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The welfare cost of imperfect competition and distortionary taxation*

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Abstract

The welfare cost of imperfect competition in the product and labor market as well as distortionary taxation is quantified in a dynamic general equilibrium model parameterized to fit the U.S. economy. We find that the welfare cost of imperfect competition in the product market is 35.74 percent while it is 0.66 percent in the labor market, taking the transition from the distorted to the optimal steady state into account. If we also take into account that the U.S. economy is characterized by distortionary taxation the welfare cost in the product market increases to 48.26 percent and 4.70 percent in the labor market.

Keywords: Monopolistic competition, distortionary taxation, welfare.

JEL classification: L1, H20, D40.

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1 Introduction

Product and labor markets are in general characterized by imperfect competition. This implies that the economic welfare is lower than what it could have been if markets where fully competitive. Many macroeconomic policies therefore aim to enhance competition. Examples of such policies are the recent deregulation of network industries in many countries and the European Commission's initiative to promote a single market where monopolies and price agreements are outlawed.

Modern economies are also characterized by distortionary taxation. Theory tells us that we should expect interaction between distortions; that is, the cost of one distortion depends on the level of another. An important policy issue is then to understand how large the interaction between imperfect competition and distortionary taxation is quantitatively.

This paper focuses on three related issues: how large is the welfare cost of imperfect competition in the product and labor markets? How is the product and labor market distortions affected by distortionary taxation? And finally, how does imperfect competition affect the welfare cost of distortionary taxation? We answer these questions by parameterizing a dynamic general equilibrium model to fit the stylized facts of the U.S. economy. The welfare cost is calculated using comparative steady state and dynamic analyses. In the latter case, the transition from the distorted to the optimal steady state is taken into account.

The economic environment features monopolistic competition in product and labor markets. In the product market each firm has monopoly power over its differentiated product and sets the price as a markup over the marginal cost. The firms act as price takers in the labor and capital markets. The households have a degree of monopoly power over their own labor services. They can be thought of as organizing themselves in so called "craft" unions and acting as wage-setters in the labor market. To this end they set the wage rate as a markup over the marginal rate of substitution between leisure and consumption. In the product and capital markets they act as price takers. The government fulfills its budget constraint period by period and finances an exogenous stream of government purchases by imposing distortive flat-rate taxes. Taxes are levied on earnings from capital and labor. The government also receive income from a consumption tax and seigniorage from the monetary authority. Money is introduced through a cash-in-advance constraint which is a simple way to model the fact that money facilitates transactions.

In our benchmark case we use the same estimates of the price and wage markups as in Bayoumi, Laxton and Pesenti (2004); that is, the price markup is 23 percent and the wage markup 16 percent. The model then implies that the welfare cost of imperfect competition in the product market is 38.19 percent. Put differently, the average household would require a permanent 38.19 percent higher consumption level in order to be as well off under the current level of competition in the product market as under perfect competition. In the labor market we find this number to be 1.22 percent. There are thus huge differences in the welfare cost of imperfect competition in the product compared to the labor market. The main reason for this is the different effects on the labor supply. The price markup does not affect the labor-leisure choice while the wage markup distorts this choice by increasing leisure. Since households derive utility from leisure the wage markup is less costly in terms of welfare. Another, but less important, reason is that the distortion is larger in the product market than in the labor market; that is, 23 percent versus 16 percent. The model's prediction is therefore that policies that enhance product market competition are the ones that are most likely to be efficient.

We find that the interaction between imperfect competition and distortionary taxation is quantitatively important for welfare. If the distortive taxes; that is, the labor income tax, the capital income tax, the consumption tax and the inflation tax, are included in the model the welfare cost of the price markup increases from 38.19 percent to 50.71 percent. For the labor market, the welfare cost increases from 1.22 percent to 5.27 percent.

We also find that the welfare cost of taxation depends on the level of competition. Jonsson and Klein (2003) quantify the welfare cost of distortionary taxation in a perfect competition framework. Their analysis is extended here by considering imperfect competition. The welfare cost of distortionary taxation is 12.34 percent under perfect competition while it increases to 16.73 percent under the current level of competition. This suggests that in order to get good estimates of the welfare cost of distortionary taxation it is necessary to take the degree of competition in the economy into account.

The welfare cost decreases if we take the transition from the distorted to the optimal steady state into account. For the price markup the welfare cost decreases from 50.71 percent to 48.26 percent and for the wage markup from 5.27 percent to 4.70 percent. For taxes, the cost decreases from 16.73 percent to 12.79 percent.

