the periods with constant (at the theoretical equilibrium level) tax rates,

based on the following estimation model (see Noussair et al., 1995):

$$y_{it} = B_{11}D_1(1/t) + B_{12}D_2(1/t) + \cdots + B_{1i}D_i(1/t) + \cdots + B_{1n}D_n(1/t) + B_2(t-1)/t + u$$

where y stands for the particular outcome (price or quantity) focused upon, i denotes the experimental session, t the trading period in the session, D_i a dummy variable which is equal to 1 for i and 0 otherwise, B_{1i} the session specific starting value of a possible convergence process, and u the error term. Note that B_2 is the asymptote of y. The model assumes that for each experimental session the dependent variable in question may start at a different initial value (B_{1i}) but will over time converge to the common asymptote (B_2). As in Noussair et al. (1995) we say that a variable 'strongly converges' to the predicted value if B_2 is not significantly different from that value. Table 4 summarizes the results of this analysis for the real variables, the relative prices, and the relative surpluses. (For a description of all variables see the note at the bottom of the table. The reported p-value results from a two-sided F-test comparing B_2 with the predicted value 'Prediction'.) Inspection of the table leads to the following general finding.

Result 2 Constant tax regime

Only a few variables strongly converge to the predicted values. Thus, from a statistical point of view the theoretical benchmark model has to be rejected.

SUPPORT. Only one of the nine asymptotic values of the price and quantity variables concerning the closed economy is not significantly different from the values predicted by the model (at the 5 percent significance level). Only a slightly better outcome is obtained for the international economy, where three of the 14 values are not significantly different from the equilibrium predictions.

The above observation is based on a relatively strong definition of convergence. Therefore, we will now look at a somewhat less demanding form of convergence than the insignificant deviation of an asymptotic value from the corresponding predicted value. As in Noussair et al. (1995), let 'weak convergence' be defined by the outcome that a strict majority of the starting values B_{1i} are further apart from the predicted value of a variable than the estimated asymptotic value B_2. The following result gives some support for the theoretical predictions, in particular for the international economy.

Table 4: Convergence results for constant tax periods

Variable	B_{11}	B_{12}	B_{13}	B_{14}	B_2	Prediction	p-value	Wald's χ^2
				Closed economy				
X	180.6	121.4	142.0	144.5	163.1	177	.001	27681.6
	(8.24)	(16.74)	(3.54)	(13.73)	(4.41)			
Y	154.8	120.5	103.1	158.5	138.9	151	.000	11865.4
	(4.33)	(8.14)	(6.36)	(14.73)	(3.05)			
K	219.1	221.8	196.6	185.9	216.1	240	.000	34287.2
	(8.95)	(8.08)	(3.75)	(9.04)	(2.43)			
L	252.2	208.5	189.6	233.2	214.6	226	.011	10241.6
	(9.74)	(19.78)	(5.09)	(16.65)	(4.50)			
r	.0800	.0539	.0581	.0933	.0588	.0504	.058	784.7
	(.0044)	(.0182)	(.0069)	(.0118)	(.0044)			
w	.2449	.2632	.2273	.2094	.2609	.2978	.000	10289.6
	(.0057)	(.0120)	(.0108)	(.0080)	(.0041)			
p_x	.2911	.3512	.3292	.3190	.3370	.3088	.000	135054.6
	(.0053)	(.0051)	(.0034)	(.0065)	(.0017)			
p_y	.3670	.3790	.3785	.6288	.3444	.3628	.000	32611.1
	(.0086)	(.0182)	(.0054)	(.0073)	(.0044)			
s	.0147	−.0827	−.0981	−.0193	−.0657	0	.000	271.7
	(.0224)	(.0422)	(.0124)	(.0329)	(.0099)			
				International economy				
X	171.9	129.0	183.6		164.7	177	.000	5561.2
	(5.97)	(8.22)	(14.59)		(3.43)			
Y_h	15.4	14.1	18.9		14.8	19	.000	1135.4
	(2.82)	(2.98)	(1.72)		(.87)			
Y_f	89.9	137.1	113.7		120.3	132	.000	11468.0
	(12.22)	(10.97)	(3.38)		(2.43)			
K	231.5	209.2	230.7		236.1	240	.204	18131.7
	(8.92)	(5.99)	(4.32)		(3.04)			
L_h	28.2	24.9	31.8		25.5	28	.084	811.7
	(2.48)	(3.51)	(4.58)		(1.43)			
L_f	167.0	175.5	204.6		186.2	197	.041	2700.0
	(12.13)	(11.26)	(14.19)		(5.27)			
r	.0141	.0164	.0201		.0169	.0307	.000	375.4
	(.0021)	(.0011)	(.0030)		(.0013)			
w_h	.1903	.2010	.1748		.1825	.1694	.001	4962.4
	(.0110)	(.0050)	(.0033)		(.0039)			
w_f	.1796	.1426	.1547		.1501	.1694	.000	5419.4
	(.0053)	(.0048)	(.0067)		(.0029)			
p_x	.1764	.2283	.1869		.2001	.1882	.038	5628.6
	(.0144)	(.0039)	(.0082)		(.0057)			
p_{yh}	.2277	.2177	.2500		.2390	.2211	.009	2016.5
	(.0171)	(.0110)	(.0120)		(.0068)			
p_{yf}	.2107	.2059	.2446		.2211	.2211	.985	30222.6
	(.0181)	(.0102)	(.0037)		(.0024)			
s_h	−.0927	−.0895	−.0070		−.1409	0	.000	29.6
	(.0676)	(.0804)	(.1129)		(.0345)			
s_f	−.2724	−.1578	−.0425		−.1174	0	.000	887.3
	(.0467)	(.0154)	(.0539)		(.0108)			

