Can a carbon permit system reduce Spanish unemployment?☆

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A B S T R A C T
This paper analyses the impact of carbon policy on unemployment in Spain and whether recycling the public revenues earned from permit auctions can alleviate this problem. While Spain's deviation from the European Union's intermediate emission goals is more serious than most other member countries' unemployment in Spain is also well above average for the European Union. We use a computable general equilibrium model that includes unemployment in the markets for unskilled and skilled labour. We find that introducing carbon permits does not aggravate Spanish unemployment. In fact, if supplied with revenue recycling schemes, unemployment rates may actually fall. Contrary to other European studies, we find that the best option is to reduce payroll taxes on relatively skilled types of labour. This reform is successful in both increasing labour demand and dampening the supply response to rising wages. However, while all of the recycling schemes generate dividends in terms of aggregate welfare, none entirely offsets the abatement costs.

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1. Introduction

Spain, as part of the European Union (EU), has ratified the Kyoto protocol, which aims at reducing greenhouse gas emissions in industrialized countries by 2008–12. Though the burden-sharing agreement within the EU allows Spain to increase emissions by 15% in this period compared with its 1990 level, a ful

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Dividends in terms of employment have also been much in focus, especially in the European debate: Mors (1995), Majocchi (1996), and Bosquet (2000) provide surveys of the quantitative studies, mainly in the EU. The costs of green policies are likely to reduce overall economic activity and employment, unless tax revenues can be targeted towards cutting distortionary taxes on labour. While highly abstracted and aggregate theoretical models have found rather restrictive conditions for environmental policy to have employment effects (see e.g., Bovenberg and van der Ploeg, 1998; Wagner, 2005), the general conclusion from previous empirical model analyses is that there appear to be small though positive employment effects of shifting taxes from labour to energy and the environment. There are several determinants of employment and unemployment effects in large-scale open economy models, the most important being factor endowments (including the composition of the labour force), the factor intensities of the different industries (including capital, energy, emissions, skilled and unskilled labour), and the factor substitutabilities. These factors determine how green taxes affect relative factor prices, which again influence labour supply, demand and searching behaviour, and result in employment and unemployment adjustment.

There is some evidence that higher employment dividends arise if measures target relatively low-skilled labour. The reason is that the demand and supply of unskilled labour both tend to be more elastic. Drèze and Malinvaud (1994) originally proposed this reform as a solution to the European unemployment problem. However, in a computable general equilibrium (CGE) analysis where the EU markets for high- and low-skilled labour are separate, Bosello and Carraro (2001) conclude that the employment effects are larger when taxes fall for all labour rather than for low-skilled labour only. As this question is of special interest for Spain in light of the distributional aspects of the extraordinarily high unemployment of low-skilled workers, we include both of these proposals in our study. In light of the pessimistic employment results in Bosello and Carraro (2001) of targeting low-skilled labour, we also supply an analysis of targeting the relatively skilled as a natural follow-up research issue. However, we should note that different recycling schemes have different distributional effects between skilled and unskilled workers, so even if one scheme is the best in terms of reducing overall unemployment, the distributional effects may be unacceptable to policy makers.

The tendency in the vast model literature on double dividends is to study welfare effects in a CGE framework that leaves out labour market imperfections, while addressing the employment effects in partial or general shorter-term econometric models that have more realistic labour market treatment but lack full or consistent measures of welfare changes. However, welfare and employment effects are highly interlinked, and it is therefore useful to model both the labour market imperfections and their full welfare impacts. Results for employment and unemployment are important determinants of the welfare results. To start with, increased unemployment represents a waste of resources that reduces the welfare potential of the economy. Furthermore, when the labour market is characterized by tax wedges or market imperfections, the economy is no longer in a first-best condition from an efficiency point of view. In general, changes in labour demand, labour supply, and unemployment may then have welfare implications, which have ambiguous signs depending on the empirical features of the distortions and reallocations.

One example relevant to our analysis is that high labour taxes, as in Spain, tend to generate excessively strong incentives for devoting time to leisure rather than job searching and working. In this setting, all changes in the labour market that affect the incentive to supply labour will have welfare implications. Analogous arguments apply if there are externalities linked to employment and unemployment; see, e.g., Hosios (1990). There are also links in the other direction—that is, from welfare gains or income to unemployment—that primarily work through stimulating labour supply and demand. Once again, the net effect will be generally ambiguous. A consistent framework is then necessary in order to bring to a close the simultaneous welfare and employment effects. We apply a CGE model that incorporates the specific labour market characteristics in Spain. This combined approach is rare in the literature, and though integrated models of the EU as an entity have been applied (Carraro et al., 1996), the Spanish case remains unaddressed.