A well known result in the optimal taxation literature is that capital income should not be taxed in steady state, see Judd (1985) and Chamley (1986). Also, papers that have quantified the welfare cost of distortionary taxation have found the capital tax to be the most distortive, see Jonsson and Klein (2003), Judd (1987) and McGrattan (1994). A recent paper by Guo and Lansing (1999) shows that with imperfectly competitive product markets the optimal capital tax can be positive, though. Our results show that the capital income tax is the most distortive tax under perfect competition. However, with imperfect competition in the product and labor market the labor income tax is more distortive than the capital tax. If we take the transition to the optimal steady state into account the welfare cost of the capital tax is only 2.09 percent compared to 5.01 percent for the labor tax.

Estimating the welfare cost from imperfect competition has a long tradition in economics.

Furthermore, these estimates have tended to vary quite significantly. At one extreme, Harberger (1954) estimated the welfare cost of monopoly power to be 0.1 percent of GNP for the U.S. economy. At the other extreme, Cowling and Mueller (1978) found a welfare cost of the order of 10 percent of GNP. These early studies were conducted in a partial equilibrium framework and may therefore not have captured all aspects of the welfare consequences. More recent studies have incorporated imperfect competition in a general equilibrium framework. Bayoumi, Laxton and Pesenti (2004) quantify the benefits for the euro area of raising competition. Increasing competition in the euro area to the U.S. level increases output by 12.4 percent in their study. This paper differs from their analysis in a number of respects. For example, we take the transition and distortionary taxation into account. Blanchard and Giavazzi (2002) construct a general equilibrium model to study the effects of product and labor market deregulation although they do not quantify the welfare cost. Galí, Gertler and Lópes-Salido (2002) quantify the welfare cost of fluctuations in the markups and find that the cost may be significant. Ebell and Haefke (2003) examine the relationship between product market deregulation and the labor market in Europe and the U.S. Their quantitative analysis suggests that differences in entry barriers in Europe and the U.S. have only a small effect on the difference in employment rates.

The paper is organized as follows. In section 2 we present the economic environment. Section 3 parameterizes the model to broadly fit the stylized facts of the U.S. economy. Section 4 reports the results from the welfare calculations. Finally, section 5 concludes.

2 The economic environment

The model economy consists of three types of private agents; retailers, households and firms as well as a government. Households supply differentiated labor services and firms produce differentiated intermediate products, facing the demand by the retailers. To make the model comparable to the standard perfectly competitive framework we assume that firms demand a composite labor service and households demand a composite product. The retailers then aggregate the differentiated labor services into a composite labor service and the differentiated intermediate products into a composite product. This market structure; that is, monopolistic competition, was introduced to macroeconomics by Blanchard and Kioytaki (1987) and Hornstein (1993).

2.1 Retailers

There are two types of perfectly competitive retailers. There is free entry into these markets, and thus, profits will be zero. The first type of retailers purchase labor inputs, h^i, from household i at nominal wage, W^i, in order to produce the composite labor, h. The retailers' maximization problem is given by

$$\max_{h^i} \left[W_t h_t - \int_0^1 W_t^i h_t^i di \right]. \tag{1}$$

where t denotes time, W the nominal wage of the composite labor services. The differentiated labor services are aggregated according to a CES production function given by

$$h_t = \left(\int_0^1 \left(h_t^i\right)^{\frac{\eta_w - 1}{\eta_w}} di \right)^{\frac{\eta_w}{\eta_w - 1}}, \tag{2}$$

where $\eta_w > 1$ is the elasticity of substitution between the different inputs. The first order condition yields the demand for labor services of household i

$$h_t^i = \left(\frac{W_t}{W_t^i} \right)^{\eta_w} h_t. \tag{3}$$

The retailers sell the composite labor to firms at a nominal wage, W, given by

$$W_t = \left(\int_0^1 \left(W_t^i\right)^{\frac{\eta_w}{\eta_w - 1}} di \right)^{\frac{\eta_w - 1}{\eta_w}}. \tag{4}$$

The second type of retailers produce an aggregated final product from intermediate inputs. The final product is used for consumption and investments by the households. Formally, the retailers' maximization problem is

$$\max_{y^j}\left[P_t y_t - \int_0^1 P_t^j y_t^j dj\right], \tag{5}$$

where y denotes the quantity of the final product, P the price of the final product, y^j the input of intermediate product j, with $j \in [0,1]$, and P^j the price of intermediate input j. The final product is produced according to a CES production function given by

$$y_t = \left(\int_0^1 \left(y_t^j\right)^{\frac{\eta_p-1}{\eta_p}} dj\right)^{\frac{\eta_p}{\eta_p-1}}, \tag{6}$$

where $\eta_p > 1$ denotes the elasticity of substitution between intermediate products. The first order condition for profit maximization yields the following demand function for input j

$$y_t^j = \left(\frac{P_t}{P_t^j}\right)^{\eta_p} y_t; \tag{7}$$

that is, the price elasticity of the demand function is given by η_p. The composite product is sold to households at price, P, given by

$$P_t = \left(\int_0^1 \left(P_t^j\right)^{\frac{\eta_p}{\eta_p-1}} dj\right)^{\frac{\eta_p-1}{\eta_p}}. \tag{8}$$