Note: X, Y, Y_h, Y_f denote sales in sectors X and Y; K denotes employed capital; L, L_h, L_f are employed units of labor; r is the relative price of capital, w, w_h, w_l are the relative wages; p_x is the relative price of X; p_y, p_{yh}, p_{yf} are the relative prices of Y; s, s_h, s_f are budget surpluses relative to gross national income; the subscripts h and f in the international economy denote the home and the foreign country, respectively. Standard errors in parentheses, corrected for session specific heteroskedasticity and AR(1).

Result 3 Constant tax regime

For the closed economy weak convergence towards the theoretical predictions occurs for three of the nine variables. For the international economy weak convergence is found for eight out of 14 variables.

SUPPORT. Follows from simple inspection of Table 4, using the above definition of weak convergence. In the closed economy the quantities of X and L as well as the wage rate w are weakly converging. In the international economy this is the case for the quantities of Y_f, K, L_h, and L_f, the relative prices r, w_h, and p_{yf}, as well as the budget surplus in the foreign country, s_f.

Note, that despite its higher complexity the international economy performs better than the closed economy, relative to the theoretical benchmark predictions. We attribute that to the higher experience level of subjects in the international economy. The following observation, that we will elaborate on in section 3.3, concerns the direction of the deviation of the asymptotic values from the theoretically predicted values.

Observation 1 Constant tax regime

For all input as well as output variables it holds that the asymptotic value is smaller than the predicted value. Except for r and in the closed economy and w_h in the international economy, this also holds for the input prices. For the output prices, on the other hand, the reverse holds, with only one exception (p_y).

Relatively good news for the theoretical benchmark model is obtained by looking at the total welfare (earnings) of consumers in the experiments in comparison with the predicted level, denoted as 'system efficiency'.[22] We focus again on the periods with constant tax rates.

Result 4 Constant tax regime

In both the closed economy and the international economy system efficiency is on average around 95%, and for (almost) all periods above 90%.

[22]The purpose of this measure, which is standard in market experiments,is not to come to unequivocal conclusions about welfare, but to get an indication of the performance of the theoretical benchmark model.

SUPPORT. See Table 5. The table reports 'system efficiency' for all sessions and all periods as well as the averages across the constant tax periods, the dynamic tax periods, and all periods.

3.2 Unemployment, taxation, and budget deficits: the vicious circle

The above results concerning weak convergence and system efficiency throw a not too negative light on the theoretical benchmark model, at least in a qualitative sense. The next result, which focuses more specifically on the development of the unemployment rate under the constant tax regime, corroborates this picture.

Result 5 Constant tax regime
In the closed and the open economies the unemployment rate converges at least weakly towards the theoretical prediction from above.

SUPPORT. As in Table 3 the unemployment rate is defined as the ratio of non-employed units of labor and the total number of labor units available in the economy. The result then follows straightforwardly from data on employment (L; L_h, L_f) in Table 4 (Result 3) and Observation 1. Figure 5 illustrates the development of the unemployment rate, averaged over the experimental sessions. Here, we focus on the periods with a constant tax rate (i.e., the first seven for the closed economy, and the first eight for the international economy).

There is, however, a downside to these weak convergence results, in general, and the development of the unemployment rates, in particular. As indicated in the following result, all economies appear to generate persistent budget deficits.

Result 6 Constant tax regime
The closed and both open economies show convergence towards a budget deficit. Moreover, in all sessions, except for one concerning the closed economy, the budget deficits also occur in early periods.