The scope for employment dividends and welfare dividends depends on the features of labour markets; in particular, their flexibility and wage formation. In many respects, Spain’s labour market institutions and unemployment problems are unique. Dolado et al. (1998) stress the high weight of unskilled unemployment in Spain compared with the EU average. Blanchard et al. (1995) identify the collective structure of wage bargaining combined with high employment protection for part of the labour force as the main reason for the high unemployment. In addition, there are large regional unemployment differences because of low labour mobility. Another common argument is that large tax wedges exist between take-home pay and the cost of labour that hamper employment. Payroll taxes in Spain are high (see, e.g., Gómez-Plana, 2007), and lowering tax wedges may reduce labour costs and encourage Spanish employment.

We represent the Spanish labour market as characterized by processes that imply a mark-up factor in wage determination and equilibrium unemployment. In particular, we model a negative relationship between the wage mark-up and unemployment. This model is consistent with several different theories, including wage curve theories on efficiency wage determination (Blanchflower and Oswald, 1994, 2005) and models emphasizing search costs externally affected by labour market behaviour (Pissarides, 2000). We also distinguish between skilled and unskilled workers to account for important differences in supply and demand and in policy response. The labour supply is endogenous, and we are thus able to separate employment effects from adjusted supply behaviour and changes in the number of unemployed. For instance, Fonseca and Muñoz (2003) conclude that coordination failures that aggravate the job search process appear to describe the labour market and persistent unemployment problems in Spain. There is also a highly intensive matching process. For example, in 1996, there were more than 8.5 million hires from a labour force of just 16 million (Castillo et al., 1998). This was mainly because of a high number of workers hired under fixed-term contracts (31.7% in 2001 while the EU average was only 13.4%). These contracts are most prominent among the less educated (Toharia, 1996). Low geographical mobility is another cause of significant mismatch problems. Large search costs can also represent frictions related to the presence of labour unions. None- theless, search specifications are rare within the Walrasian framework of CGE models, and Balistreri (2002) offers a practical and tractable way of integrating these approaches that we follow.

The paper itself is structured as follows. Section 2 presents the design of the analysis and the main features of the CGE model. Section 3 provides the numerical results. The final section concludes.

2. Method

2.1. Analytical design

We perform our analysis based on simulations of a large-scale CGE model for the Spanish economy. The main question posed in this analysis is whether establishing a national market for carbon permits can provide an employment dividend, given that the government collects the revenue and recycles it back to the economy. We define the employment dividends in terms of unemployment rate reductions

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1 Bosello and Carraro (2001) model the European labour market using assumptions about union bargaining power.

2 Another example is the complex labour market module of the MIMIC model of the Dutch economy (Bovenberg et al., 2000).
rather than employment formation in order to account for changes in both labour demand and supply. However, we also report the employment effects. In addition, we examine the possible welfare dividends of the reforms; i.e., gains in welfare exclusive of any environmental effects. The Hicksian equivalent variations index measures the welfare effects. It defines the income change (positive or negative) that has equivalent value for the representative consumer in terms of welfare as moving to the new post-reform situation.

It includes voluntary leisure priced at reservation wages, while we assume that involuntary or forced leisure linked to unemployment has no social value.5

We address these questions by simulating reductions in the number of emission permits from the benchmark level. We present the results of a 25% reduction.6 The benchmark price for permits is zero, but when permits become scarce, firms begin to bid for these, and the price increases. We can interpret this as an open auction of permits with a uniform price (or equivalently, uniform carbon taxation). We simulate four recycling alternatives.

Case A: Lump sum transfers to households.
Case B: Reduced payroll tax rates for all labour, irrespective of skill level.
Case C: Reduced payroll tax rates exclusively for unskilled labour.
Case D: Reduced payroll tax rates exclusively for skilled labour.

As lump sum recycling is by definition nondistortionary, the simulation in Case A is useful for cultivating the pure effects of introducing a price on emissions (the pure abatement effects). Comparing the other more policy-relevant recycling cases with Case A enables us to isolate the contributions of the different recycling schemes (the recycling effects). Comparing the different recycling schemes in Cases B, C and D illuminates how recycling should be directed in order to minimize unemployment and reveals the extent to which the reforms are associated with trade-offs between the welfare and employment dividends. We close the analysis by investigating the sensitivity of our results to model characteristics and parameter assumptions. Section 2.2 outlines the main characteristics of the numerical model; details are in Appendices A–C.