2.2 Households

The economy is inhabited by a continuum of households distributed on the unit interval, $i \in [0,1]$. Households are identical, except for the differentiated labor service they supply. Each household, i, has preferences, $\mathcal{U}$, over consumption, c and leisure, ℓ, according to

$$\mathcal{U}^i = \mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t U\left(c_t^i, \ell_t^i\right)\right], \tag{9}$$

where E denotes the unconditional expectation operator, $U(\cdot)$ the utility function, and $\beta \in (0,1)$ the subjective discount factor. The utility function is parameterized as log-utility

$$U\left(c_t^i, \ell_t^i\right) = \alpha \ln c_t^i + (1-\alpha) \ln \ell_t^i, \tag{10}$$

where α denotes the weight on consumption relative to leisure.

The intertemporal budget constraint of household i, in nominal terms, is given by

$$(1+\tau^c) P_t c_t^i + P_t i_t^i + m_{t+1}^i = \left(1-\tau^k\right) R_t^k k_t^i + \tau^k \delta k_t^i + \left(1-\tau^h\right) W_t^i h_t^i + m_t^i + T_t^i + \Pi_t^j, \quad (11)$$

where τ^c denotes the consumption tax, τ^h the labor income tax, τ^k the capital income tax, δ the depreciation rate, which is modelled as tax deductible, k the physical capital stock, i investment expenditure (abusing notation somewhat), R^k the nominal rental rate of capital, P the general price level; that is, the money price of products, m the money stock, Π^j profits from firms producing intermediate inputs, and, finally, T denotes the transfers from the government including the seigniorage. Throughout the paper capital letters denote aggregated per capita variables and lower-case letters individual decision variables. For prices; that is, R^k, W, P, capital letters denote nominal prices and lower-case letters denote real prices.[1]

The households time constraint is

$$\ell_t^i + h_t^i = 1, \quad (12)$$

that is, we normalize the households' time endowment to unity.

Money is introduced through a cash-in advance constraint

$$\omega (1+\tau^c) P_t c_t^i = m_t^i + M_t^s - M_{t-1}^s, \quad (13)$$

where ω denotes the fixed ratio of cash holdings to consumption expenditure and M^s aggregate money supply.

Finally, each household accumulates capital and rents it to the firms. The accumulation technology is

$$k_{t+1}^i = i_t^i + (1-\delta) k_t^i. \quad (14)$$

[1] We stick to the convention of letting Π denote profits and π the inflation rate though.

The first order conditions for the households can be summarized, in real terms, by the following three conditions

$$\left(1-\tau^h\right) w_t = \nu_w \frac{U'_{\ell_t^i}}{\frac{U'_{c_t^i}}{1+\tau^c} - \omega\lambda_t^i}, \tag{15}$$

$$\frac{U'_{c_t^i}}{1+\tau^c} - \omega\lambda_t^i = \beta \mathrm{E_t}\left[\left(\frac{U'_{c_{t+1}^i}}{1+\tau^c} - \omega\lambda_{t+1}^i\right)\left(1+\left(1-\tau^k\right)\left(r_{t+1}^k - \delta\right)\right)\right], \tag{16}$$

$$\frac{U'_{c_t^i}}{1+\tau^c} - \omega\lambda_t^i = \beta \mathrm{E_t}\left[\frac{1}{\pi_{t+1}}\left(\frac{U'_{c_{t+1}^i}}{1+\tau^c} + (1-\omega)\lambda_{t+1}^i\right)\right], \tag{17}$$

where $\mathrm{E_t}$ denotes the expectation operator conditional on information in period t, λ^i the marginal value of liquidity; that is, money and

$$\pi_{t+1} = \frac{P_{t+1}}{P_t}, \tag{18}$$

$$\nu_w = \frac{\eta_w}{\eta_w - 1}, \tag{19}$$

where ν_w denotes the wage markup. The first condition, (15), shows how the households set the wage rate as a markup over the marginal rate of substitution between leisure and consumption. Condition (16) is the standard Euler equation relating consumption growth to the net return on capital. The final condition (17) defines the optimal level of money holdings over time. Note that the wage markup, the labor income tax, the consumption tax and inflation distorts the marginal rate of substitution between leisure and consumption in the same way. The consumption tax and inflation also distort the optimal allocation of consumption over time together with the capital income tax.