SUPPORT. Table 4 shows that in the closed and the open economies the asymptotic value of the relative budget surplus (nominal budget surplus as a fraction of national income) is negative and significantly different from zero (see the variables s, s_h, and

Table 5: System efficiency: Sum of consumers welfare relative to theoretical prediction (in percent)

	Closed economy				International economy								
	CE01	CE02	CE03	CE04	OE01			OE02			OE03		
Period					Home	Foreign	Total	Home	Foreign	Total	Home	Foreign	Total
1	97.0	92.2	90.0	94.7	61.3	93.6	83.0	94.5	95.2	95.0	97.7	98.7	98.4
2	98.4	88.0	91.8	92.6	106.3	91.2	96.1	96.4	96.9	96.7	101.0	96.6	98.0
3	99.0	92.0	92.4	97.1	89.8	95.7	93.8	61.9	95.1	84.3	97.6	98.0	97.9
4	99.4	92.4	95.1	99.2	88.7	95.1	93.0	96.9	96.9	96.9	93.8	98.9	97.2
5	97.6	92.5	94.9	97.7	98.8	93.9	95.5	93.8	97.5	96.3	101.3	99.0	99.8
6	96.7	91.2	95.3	99.6	95.5	96.0	95.8	95.2	97.5	96.8	92.9	98.9	96.9
7	96.7	91.9	93.6	95.2	98.9	93.5	95.3	61.6	98.3	86.3	94.9	98.7	97.4
8	96.8	92.8	95.4	92.8	94.2	96.8	96.0	95.8	96.9	96.5	100.2	98.6	99.1
9	94.5	91.3	95.7	93.5	82.2	91.3	88.3	83.9	95.1	91.4	65.5	98.6	87.8
10	80.2	92.4	94.9	88.3	78.2	90.6	86.6	86.2	94.5	91.8	92.9	98.2	96.5
11	96.6	88.9	95.3	93.3	83.0	94.0	90.4	89.2	90.0	89.7	98.2	98.9	98.7
12	95.6	89.5	94.4	92.0	82.4	93.7	90.0	77.4	87.9	84.4	101.4	98.7	99.6
13	96.6		94.1	93.3	77.6	93.8	88.5	87.6	94.0	91.9	101.3	98.3	99.3
14	97.3			92.1	84.3	94.8	91.3	87.9	93.0	91.4	97.4	98.6	98.2
15					88.9	94.9	93.0	93.0	93.8	93.6	97.7	98.4	98.1
16					83.8	95.0	91.4	70.6	89.5	83.3	96.7	97.3	97.1
Averages across:													
Constant tax periods	97.8	91.4	93.4	96.6	91.7	94.5	93.6	87.0	96.8	93.6	97.4	98.4	98.1
Variable tax periods	93.9	91.0	95.0	92.2	82.5	93.5	89.9	84.5	92.2	89.7	93.9	98.4	96.9
All periods	95.9	91.3	94.1	94.4	87.1	94.0	91.8	85.7	94.5	91.6	95.7	98.4	97.5