2.2. The numerical model

The numerical model is a static CGE model. The main refinements we have made are aimed at capturing the relevant welfare and employment outcomes for the Spanish economy of changes in carbon policy and labour taxation. In particular, the model incorporates important features of the imperfect Spanish labour markets and a comprehensive description of the existing tax structure, imperfect competition and other distortionary wedges within the Spanish economy. The structure of household utility, production and factor markets clear through labour and capital markets. Any revenues from the market sales of CO2 permits are included in public income. The primary factor endowments are given to the public sector (see Table 1).

Table 1

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<tr>
<th>Sectors</th>
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<td>Agriculture</td>
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<td>Commerce and hotel trade</td>
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<td>Finance and insurance</td>
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<td>Other services</td>
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We model Spain as a small open economy. Goods are differentiated by origin (domestic and foreign), according to the Armington assumption. The balances of trade and financial cross-border flows are fixed. All agents, except the public sector, have optimizing behaviour. The public sector balances revenues according to an exogenous restriction, which we keep constant; i.e., all policy changes are revenue neutral. A macroeconomic restriction fixes public investment and the deficit (or surplus), implying that public savings are also fixed. Any revenues from the market sales of CO2 permits are included in public income. The primary factor endowments are given to the public sector across industries, and factor markets clear through adjustment in factor prices. Given that labour markets far from clear in the Spanish economy, we allow for unemployment as below. At the macro level, investments and savings balance.

Identical firms comprise each industry, and they compete under Cournot conjectures. Technologies have increasing returns-to-scale because of the existence of some fixed labour and capital costs, and marginal cost is constant. The pricing rule (see Eq. (A15) in Appendix B7) involves a mark-up on price. There is the free entry and exit of firms, so that in equilibrium, profits are zero and the industry-specific mark-up just covers fixed costs. When profits are positive, more firms enter the industry, adding up to more total fixed costs, reducing the mark-up revenue (see Eq. (A15)) and driving profits down. If profits are negative, some firms exit the industry, so total fixed costs decrease and mark-up revenue increases, thereby increasing profits. In order to model the way that market power is prevalent in many Spanish industries, the degrees of competition and mark-up pricing are allowed to vary among industries according to the degree of firm concentration (measured as H in Eq. (A15) and equivalent to the Herfindahl index). For example, a high concentration (Herfindahl) index corresponds to a less competitive sector.

Sixteen industries represent the production sector (see Table 1). Firms maximize profits subject to a production technology characterized by a detailed nested structure (see Fig. 1). CO2 emissions from firms originate from the use of fossil energy as input factors. In our static framework, investments influence the economy as a component of final demand. We assume that private households hold homothetic and identical preferences and can be represented by a single, representative household. The household maximizes a nested utility function (see Fig. 2) by choosing savings,8 leisure, and the consumption of goods (including energy). The utility function does not include the quality of the environment. The household generates CO2 emissions when it consumes coal, oil and gas, and the endowments of capital and skilled and unskilled labour are fixed. The labour supply is elastic up to these fixed maximum amounts. This feature of the model enables us to analyse the extent to which adjustments in the labour supply explain changes in the unemployment rate.

5 This assumption is common in the welfare economics literature (see Johansson, 1991, pp. 66–67), although the empirical estimates of the value of the time spent unemployed vary considerably. Some studies like Di Tella and MacCulloch (2006) even find that unemployment is associated with negative utility.
6 Smaller and larger reductions show the same qualitative results, and all variables react smoothly to the variation in emission restrictions.
7 Appendix B lists all equations in the full model. See Appendix A for the model notation.
8 Given our static approach, we consider unitary elasticity of substitution between consumption and savings (see Hove, 1975). Savings can be interpreted as the purchase of bonds for future consumption.
Our modelling of the labour market explicitly takes into account the fact that there is a positive difference between the market wage, $W_j$, and the reservation wage of the suppliers; i.e., the value they put on their leisure time, $W_0^j$. The relative difference is modelled as a mark-up, $S_j$, giving the following arbitrage equation for the labour suppliers:

$$W_j = S_j W_0^j; j = s, us$$

where $s =$ skilled workers and $us =$ unskilled workers.