2.3 Firms

Firms produce intermediate products. They act as monopolists and face the demand function y^j for product j. Each product is produced by a single firm. The firms take the wage rate, the rental rate of capital and the prices of the other firms as given when choosing prices, labor and capital to maximize profits. There is no entry or exit and potential profits are allocated to the households. It is convenient to solve the firms' maximization problem by first defining the cost function. Firm j has a cost function for a given level of output defined by

$$C(y_t^j; R_t^k, W_t) = \min_{h^j, k^j} \left[W_t h_t^j + R_t^k k_t^j \right], \tag{20}$$

subject to the increasing returns to scale production function

$$y_t^j = (k_t^j)^\theta ((1+\gamma)^t\, h_t^j)^{1-\theta} - \chi, \tag{21}$$

where γ denotes the real growth rate, χ a fixed cost independent of the scale of production and θ capital's share of output. The profit maximization problem can then be formulated in the following way

$$\max_{P_t^j} \left[P_t^j y_t^j - C(y_t^j; R_t^k, W_t) \right]. \tag{22}$$

The growth adjusted first order conditions and profits are given by

$$P_t^j = \nu_p MC_t^j, \tag{23}$$

$$\nu_p w_t = (1-\theta) \left(\frac{k_t^j}{h_t^j} \right)^\theta, \tag{24}$$

$$\nu_p r_t^k = \theta \left(\frac{h_t^j}{k_t^j} \right)^{1-\theta}, \tag{25}$$

$$\Pi_t^j = \left(1 - \frac{1}{\nu_p} \right) (k_t^j)^\theta (h_t^j)^{1-\theta} - \chi, \tag{26}$$

where MC^j denotes the marginal cost to firm j of producing an additional unit of output and

$$\nu_p = \frac{\eta_p}{\eta_p - 1}, \tag{27}$$

where ν_p denotes the price markup. These first order conditions say, among other things, that firms set their price as a markup over marginal cost. When solving for the equilibrium we assume a symmetric equilibrium where all firms produce at the same level, employ the same labor and capital, and charge the same relative price.

2.4 The government

The money supply is determined by the following law of motion

$$M_t^s = \mu_t M_{t-1}^s, \tag{28}$$

where μ denotes the growth rate of the money supply. The monetary authority (or government) follows a rule for the growth rate of the money supply. The rule is simply given by

$$\mu_t = \bar{\mu}, \tag{29}$$

where $\bar{\mu}$ denotes the steady state money growth rate.[2] There are thus no endogenous responses of monetary policy to the state of the economy according to this rule. However, this is of no loss of generality in the steady state analysis that we perform.

The government's budget constraint is given by

$$P_t T_t + P_t G_t = \tau^c P_t C_t + \tau^h w_t P_t H_t + \tau^k \left(r_t^k - \delta \right) P_t K_t + M_t^s - M_{t-1}^s. \tag{30}$$

The transfers are determined residually and hence endogenously. The other government policy variables, G, τ^c, τ^h and τ^k are exogenous.

2.5 Equilibrium

We assume a symmetric and competitive equilibrium in which behavior is identical across households and across firms. This allows us to treat the economy as comprising of a representative household and a representative firm. An equilibrium consists of prices and quantities, such that:

1. Taking prices as given, retailers maximize profits subject to their constraints and given government policy.

[2] A bar denotes a steady state value.

2. Each household chooses consumption, investment, leisure, labor, wages, capital and money holdings to maximize its expected lifetime utility subject to its constraints and given government policy.

3. Each firm chooses capital, labor and the price to maximize profits subject to its constraints and given government policy.

4. The monetary authority follows its money supply rule and the government satisfies its budget constraint.

5. In addition to aggregate consistency, the aggregate resource constraints hold and the capital, product, labor and money markets clear.

To have a stationary steady state the real variables are detrended by technological growth, γ, in the manner of Hansen and Prescott (1995). The nominal variables are detrended with nominal money balances; that is, we assume that the real money growth rate is stationary.

2.6 Measuring the welfare cost

To study the welfare consequences of imperfect competition and distortionary taxation we compute the percentage increase in consumption that a household would need to be as well off under the distorted allocation as under the non-distorted allocation. This number is denoted by Δ. Under the non-distorted allocation the economy is characterized by perfect competition in the product and labor markets, the cash-in-advance constraint is non-binding and the distortionary taxes are replaced by lump-sum taxes.[3] In the steady state analysis we solve for Δ in the equation

$$U\left(\bar{c}^{*},\bar{\ell}^{*}\right)=U\left(\bar{c}\left(1+\Delta\right),\bar{\ell}\right), \tag{31}$$

[3] The distortionary cost of inflation is zero when the money growth rate equals the discount factor β.

where c^* and ℓ^* denote consumption and leisure, respectively, in the non-distorted economy and c and ℓ consumption and leisure, respectively, under the policy in question.

In the cases when we take the transition into account we calculate Δ from the following equation

$$\mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t U\left(c_t^*, \ell_t^*\right)\right] = \mathrm{E}\left[\sum_{t=0}^{\infty} \beta^t U\left(c_t\left(1+\Delta\right), \ell_t\right)\right], \tag{32}$$

where c^* and ℓ^* denote, in this case, the transition from the distorted to the non-distorted steady state of consumption and leisure, respectively.