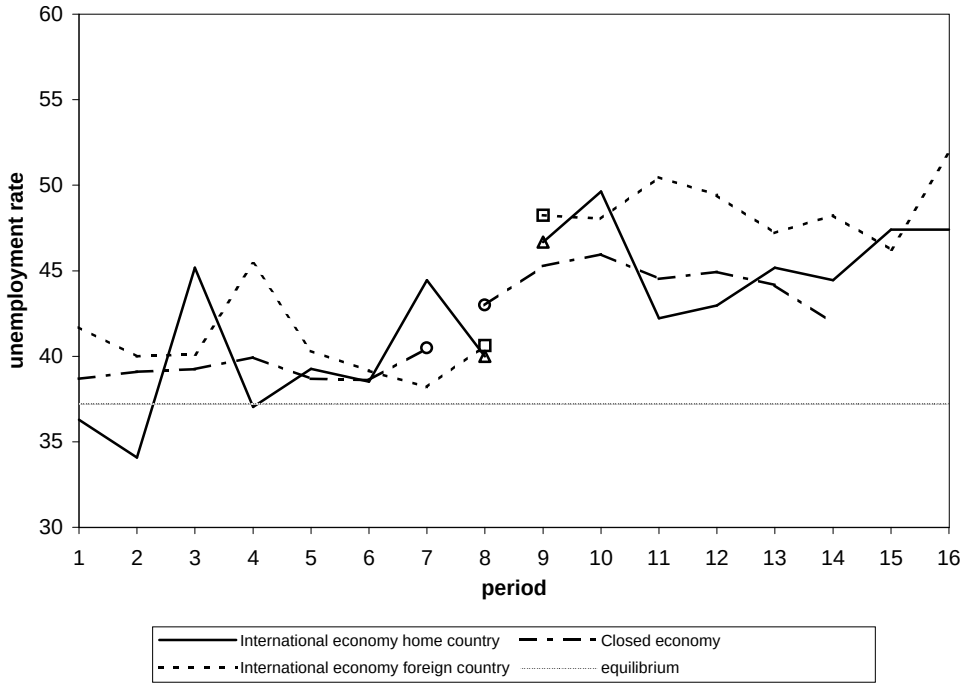


Figure 5: Unemployment rates (percentage of potential labor force)

s_f). In addition, in the closed economy all but one starting values are negative, and in the international economy both open economies start with a budget deficit in all three sessions. Figure 6 illustrates the time series for the relative budget surplus for the closed economy and the home as well as foreign country of the international economy, averaged over the experimental sessions. The series clearly show a persistent budget deficit for the periods with a constant tax rate.

Results 5 and 6 suggest that the observed relatively low unemployment rates are at least partly due to the accompanying 'deficit spending'. Up to now, we restricted our analysis to the periods with a constant wage tax. In view of the observed deficits it is a natural next step to ask how the economies will perform under some fiscal discipline, by having tax rates adjust towards a balanced budget.

Variable tax regime. In this tax regime the wage tax rate adjusts to the budget deficit (or surplus) in the previous period, such that, ceteris paribus, the budget would have been balanced. In the closed economy this happens as of period eight and in the international economy as of period nine. It turns out that the introduction of this tax adjustment process changes the picture rather dramatically, as the next result shows.

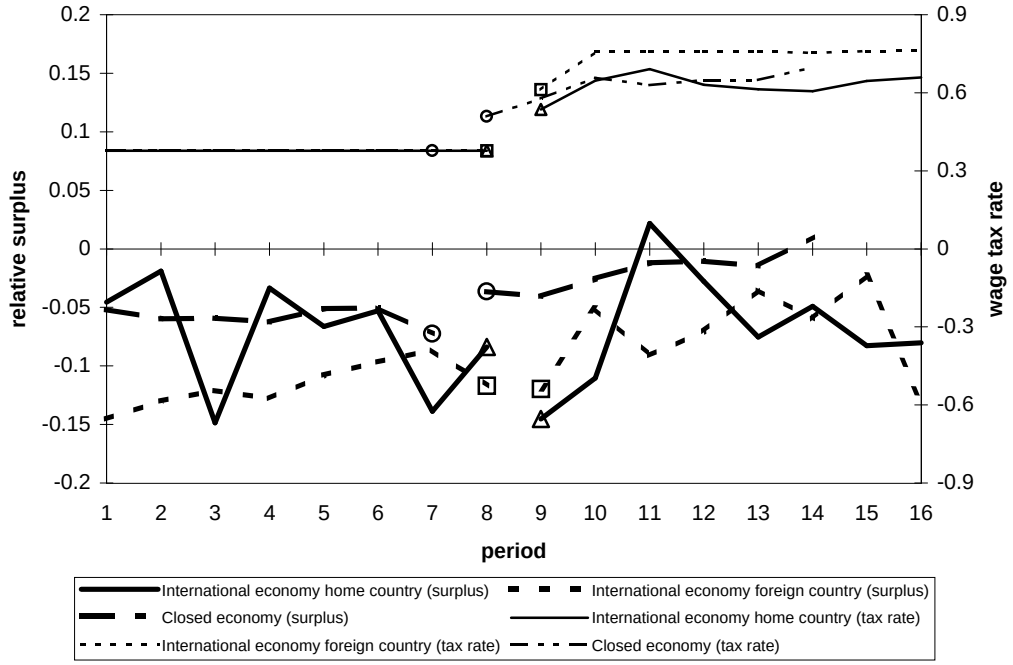


Figure 6: Budget surplus (as a fraction of national income) and wage tax rates

Result 7 Variable tax regime

Once the tax rate starts to adjust to the budget deficit, in all economies the deficit becomes smaller, while the tax rate as well as the unemployment rate increases to a level substantially higher than predicted by the theoretical benchmark model.

SUPPORT. See Figures 5 and 6. Recall that the theoretically predicted tax rate is at the constant level of the initial periods shown in figure 6. Furthermore, the predicted unemployment rate is at 37.2 percent (see the straight horizontal line in figure 5), while the deficit should be zero.