The presence of a mark-up is consistent with several different theories. For example, the mark-up can be regarded as necessary in order to ensure that employees work efficiently as in efficiency wage theories (Shapiro and Stiglitz, 1984), or to encourage suppliers to make the effort to search for jobs in a market with frictions as in search theory (Pissarides, 2000). These frameworks are complementary. In addition, bargaining and trade union theories can also explain such wage determination (Mortensen and Pissarides, 1999). Empirical evidence also suggests that the mark-up is dependent on aggregate market conditions. Specifically, and in accordance with, e.g., Blanchflower and Oswald (1994, 2005), Burda and Wyplosz (1994), Castillo et al. (1998), and Balistreri (2002), we model the mark-up as negatively dependent on changes in the unemployment rate, $U_j^t$, from the benchmark value, $U_j^t$, and negatively dependent on labour demand, $LD_j^t$, relative to its benchmark value, $LD_j^t$:

$$S_j = \phi_j \left( \frac{LD_j}{LD_j^t} \right)^{-\eta_j} \left( \frac{U_j}{U_j^t} \right)^{-\eta_1}; j = s, us$$

This modelling reproduces the reduced-form local approximation in Balistreri (2002). It implies that there are externalities of aggregate labour market behaviour in the wage determination. The externalities stemming from increases in the unemployment rate can be interpreted as though suppliers are frightened into demanding less compensation for participating in the labour markets when the unemployment rate increases. Thus, $\eta_1 \geq 0$. An expansion of economic activity, as proxied by labour demand expansion relative to the benchmark, is also supposed to reduce the mark-up as an external effect. The intuition is that suppliers need to devote less search effort...
when labour market conditions improve; thus, \( \eta_0 \geq 0.9 \phi_j \) is the mark-up calibrated in the benchmark as:

\[
\phi_j = \frac{1}{1 - U_j}, \quad j = s, us.
\]  

(3)

In other words, we assume that the mark-up in the benchmark is the inverse of the probability of finding a job if searching \( (1 - U_j) \).

We solve the model with Rutherford’s (1999) method, which treats general equilibrium models as mixed complementarity problems following Mathiesen (1985), and implement it with GAMS/MPGSE. The model is calibrated using the Spanish Social Accounting Matrix for 1990 (MCS-90) developed in Uriel et al. (1997) and Gómez-Plana (2001) as the reference equilibrium. The numéraire is the consumer price index, and the elasticities are from available empirical evidence. See Appendix C for more information on the calibration and data used.

### 3. Employment and welfare effects of carbon permits

#### 3.1. Case A: Lump sum recycling

In Case A, recycling effects are neutral, and the introduction of quota restrictions on \( CO_2 \) emissions causes the real effects of the reform. The direct effect is to impose a price wedge between the consumer and producer prices of fossil fuels in a number of markets. With our focus on employment effects, we present the move to a new equilibrium by explaining the main direct impacts and repercussions in the labour markets.  

First, higher consumer prices cause a downward shift in the supply and demand for labour. The latter works through smaller home markets in the wake of increased energy prices. Furthermore, the higher energy costs of firms reduce their market shares (both domestically and internationally), and this shifts labour demand further downwards.  

Neither the internationally exposed goods nor consumer goods have very high direct fossil fuel intensities, but as the prices of inputs increase (starting with electricity and transport services), the \( CO_2 \) permit pricing significantly raises costs within exposed and final goods industries. The capital-intensive industries tend to face the highest \( CO_2 \) permit costs. This implies a counteracting effect on labour demand at the macro level because of the substitution of relatively labour-intensive for capital-intensive production. However, as fossil fuel-intensive industries represent a low share of total capital use, this effect is inferior.

Overall, the demand shifts dominate the supply shifts in both labour markets. Consequently, either wages will have to decrease or unemployment rates will have to increase in order to restore the (unemployment-adjusted) equilibrium. Table 2a shows that the introduction of the \( CO_2 \) permit reform does not particularly affect aggregate unemployment. This reflects the fact that the fossil fuel-intensive part of the Spanish economy is not very labour intensive, and so contraction only releases a small amount of labour. In fact, total employment increases slightly, reflecting the fact that the negative shift in labour demand is more than offset in the new equilibrium by wage reductions that stimulate demand. However, as labour supply simultaneously rises, the unemployment rate remains unaltered. The disaggregated results reveal that the rise in employment only benefits unskilled labour, while the employment of skilled labour falls marginally. The increased demand for unskilled labour most prominently takes place within Agriculture, Trade and Other Manufacturing (including the unskilled intensive manufacture of textiles and wood products).

Consumption and leisure fall in the new equilibrium, implying a welfare loss of 0.93%. This pure abatement cost lies in the lower range of comparable European studies (see IPCC, 2001, Bye et al., 2002, Bosquet, 2000). One possible explanation is differences in the employment effects. Contrary to our findings for Spain, other European studies usually find that employment falls. This tends to increase abatement costs because of significant tax interaction effects with existing labour taxes. The avoidance of adverse effects on employment and unemployment rates from the abatement policy per se point to potential employment dividends (and even welfare dividends) when the carbon permit sales are linked to adequate recycling schemes. We explore three recycling alternatives in the following sections.