Taking the transition into account reduces the welfare cost of the distortions. Consumption reaches a new and higher level eventually but future consumption has a relatively low value because of discounting. The transition is particularly important in the case of a capital income tax. The reason for this is that a higher capital tax lowers the capital-output ratio. This implies that an initial *lowering* of consumption is necessary in order to build up the higher capital-output ratio. This initial sacrifice has a relatively high weight.

3 Parameterization

The model is parameterized to fit the stylized facts of the U.S. economy. We use estimates from the literature as well as our own estimates in order to choose values for the parameters. The data, 1960-2003, are from the Federal Reserve Bank of St. Louis Economic Data-Fred II. The length of a time period is assumed to be one year. To check the robustness of the results, sensitivity analysis is performed with respect to the parameter values.

The parameters β, θ, and δ are taken from Christiano, Eichenbaum and Evans (2004). The effective discount factor, β, is set to 0.97, which implies an annual real interest rate in steady state of 3 percent. The capital's share of output, θ, is set to 0.36 and the real depreciation rate,

δ, to 0.10.

The parameter α is set so that the average time an individual spends in employment is about 1/3 of total time. This is the average time people between 18-64 years spend in employment, see Juster and Stafford (1991). The price and wage markups are taken from Bayoumi, Laxton and Pesenti (2004); that is, the price markup is 23 percent and the wage markup 16 percent.[4] The effective tax rates are set as follows: $\tau^k = 0.43, \tau^h = 0.25$ and $\tau^c = 0.06$, as reported in Mendoza, Razin and Tesar (1994).

We set the ratio of cash holdings to consumption, ω, to match

$$\omega = \frac{\bar{M}}{(1+\tau^c)\,\bar{C}\,\bar{P}}. \tag{33}$$

To pin down the fixed cost we assume that profits are zero in steady state, in accordance with Hall (1988), which implies that

$$\chi = \left(1 - \frac{1}{\nu_p}\right) \bar{K}^{\theta} \bar{H}^{(1-\theta)}. \tag{34}$$

Finally, the average government consumption to GDP ratio is 0.23, the money growth rate (M2) 5.60 percent, and the real GDP growth rate 1.64 percent in the U.S. data 1960-2003. The parameter values are summarized in Table 1.

4 Quantitative analysis

4.1 Comparative steady state analysis

We measure the welfare cost of imperfect competition by comparing two cases: one is the equilibrium generated by the current level of competition, the other is the equilibrium generated by perfect competition. How the welfare cost of imperfect competition depends on the current level

[4] The wage and price markups used in Bayoumi, Laxton and Pesenti (2004) are based on work by Martins, Scarpetta and Pilat (1996) and Jean and Nicoletti (2002).

of taxation is also quantified. Finally, we quantify by how much the welfare cost of distortionary taxation is increased if the current level of imperfect competition is taken into account.

Under the assumption of no distortionary taxation the welfare cost of imperfect competition in the product market is 38.19 percent, see Table 2. This number tells us how much extra consumption, permanently, the average household would need to be as well off under the current level competition as under an allocation with perfect competition. For the labor market, on the other hand, the welfare cost is fairly low, 1.22 percent. There are thus huge differences in the welfare cost of imperfect competition in the product market compared to the labor market. This difference can be understood in the following way. The price markup does not distort the labor-leisure choice. A higher price markup lowers the wage rate but with Cobb-Douglas utility the substitution and income effects of a change in the wage rate exactly offset each other and leave hours worked unaffected. The wage markup, on the other hand, distorts the labor-leisure choice by decreasing labor and increasing leisure. Both distortions lead to lower output and consumption, though. Given that the households derive utility from leisure, the product market distortion is more harmful. In the case of the wage markup the lower consumption level is almost offset by the increase in leisure. The welfare cost of imperfect competition in both the product and labor markets is 39.88 percent.

Theory tells us that the cost of one distortion should depend on the level of another, see for example Jonsson and Klein (2003). If the distortive taxes are included in the model the welfare cost of imperfect competition is likely to increase. It also gives a more realistic estimate of the welfare cost since the economy is in fact characterized by distortionary taxation. To quantify this interaction effect we calculate the following number: how much extra consumption would the average household need to be as well off under the current level competition and current level of taxation as under an allocation with perfect competition and the current level of taxation. By taking the distortionary taxes into account the welfare cost of imperfect competition increases from 38.19 to 50.71 percent in the product market and from 1.22 to 5.27 percent in the labor market, see Table 2. The interaction between imperfect competition and distortionary taxation is thus quantitatively important.