Note from Figure 3 that not only the employment of labor but all levels of inputs and outputs are adversely affected by the tax adjustment, in both the closed and international economy. The same holds for our measure of system efficiency, as shown in Table 5. To give an impression of the effects in quantitative terms we focus on two economic measures: the unemployment rate and real GNP.[23] We compare for these

[23]For convenience, we measure the unemployment rate as deviation from the general equilibrium rate. One might call it therefore 'disequilibrium unemployment'. In view of the discussion in Rogerson (1997) concerning the usefulness of these kind of labels for the phenomenon of unemployed labor units, we believe that one should use it with the necessary restraint. Additionally, here the term equilibrium

measures the asymptotic outcomes of a convergence analysis (as used for Result 2) applied to the constant and variable tax regime.[24] This analysis shows that the unemployment rate increases from 3.2 to 11.3 percent in the closed economy, from 5.5 to 10.3 percent in the home country and from 3.4 to 15.0 percent in the foreign country of the international economy.[25] Real GNP decreases by 5.8 percent in the closed economy, by 5.4 percent in the home country and by 18.0 percent in the foreign country of the international economy.

Figure 3 shows that, in contrast with the employment of labor, the use of capital recovers in the later periods, in both the closed and international economy. Figure 4 shows that the latter is facilitated by a decrease in the price of capital. Although the before-tax wage rate also decreases, the increase of the tax rate negatively affects the wage costs. Note that, due to the balancing of the budget in the variable tax regime, any decrease in the before-tax wage rate is counteracted by an increase in the tax rate, even if the employment of labor stays constant.

In order to investigate the role played by the wage tax more deeply, we will first look at the impact of the unemployment rate in a period on the tax rate in the subsequent period. Note in this context that the tax adjustment rule does *not* necessarily imply a positive correlation between the next period's tax rate and the previous period's unemployment rate, since the previous period's wage rate also plays a role. Note furthermore, that in each period the economic environment is exactly the same except that the tax rate adjusts to the budget surplus in the *previous* period such that the budget would be balanced if everything else stayed the same.

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refers to the benchmark model that is based on a particular set of behavioral assumptions, which are not necessarily satisfied. We therefore, refrain from using the term 'disequilibrium unemployment' in the main text. For the calculation of real GNP we use the first trading period as base 'year'; that is, the respective trading period 1 prices (p_x^1 and p_y^1) are used as weights for the produced quantities of X^t and Y^t in period t. Hence, real GNP in period t is given by $(p_x^t X^t + p_y^t Y^t)/(p_x^1 + p_y^1)$. Similar results are obtained with other periods as base year.

[24] The regression model for the variable tax regime is the same as for the constant tax regime except that the trading periods for the former case are redefined such that trading period 9 becomes period 1 in the regression.

[25] For the variable tax regime these asymptotic values of the unemployment rate are also significantly larger than the predicted value. The F-test produces (two-sided) p-values smaller than 0.001 for all three economies.

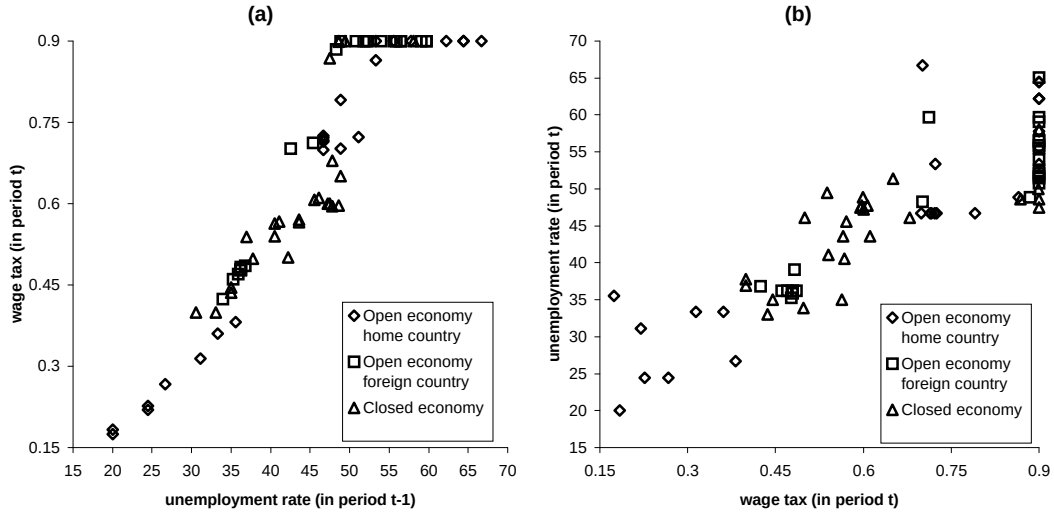

Figure 7: The vicious circle between unemployment and wage tax rates

Result 8 Variable tax regime

The tax rate is significantly positively related to the unemployment rate of the previous period.