#### 3.2. Case B: Recycling through reduced payroll tax rates on all labour

Adding the recycling effects of reduced payroll taxes on all labour to the pure abatement effects in Case A corresponds to the more policy-relevant Case B. The reduction in labour costs from recycling has the opposite effect on the labour market as \( CO_2 \) pricing. As a first-round effect, this stimulates both labour supply and demand. The demand shift is the stronger. It is fuelled by a substitution of labour, a general improvement in firm competitiveness, and a home market effect through real income gains. This induces upwards pressure on market wages and/or downwards pressure on the unemployment rate in order to regain the unemployment-adjusted labour market equilibrium.

As in Table 2b, the new equilibrium shows that this particular recycling scheme strengthens the employment dividend and partly offsets the welfare loss caused by the \( CO_2 \) pricing. Table 2b also shows that the unemployment rates for skilled and unskilled labour fall by...
0.11% and 0.08%, respectively, because of the recycling scheme. However, the effects are small, as also found in Mors (1995), Majocchi (1996) and Bosquet (2000). The recycling effects increase welfare by 0.46%. Important reasons are that the substantial labour tax wedge is reduced and that employment increases. Comparing Case B with Case A, we can see that the welfare gain of recycling almost halves the abatement cost of the CO2 permit system. These weak double (welfare) dividends of labour tax recycling are mentioned in almost all of the European studies referred to earlier.

3.3. Case C: Recycling through reduced payroll tax rates on unskilled labour

Distributional reasons could call for a recycling policy designed to stimulate unskilled labour, particularly because the unemployment rate for unskilled labour is twice as high as that for skilled labour. This could also be a case for reaping higher employment dividends than with non-discriminatory payroll recycling. As the fossil fuel-intensive industries use unskilled labour relatively more intensively than skilled labour, a subsidy to the employment of unskilled workers could help absorb the released labour more efficiently. In addition, the percentage change in wage costs of lowering payroll taxes will be higher for unskilled labour than for skilled labour because of the low wage rates of unskilled workers, implying that the change in wage costs will be larger.

However, our results contradict the hypothesis that employment dividends increase when recycling targets low-skilled labour. On the contrary, the aggregate unemployment rate (which decreased in Case B) increases by 0.07%; see Table 2b. While the non-discriminatory recycling in Case B provided gains for both groups, recycling exclusively through the costs of unskilled labour reduces the unemployment rate only for this group. This is more than offset by a rise in the unemployment rate of skilled labour, and this explains the aggregate rise in unemployment. The increase in aggregate employment is also lower than in Case B. Importantly, while the employment effect for unskilled labour more than doubles, the employment of skilled labour simultaneously decreases and reduces aggregate employment when compared with Case B.

Fig. 3A and B qualitatively illustrates the recycling effects in the market diagrams for unskilled and skilled labour. In the unskilled market, one important effect of reducing payroll taxes is to shift labour supply upwards via reductions in consumer prices. Simultaneously, labour demand shifts upwards. While the underlying mechanisms are the same as described for the labour market reactions in Case B, an additional effect is significant in this case, namely a strong substitution in favour of unskilled workers. This contributes to a significantly higher demand for unskilled labour in Case C than in Case B. Cost changes through factor price increases modify these shifts. The subsequent labour supply deficit is neutralized by an increased unskilled wage rate and a reduced unemployment rate. In the new equilibrium, the recycling scheme has contributed to an increase in unskilled labour wages by as much as 4.78%, while the unemployment rate has fallen by 0.18%, reflecting a labour demand increase of 1.05% and a somewhat weaker labour supply increase of 1.0%.
In the market for skilled labour, the shifts are weaker, particularly the demand shift, because of the significant countereffecting substitution away from skilled labour caused by the unskilled labour cost reduction. Before any adjustments in the wage rate and the unemployment rate of skilled labour, the labour market imbalance is less serious than in the market for unskilled labour. In equilibrium, the responses in the unemployment rate and the wage rate for the skilled part of the labour force are to increase by 0.07 and 0.61%, respectively. The increased unemployment rate reflects that the substitution effects are strong, and this contributes to leaving skilled labour unemployment 0.3% lower than the lump sum case.