How does imperfect competition affect the welfare cost of distortionary taxation? Table 3 shows the welfare cost of distortionary taxes under perfect competition and under the current level of competition in the product and labor markets. In previous studies on the welfare cost of taxation the analysis has been performed in models with perfect competition, see for example Chamley (1981), Jonsson and Klein (2003) and McGrattan (1994). We show that the welfare cost of taxes is underestimated if the degree of competition is not taken into account. The results suggest that under the current level of imperfect competition in the product and labor markets, the welfare cost of the consumption tax, labor income tax and the inflation tax approximately doubles. For example, the cost of the inflation tax increases from 0.39 percent to 0.99 percent. The cost of the capital income tax is increased to a lesser extent though. The cost increases from 3.80 percent to 4.33 percent. The welfare cost of all distortionary taxes is 12.34 percent under perfect competition but 16.73 percent under the current level of competition. The total welfare cost of both imperfect competition and taxation in the U.S. economy is a staggering 76.13 percent.

4.2 Dynamic analysis

How is the welfare cost affected if the transition between the two steady states is taken into account? This is the most realistic case to consider since the economy cannot simply jump between different steady states. Table 2 presents the welfare cost of imperfect competition when the transition is taken into account. First, consider the case with no taxes. The total cost of imperfect competition in the product and the labor market is decreased from 39.88 percent to 36.72 percent. This suggests that, in quantitative terms, taking the transition into account when calculating the welfare cost of imperfect competition is not that important. In an economy with distortionary taxation the transition is somewhat more important for welfare. The welfare cost decreases from 57.22 percent to 53.98 percent in this case. Taking the transition and the distortionary taxes into account the welfare cost of imperfect competition is 48.26 percent in the product market and 4.70 percent in the labor market.

The welfare cost of distortionary taxation when taking the transition into account is presented in Table 3. Under perfect competition the transition reduces the welfare cost of all distortionary taxes from 12.34 percent to 8.43 percent. A reduction of about 4 percentage points. Also under imperfect competition the reduction is about 4 percentage points; that is, it reduces from 16.73 percent to 12.79 percent. The main part of this reduction is due to the capital income tax. Shifting from a capital tax to a lump sum tax induce the households to lower their consumption initially in order to build up a new and higher capital stock. The other distortions; that is, the price and wage markups, the labor, consumption and inflation taxes do not induce an initial lowering of consumption. Instead, consumption increases smoothly to its new and higher level. Consequently, the effect of the transition is not as important for these distortions as for the capital tax.

The dynamic analysis confirms that it is important to include imperfect competition in order to calculate the welfare cost of taxation. The welfare cost of all taxes is 8.43 percent under perfect competition while it is 12.79 percent under imperfect competition when the transition is taken into account. The welfare cost of the current level of taxation and imperfect competition is 67.05 percent.

We find that the labor income tax is more distortive than the capital tax when the interaction of distortionary taxation and imperfect competition is taken into account. The welfare cost of the labor tax is 6.14 percent while it is 4.33 percent for the capital tax. If we take the transition into account the difference is even larger; that is, 5.01 percent versus 2.09. From the optimal taxation literature we know that capital income should not be taxed in steady state, see Judd (1985) and Chamley (1986). And further, papers that have quantified the welfare cost of distortionary taxation have found the capital tax to be the most distortive, see Jonsson and Klein (2003), Judd (1987) and McGrattan (1994). However, all of these papers quantified the welfare cost in a perfect competition framework. A recent paper by Guo and Lansing (1999) shows that with imperfectly competitive product markets the optimal capital tax can, under some assumptions, be positive. Our results illustrate that under perfect competition the capital tax is the most distortive tax. But, with imperfect competition in the product and labor market the labor tax become more distortive than the capital tax.

4.3 Sensitivity analysis

The sensitivity analysis is performed with respect to the following parameters: the price markup ν_p, the wage markup ν_w, the weight on consumption relative to leisure in the utility function α, the discount factor β, the depreciation rate δ, the capital share θ and the intertemporal elasticity of substitution of labor supply. We abstract from the transition in this analysis.

Figure 1 shows how the price and wage markups affect the welfare cost both under lump sum taxation and the current level of distortionary taxation. The price and wage markups are varied between 0 to 100 percent. The very high welfare cost of the price markup and that the welfare cost is a convex function of the level of competition is well illustrated. For example, a price markup of 30 percent implies a welfare cost around 50 percent while a price markup of 60 percent implies a welfare cost around 110 percent. Estimates of the price markup in the literature vary between 15 to 100 percent. On the high end, Hall (1988) estimates a price markup around 100 percent for six of seven one-digit sectors. Morrison's (1990) estimates lie in the range between 20 to 40 percent, Domowitz, Hubbard, and Petersen's (1988) estimates vary between 40 to 70 percent, Jonsson and Palmqvist's (2004) estimate is 25 percent and, finally, Rotemberg and Woodford's (1995) estimate is 17 percent.