SUPPORT. Figure 7(a) clearly shows a positive dependence of the tax rate on the previous period unemployment rate (up to the imposed maximum rate of 0.9, which is sometimes obtained as the upper part of the figure shows). The Spearman rank order correlation coefficients are high for both the closed economy (0.93) and the home (0.96) as well as foreign country (0.92) of the international economy, and highly significant ($p < 0.001$ in all cases). This positive correlation is corroborated by Tobit regressions (with robust standard errors) with the tax rate in period t ($\tau_w(t)$) being the independent variable and the unemployment rate in period $t-1$ ($u(t-1)$) as the explanatory variable. For all economies (closed economy, and the home and foreign country of the international economy) the coefficient of $u(t-1)$ is positive and highly significant ($p < 0.001$ in all cases).

The next result concerns the relationship between the unemployment rate in a period and the tax rate that holds for that period.

Result 9 Variable tax regime

The unemployment rate in its turn is significantly positively related to the tax rate.

SUPPORT. Figure 7(b) illustrates. The Spearman rank order correlation coefficient clearly shows a positive relationship for both the closed economy (0.67) and the home (0.80) as well as foreign country (0.80) of the international economy, and is highly significant ($p < 0.001$). Qualitatively the same results are found by running Tobit regressions (with robust standard errors) with unemployment in period t ($u(t)$) as independent and the tax rate in period t ($\tau_w(t)$) as explanatory variable. In all cases (closed economy, and the home and foreign country of the international economy) the coefficient of $\tau_w(t)$ is positive and highly significant ($p < 0.001$). Note, that this is a controlled observation, since the tax rate (which is the only parameter that changes over periods) is given at the beginning of a period.

Together, Results 7 to 9 clearly point at the existence of a vicious circle (Snower's cycle), as discussed in the Introduction. In the experimental economies, the budget deficit developed under a constant tax rate triggers a dynamic adjustment process with increasing tax rates and unemployment rates that only gradually appears to stabilize at substantially higher rates for these variables (cf. Result 7). These results are found for both the closed and the international economy, and in the latter case for both the home and the foreign country. The next result makes this outcome explicit.

Corollary 1 *The experimental results provide evidence for a vicious circle in the dynamic interaction between wage taxation and unemployment.*

Finally, it is noticed that the positive relationship between the unemployment rate and the wage tax rate is consistent with the conclusion that budget deficits have a beneficial (short-run) impact on unemployment, as witnessed by the periods with a constant tax rate.

3.3 A behavioral explanation of the unemployment rate

The relatively bad performance of the economies in terms of employment (and other performance measures, like real GNP) clearly asks for an explanation. In particular, the role played by the wage tax is of interest in this respect. Given the complexity of the examined market systems we clearly cannot provide a definitive answer to this issue, at this stage. The experimental method, however, gives us the possibility to

Table 6: Fraction of producers where marginal revenue product of a production factor exceeds the (after tax) input price

	Closed economy	International economy		
		Home country	Foreign country	Both countries
Labor	0.52	0.54	0.62	0.58
	(0.20)	(0.14)	(0.00)	(0.00)
Capital	0.69	0.72	0.70	0.72
	(0.00)	(0.00)	(0.00)	(0.00)

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.

examine individual behavior more closely. We believe that the following evidence and discussion at least reveals an under-exposed determinant of unemployment and provides an interesting and important angle for further research.

Our starting point is Observation 1 indicating that during the constant tax periods inputs and consequently outputs are below the theoretically predicted levels and tend to be accompanied by lower than predicted input prices and higher than predicted output prices. It seems that in the economies there is a downward pressure on the employment of production factors, labor as well as capital. To obtain a further piece of evidence in this respect, we examined the average per period percentage of producers for which the marginal revenue product of labor and capital exceeded the respective input price, using the average current period input and output prices.[26] Accounting for errors, a percentage of 50% would be in line with (risk-neutral) profit maximizing behavior. The following is observed, however.

Observation 2 *For the closed economy and the home as well as foreign country of the international economy it holds that, on average, for about* 70 *percent of the producers the marginal revenue product of capital exceeds the input price. For labor this fraction is smaller, though with approximately* 55 *percent still above the fifty percent level. This*

[26]Similar results are obtained if the average previous period product price is taken for the expected output price.

is related to the fact that for labor this fraction shows a temporary drop when the wage tax rate (which is part of the input price) starts to adjust to the budget deficit, pointing at some inertia in the behavioral adjustment process.