Three substitution mechanisms mainly explain the downward pressure on skilled labour demand. To start with, a general substitution of unskilled for skilled labour takes place in each firm, encouraging the employment of the unskilled at the expense of the skilled. The second effect is that the relatively skill-intensive part of the economy (mainly the service sector) has a reduced ability to attract resources as costs increase more than averagely. This reduces skilled labour demand at the macro level. The final effect is through the interplay between capital and labour demand. The direct effect of subsidizing unskilled labour costs is to reduce the relative prices between unskilled labour and capital more strongly than in Case B. In relatively unskilled-intensive and capital-intensive industries, a substitution between labour types and a substitution for capital takes place. Thus in the expanding part of the economy, mostly trade and unskilled labour-intensive manufacturing, capital demand decreases. The capital must be absorbed elsewhere, and through relative factor price adjustments, the contracting, skill-intensive part of the economy is stimulated to absorb capital. Subsequently, capital demand increases despite reductions in output in the skill-intensive service sector, implying that both unskilled labour and capital squeeze skilled labour. As a result, aggregate production and employment fall relative to Case B, and this tends to take place in the relatively skill-intensive part of the economy, primarily the service sector.

The targeted recycling to unskilled labour generates a weak welfare dividend of about the same magnitude, as does recycling through all payroll taxes in Case B. This reflects the strong significance of employment effects in generating welfare. That is, aggregate employment rises to about the same extent in the non-discriminatory and discriminatory recycling schemes, and this contributes to increasing welfare both directly (as employment is initially suboptimally low) and through decreasing the number of unemployed.

Our results counter the claim that targeting revenue to the low-skilled reduces unemployment more effectively. As in Bosello and Carraro (2001), we find that subsidizing the costs of both types of labour is better than targeting revenue merely to the unskilled. While substitutability between both labour types within the production process mainly explains these results, our findings for Spain also point to important effects from changes in the industrial structure, and from the substitution between capital and labour both at the firm level and at the macro level through resource reallocations among industries. This naturally leads to the question, addressed in the next section, of whether targeting skilled labour has more promising employment effects.

3.4. Case D: Recycling through reduced payroll tax rates on skilled labour

The most interesting observation from the analysis of Case D is the strong employment dividend obtained at the macro level. The overall unemployment rate drops by 0.31%, which implies that recycling through skilled payroll tax rates is the most recommendable scheme in terms of employment dividends and noticeably more effective than recycling though the wage costs of unskilled labour (Case C). Underlying this result is both a higher labour demand and a lower labour supply than in Case C.

The higher labour demand is partly explained by a stronger effect on demand for the subsidized skill type in Case D than in Case C, because the tax cut is more substantial when allocated to relatively fewer skilled workers. In addition, the higher labour demand results from a weaker negative impact on the disfavoured skill type in Case D than in Case C. We have to revisit the role of the linkages between the demand for capital and both types of labour to understand this. In both cases of discrimination, the subsidized skill type increases its intensity within firms, and industries using the subsidized skill type relatively intensively increase their share of total production. However, the two recycling schemes differ in their effects on capital demand. Compared with unskilled-intensive industries, skill-intensive industries are less capital intensive, and the substitution between capital and labour is smaller. Thus, reducing the payroll tax on skilled labour, and thereby increasing the relative costs of capital in the skill-intensive part of the economy, releases less capital ceteris paribus than the reduction of payroll taxes for unskilled labour. Consequently, when recycling targets the use of skilled labour, the absorption of the capital released (which now takes place within the unskilled and relatively capital-intensive contracting parts of the economy) is a smoother process than in Case C. Less labour is substituted by capital within these industries than within the contracting industries of Case C. Subsequently, the decrease in unskilled labour demand is smaller than the decrease in skilled labour demand in the former case. When recycling targets skilled employment, industries that require high skills, as the service industries, expand first. However, when compared with the targeting of unskilled labour, the contraction of industries that use the relatively disfavoured skill type more intensively (in this case, unskilled labour) is less pronounced. Overall, production and employment increase compared with the other and more frequently analysed cases of payroll reductions.

Along with higher aggregate labour demand, lower aggregate labour supply also explains the lower unemployment rate in Case D relative to Case C. This relates to the higher labour supply elasticity of unskilled workers compared with that of skilled workers. The wage rate of the non-subsidized skill type (also in real terms) falls by about the same magnitude in both cases. However, the subsequent discouragement of skilled labour in Case C is much smaller than the discouragement of unskilled labour in Case D and contributes to a lower aggregate supply in the latter. The wage rate of skilled labour (also in real terms) increases considerably more in Case D when the skilled are favoured than the wage rate of unskilled labour increases in Case C, and this modifies the difference in aggregate supply between the two cases. Regardless, the overall effect on aggregate supply is weaker when the subsidies target skilled rather than unskilled employment.