The welfare cost of imperfect competition in the labor market is of a different magnitude than in the product market. However, it is, in relative terms, affected by distortionary taxes to a larger extent. This is due to the fact that the wage markup distorts the labor-leisure choice in the same way as the labor income tax, the consumption tax and the inflation tax, see equation (15).

How changes in the other parameters; that is, α, β, δ and θ, affect welfare is presented in Table 4. The distortionary taxes and government consumption are set equal to zero in this analysis. The results show relatively small effects on the welfare cost for reasonable changes in the parameter values.

To make sensitivity analysis with respect to the intertemporal elasticity of substitution of labor supply it is convenient to use the following functional form for the utility function

$$U\left(c_t^i, \ell_t^i\right) = \ln(c_t^i) - \nu \frac{\left(1 - \ell_t^i\right)^{\left(1+\frac{1}{\eta}\right)}}{1 + \frac{1}{\eta}}. \tag{35}$$

With this specification, η denotes the compensated elasticity of labor supply (or the Frisch intertemporal elasticity of substitution) and ν is a parameter determining the level of labor supply. Log utility in consumption is consistent with a balanced growth path.

The welfare cost of the price markup is unaffected of changes in the Frisch elasticity. The welfare cost of the wage markup is not, though. Figure 2 shows the welfare cost when varying the Frisch elasticity from 0.1 to 4.0 holding the wage markup fixed at 16 percent. The solid line shows the cost under lump sum taxation while the dashed line shows the cost under the current level of distortionary taxation. In general, a higher degree of elasticity of substitution implies a higher welfare cost since the behavior is then affected to a larger extent. This is also the case here, a higher intertemporal elasticity of substitution of labor supply increases the welfare cost of the wage markup. The welfare cost is relatively sensitive to this parameter, particularly if the interaction with distortionary taxation is taken into account. Most empirical studies suggest that the elasticity of substitution is relatively low; that is, in the range of 0 to 0.5, see Domeij and Flodén (2001). However, as argued in Domeij and Flodén these estimates may be biased downwards by as much as 50 percent. So when the true elasticity is 1 estimates of the elasticity is 0.5. An elasticity of 1 gives approximately the welfare cost reported in our benchmark case.

5 Conclusions

We have quantified the welfare cost of different distortions in the U.S. economy; that is, imperfect competition in the product and labor markets and distortionary taxation. We have found that the price markup, in comparison to the wage markup and the distortionary taxes, is by far the most costly distortion. This can be understood in the following way. The wage markup and the distortionary taxes distort the labor-leisure choice by increasing leisure while the price markup does not distort this choice. Since households derive utility from leisure these distortions are less costly in terms of welfare. The policy implications are therefore that polices that enhance product market competition are the most likely ones to be efficient in terms of increasing welfare. Even more so than reforming the tax system. This conclusion is not very sensitive to the transition and the parameterization of the model.

We have also shown that to get good measures of the welfare cost of imperfect competition it is important to include the fact that the economy is characterized by distortionary taxation. Put differently, the interaction between distortions; that is, how the cost of one distortion depends on the level of another, is quantitatively important. At the same time, to get good measures of the welfare cost of distortionary taxation it is necessary to include the level of imperfect competition in the product and labor markets.

A standard result in the optimal taxation literature is that capital income should not be taxed in steady state, see Chamley (1981). We have also found that the capital tax is the most costly tax in a steady state characterized by perfect competition. However, in an economy characterized by imperfect competition, the labor income tax becomes more costly due to the interaction with the wage markup. In fact, we have found that the labor income tax is even more costly in terms of welfare than the capital tax in the U.S. economy.

There are a number of ways in which this analysis can be extended. For example, the labor market is modelled in a very stylized way. Considering the importance of the labor market for the results, introducing a more realistic wage-bargaining problem and a search and matching framework are presumably interesting areas for future research. The framework developed by Pissarides (2000) and Ebell and Haefke (2003) may be useful for this purpose.

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Table 1: Parameter values.

Parameter	Description	Value
α	Weight on consumption relative to leisure	0.38
β	Discount factor	0.97
δ	Depreciation rate	0.10
θ	Capital share	0.36
ν_p	Price markup	1.23
ν_w	Wage markup	1.16
τ^k	Capital income tax	0.43
τ^h	Labor income tax	0.25
τ^c	Consumption tax	0.06
G/Y	Government consumption to GDP ratio	0.23
ω	Money to consumption ratio	0.79
γ_Y	GDP growth rate	1.64%
γ_M	Money (M2) growth rate	5.60%

Table 2: The welfare cost of imperfect competition (in percent).