SUPPORT. See Table 6, which shows the fraction of cases in which producers employed factors such that the marginal revenue product of the factor exceeded the after tax input price. It shows that in all economies and for both production factors this fraction is above 50%. In all but two cases this difference is also statistically significant. Interestingly, the results are even somewhat stronger for the open economies where subjects (having participated in the closed economy before) were more experienced. As regards the effect of the tax rate on this fraction, in particular with respect to labor input, the following is observed. In the closed economy, for example, the fraction concerning labor temporarily drops from an average of 54 (61) percent over the last three (all) periods of the constant tax regime to 38 percent in the first two periods of the variable tax regime, in which the tax rate substantially increases. It gradually increases again thereafter. This explains why - on average - the fraction is smaller for labor than for capital. Figure 8 illustrates this for the inputs of X-producers in the closed economy (where t ($t-1$) indicates that the current (previous) period product price is taken for the expected output price).

Together with Observation 1 this observation supports the view that producers' reluctance to buy inputs is key for explaining the high unemployment rate. It is important to note that it is not a lack of labor supply that can account for the higher than predicted unemployment level. Using the theoretical labor supply function - for each consumer and trading period - it turns out that a great majority of the consumers actually supplied too much labor at current period prices.[27]

[27]For the closed as well as the small and large country of the international economy, this happens (averaged over consumers and periods) in at least 80 percent of the cases, for both the constant and the variable tax regime. These results are significantly different from 50 percent, using a binomial test ($p < 0.001$, one-sided). We can think of two factors that may have biased consumer behavior in this direction. First, the relatively small weight (1/9) attached to leisure in the utility function may have played a role here (see Table 1). Second, the fact that the labor supply function is steep at the low wage rates (close to the minimum level of the unemployment benefit) that subjects were confronted with may have led to 'overshooting' due to errors.

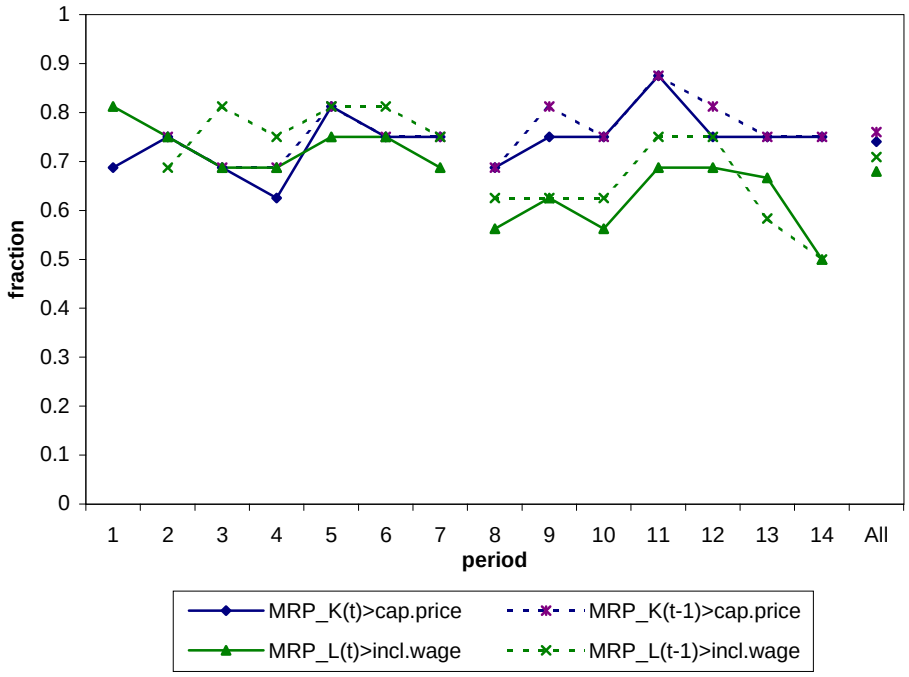

Figure 8: Fraction of producers where marginal revenue product of a production factor is larger than the (after tax) input price (X-producers in closed economy)

In our view a key factor in the explanation of the downward pressure on input demand seems to be that in a real economy - like in the lab - producers are facing a risk when buying inputs, which is not accounted for in a general equilibrium model. This risk is due to uncertainty about the prices and thus revenues that the goods produced with the inputs will make in the output markets. The fact that producers are facing this risk, in combination with risk or ambiguity aversion, can explain the reluctance of producers to employ 'enough' labor and capital, as well as the observed downward pressure on input prices and upward pressure on output prices (see Observation 1). Interestingly, a similar *risk-compensated price mechanism* has been observed by Noussair et al. (1995) in their experimental investigation of patterns of international trade.[28] It is important to note that in their study simultaneous input and output markets are used. This suggests that the mechanism is also at work when the sequentiality between input and output markets is minimized.[29] Furthermore, some theoretical (albeit par-

[28]Noussair et al. speak of a 'risk-compensated input/output price-adjustment process'.