To sum up, employment effects are 0.05 percentage points higher and supply effects 0.03 percentage points lower in aggregate terms in Case D compared with Case C. This explains the considerably lower $U$. It is, however, worth noticing the adverse effects that the scheme in Case D has on the distribution of the burden of unemployment. In all the other cases, the recycling schemes work to reduce the unemployment rate of unskilled labour. Subsidizing skilled employment produces the opposite result.

Recycling through the payroll tax rates for skilled labour generates a slightly higher welfare contribution than recycling through unskilled

11 In the benchmark case, the value-added for skilled workers relative to unskilled workers is 75.24%.
labour. This partly reflects the fact that skilled workers are relatively more productive: gross output increases by 0.25% as opposed to 0.22% when revenue is recycled through reduced payroll taxes for unskilled labour. It is worth stressing that the welfare measure does not consider distributional concerns with respect to factor ownership, including skills, or with respect to income groups. We comment on the distribution of unemployment above. We can consider the distributional changes among the different factor owners under the different recycling schemes by studying the changes in factor prices in Table 2. While the wage rate increases for the skill type that receives recycling and falls for the non-subsidized skill type, capital rents will fall in all scenarios. Thus, the distributional effects of all recycling scenarios are unfavourable for owners of capital.

3.5. Sensitivity analyses

This section illustrates the sensitivity of the results to some key assumptions. The results reported in Table 3 apply to the sensitivity analysis of Case D; i.e., when we cut CO2 emissions by 25% and revenue is recycled through payroll taxes on skilled labour. This is the case where we obtain the strongest employment dividend. For the other recycling cases, the sensitivity analyses do not markedly deviate. Finally, we have performed a comparison of the recycling responses of simplified, stylized models with different wage formation, to shed light on the implications of the specification we have chosen in this study.

3.5.1. Sensitivity to the elasticities in the wage mark-ups

In the calibration of the elasticities of the wage rate function, we chose estimates from search models. As different econometric estimates exist on the values of the externality parameters in the wage functions for Spain, we compare the results of Case D, based on values from Burda and Wyplosz (1994) (BW), with alternative estimates provided in Castillo et al. (1998) (CJL). See Appendix C for the calibration. The elasticities w.r.t. expansion of the labour markets from these studies exist on the values of the externality parameters in the wage functions.

3.5.2. Sensitivity to the elasticity of substitution between skilled and unskilled labour

We performed 100 simulations where different elasticities of substitution are randomly drawn from a uniform probability distribution. Corresponding to the most common results in the literature, the distribution’s lower and upper bounds are fixed at 0 and 5, respectively. Table 3 shows the average result and the standard deviation (in parentheses). The main conclusion is that, on average, the results do not appear very sensitive. The small values of the standard deviation confirm this perspective.

3.5.3. Sensitivity to the definition of unskilled workers

We also check the influence of our definition of unskilled workers. Until now, this category included workers with primary education, illiterate and unschooled. In the sensitivity analysis, we redefine those with primary education as skilled, restricting the unskilled category to only the illiterate and unschooled. Table 3 shows that the results are robust in sign for the unskilled labour and aggregate variables. Nevertheless, the greater number of skilled workers at the benchmark alternative target the skilled, we find more pronounced changes for skilled labour than unskilled labour. At the macro level, the sensitivity to altering the elasticities is, however, small, since there is more unskilled labour than skilled labour. The smaller welfare reduction reflects smaller negative externalities on the mark-up in the wage related to the reduced unemployment rate, even though the unemployment rate reduction is more pronounced.

3.5.4. Sensitivity to the labour supply elasticity

In Table 3, we present two scenarios where we first double then halve the elasticity of labour supply. Qualitatively the results do not change, and quantitatively only the employment changes appear significantly larger. In general, we find that the larger the elasticity of labour supply, the more favourable the results in terms of unemployment rates and welfare.

3.5.5. Comparison of different wage formation models

To calibrate the labour market easily within alternative models, we chose to perform analyses by means of simple, aggregate toy models