	No taxes No transition	Taxes No transition	No taxes Transition	Taxes Transition
Δ_{ν_p}	38.19	50.71	35.74	48.26
Δ_{ν_w}	1.22	5.27	0.66	4.70
Δ_{ν_p,ν_w}	39.88	57.22	36.72	53.98

Table 3: The welfare cost of distortionary taxation (in percent).

	PC No transition	IC No transition	PC Transition	IC Transition
Δ_{τ^c}	0.32	0.84	0.10	0.62
Δ_{τ^h}	3.59	6.14	2.48	5.01
Δ_{τ^k}	3.80	4.33	1.47	2.09
Δ_{π}	0.39	0.99	0.14	0.74
$\Delta_{\tau^c,\tau^h,\tau^k,\pi}$	12.34	16.73	8.43	12.79
$\Delta_{\tau^c,\tau^h,\tau^k,\pi,\nu_p,\nu_w}$	76.13	–	67.05	–

Table 4: Sensitivity analysis.

	$\alpha = 0.30$	$\alpha = 0.38$	$\alpha = 0.45$
$\nu_p = 1.23$	38.19	38.19	38.19
$\nu_w = 1.16$	1.37	1.22	1.09
	$\beta = 0.96$	$\beta = 0.97$	$\beta = 0.98$
$\nu_p = 1.23$	38.19	38.19	38.19
$\nu_w = 1.16$	1.61	1.22	0.77
	$\delta = 0.05$	$\delta = 0.10$	$\delta = 0.15$
$\nu_p = 1.23$	38.19	38.19	38.19
$\nu_w = 1.16$	1.54	1.22	1.08
	$\theta = 0.30$	$\theta = .36$	$\theta = 0.40$
$\nu_p = 1.23$	34.41	38.19	41.20
$\nu_w = 1.16$	1.10	1.22	1.32

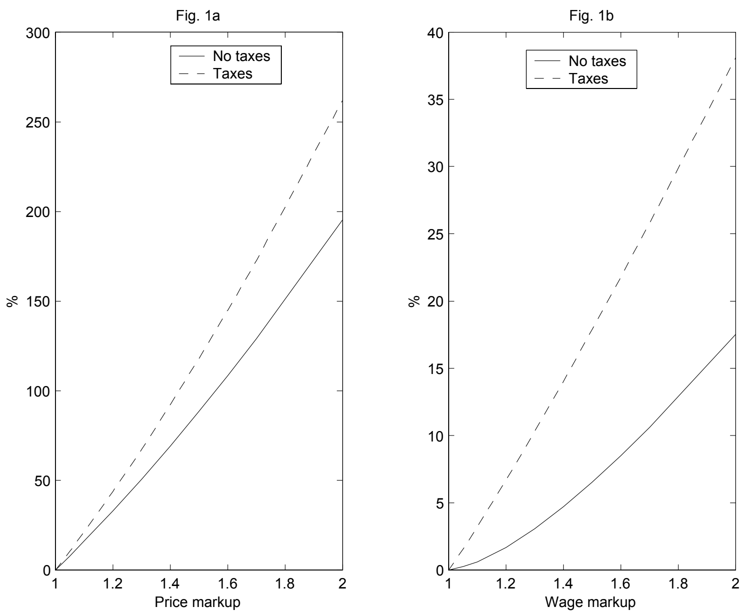

Figure 1: The welfare cost when varying the price and wage markup.

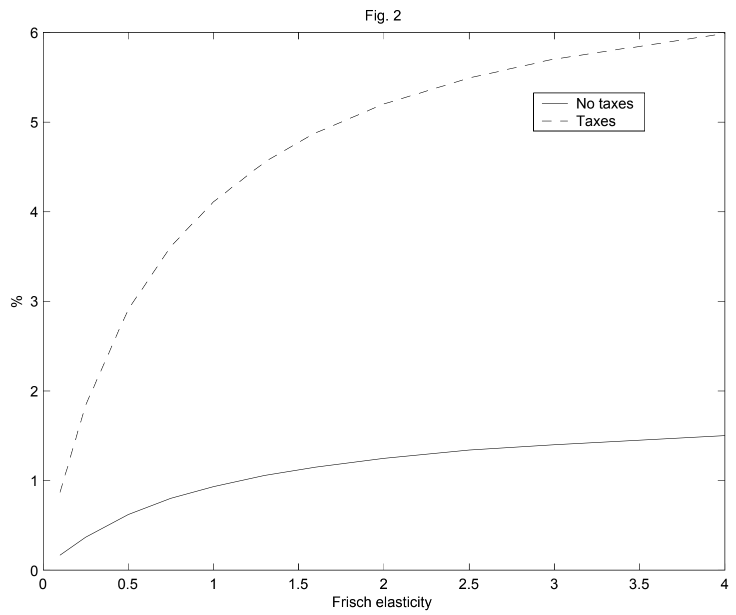

Figure 2: The welfare cost when varying the Frisch elasticity.

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