[29]Hey and di Cagno (1998), investigating experimentally two sequential double auction markets, also report as a general finding that not enough trade took place compared with the competitive equilibrium predictions.

tial equilibrium) studies exist showing that price uncertainty will indeed reduce factor demand by a risk-averse competitive firm (see Batra and Ullah (1974), Hartman (1975, 1976), Holthausen (1976)). In this context it is noted that risk-averse behavior seems to be a realistic assumption. However, so far field empirical studies addressing the consequences for input demand appear to be lacking.[30]

Although further empirical as well as theoretical research is needed to establish the precise power of the explanation offered above, it points at an important and under-exposed determinant of unemployment. Moreover, it has an important bearing on the debate concerning the pernicious character of wage taxation (and, more generally, the taxation of inputs). If producers are indeed reluctant to buy inputs due to uncertainty about output prices, having to pay taxes up-front would seem to exacerbate the negative effects on employment.[31] From this perspective, shifting taxation from labor to production or sales - which effectively makes the government share the risk faced by the producer - would be an alternative worth investigating.

4 Concluding discussion

For the closed as well as the small and the large country of the international economy, we have found evidence for negative economic effects of wage taxation as a means of financing unemployment benefits. Our results provide empirical support for a vicious circle in the dynamic interaction between the wage tax and the unemployment rate. Furthermore, it turned out that employment is boosted (in the short run) by allowing budget deficits. Keeping the tax rate constant at the level predicted by the competitive equilibrium model, convergence towards the competitive equilibrium is observed for

[30]For an empirical study showing risk-aversion by firms, see Gunjal and Legault (1995). 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". Furthermore, a study by Brockhaus (1982) suggests that there is no difference in this respect between producers ('entrepreneurs' and managers) and the population at large. See also Ghosal (1995). A somewhat related area of research focuses on the effect of macro-economic uncertainty on private investment. Also here few empirical studies exist, typically showing a negative effect (of inflation, for instance; see Aizenman and Marion (1993), Brunetti and Weder (1998)).

[31]Loss aversion, as in prospect theory (Kahneman and Tversky (1979)), would make this negative effect only stronger.

many variables. However, this development is accompanied by economically significant budget deficits. Once the wage tax is forced to adjust in the direction of a budget balance the employment level, as well as real GDP and other indicators of economic performance, gradually tend to stabilize at a level that substantially falls short of the equilibrium prediction.

An important observation in this context is that there appears to be downward pressure on the employment of production factors, which is not accounted for in existing general equilibrium models. The uncertainty risk or ambiguity averse producers are facing when buying inputs before precisely knowing what they will make for their outputs can explain this phenomenon. Because of the uncertainty producers restrict the purchase of inputs, which restricts outputs. Consequently, there is a tendency for input prices to be lower, and for output prices to be higher than the equilibrium predictions. It is consistent with this so-called risk-compensated price mechanism that a wage tax exacerbates these effects.

Our findings suggest that policymakers relying on the outcomes of (theoretical) models neglecting this mechanism would underestimate the negative effects of wage taxation. According to the European Commission (1994), plans for an alternative, employment friendlier fiscal structure deserve greater attention and serious study. Our study suggests that shifting taxation from labor, and more generally any kind of inputs, to outputs is worthwhile to be investigated. Another interesting issue for future research would be to investigate the effects of adjusting the unemployment benefit instead of the wage tax to balance the budget (cf. Rochetau (1999)).

From a theoretical perspective, our experimental study suggests that a better understanding of the determinants of unemployment can be obtained by allowing for output price uncertainty and risk or ambiguity aversion in economic models. In this respect, this paper provides support for some existing partial equilibrium models bearing this out. By neglecting these issues, present general equilibrium models seem to foster a too rosy view of the economic effects of wage taxation.

From a broader methodological point of view, the technology developed for running macro-economic experiments opens up the possibility to study many other important issues in the lab, like public debt or the impact of labor market institutions, for example.

In light of the findings obtained so far, macro-economic experiments seem to offer an interesting and challenging research tool which complements the more traditional theoretical and field empirical analysis.

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