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Sensitivity of results in Case D: 25% CO2 abatement and skilled pay roll tax recycling.</th>
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<tr>
<td>Base case</td>
<td>Sensitivity analyses</td>
</tr>
<tr>
<td>Case D</td>
<td>Weak unemployement externalities in wage</td>
</tr>
<tr>
<td>Unemployment rate skilled</td>
<td>−0.33</td>
</tr>
<tr>
<td>Unemployment rate unskilled</td>
<td>0.04</td>
</tr>
<tr>
<td>Unemployment (agg)</td>
<td>−0.31</td>
</tr>
<tr>
<td>Employment skilled</td>
<td>1.56</td>
</tr>
<tr>
<td>Employment unskilled</td>
<td>−0.23</td>
</tr>
<tr>
<td>Employment (agg)</td>
<td>0.54</td>
</tr>
<tr>
<td>Labour supply skilled</td>
<td>1.52</td>
</tr>
<tr>
<td>Labour supply unskilled</td>
<td>−0.32</td>
</tr>
<tr>
<td>Labour supply (agg)</td>
<td>0.48</td>
</tr>
<tr>
<td>Welfare</td>
<td>−0.47</td>
</tr>
<tr>
<td>Market wage rate skilled</td>
<td>3.55</td>
</tr>
<tr>
<td>Market wage rate unskilled</td>
<td>−1.76</td>
</tr>
<tr>
<td>Capital rent</td>
<td>−2.07</td>
</tr>
</tbody>
</table>

12 These apply to the elasticities w.r.t. vacancies, while our proxy is the labour demand; see also Appendix C on calibration.
distinguishable by their wage formation mechanism. In the first model, wages are fully flexible and so eliminate all unemployment. In the second model, we implement our model with mark-up on wages and equilibrium unemployment, while the third model is characterized by rigid wages. We study a uniform tax cut on all labour and find that decreasing the tax increases employment in all models. Compared with the flexible wage model, employment increases more with our model as unemployment and the mark-up on wages fall. However, compared with a model with total wage rigidity, employment increases less. The reason is that the wage is adjusting, even if there are frictions in the labour market.13

4. Conclusion

This paper addresses the special challenges of Spain in meeting the international commitment on greenhouse gas emissions, while simultaneously attending to its problems with severe unemployment. Within a CGE framework, we use a model with unemployment calibrated to search model estimates for Spain. This allows us to study the welfare and employment dividends of carbon policies by taking into consideration the effects on the labour supply. The endogeneity of supply has led us to define employment dividends in terms of unemployment rates instead of employment to distinguish these effects from any voluntary choices of leisure. However, our qualitative ranking of recycling alternatives does not hinge on this change in definition. One contribution of our work is to account for the substantial differences between the unskilled and skilled labour markets in Spain. This enables us to supplement previous studies with assessments of policy alternatives directed to one of the labour market segments only.

We find, in line with most other work, that in most cases, a carbon permit market in Spain, combined with revenue recycling through payroll tax reductions, reduces the unemployment rate and increases employment. Our results are fairly optimistic, as adverse unemployment effects are avoided also in case of lump sum recycling; i.e., when no payroll tax reductions are accounted for. This mainly reflects the fact that carbon-intensive sectors represent a low share of employment, especially skilled employment, so that the economy is able to absorb workers through expansion in other relatively labour-intensive industries.

The recycling schemes have different potentials for reducing unemployment rates. As Bosello and Carraro (2001) find for Europe, the potential for increasing Spanish employment is least promising when payroll taxes fall for unskilled labour only. We actually find a slight increase in aggregate unemployment using this recycling alternative. However, a case not analysed by Bosello and Carraro (2001) appears to be the most promising: namely, reducing payroll taxes exclusively for skilled workers. When we consider how the supply effects and the unemployment rates are calculated, the employment dividends appear to be quite sensitive to the recycling scheme. For instance, using revenue to lower payroll taxes on unskilled labour increases the aggregate unemployment rate by 0.07%, while recycling through skilled payroll taxes reduces the rate by 0.31%. Recycling to both groups yields an unemployment result in between (−0.09%). The stronger employment dividend from recycling through the costs of skilled labour is partly the result of a weaker supply response to rising wages and partly because of a stronger stimulation of labour demand. We explain the weaker supply effect by the lower labour supply elasticity of skilled workers. The stronger demand effect has two important explanations. To some extent, it reflects the fact that the cut in costs of the subsidized labour type is stronger, as skilled labour constitutes a smaller group. In addition, its interplay with capital is important. That is, skilled labour tends to work in the least capital-intensive part of the economy, implying that increased demand for skilled labour causes a modest substitution for capital and a subsequently modest need for capital absorption by crowding out unskilled labour in other parts of the economy. This finding poses a dilemma to policy makers because of its distributional implications. In spite of a stronger aggregate employment dividend, recycling exclusively to skilled workers will widen the gap between the two skill groups in terms of their unemployment rates. The entire employment dividend will then accrue to the relatively advantaged and prosperous group of skilled workers, while the unskilled worker unemployment rate will somewhat increase. While it is beyond the scope of this paper, this scheme would require some other policy measures to improve the distributional outcome; i.e., a policy mix that could secure the macroeconomic effects without the adverse distributional outcome. On the contrary, reducing taxes on the employment of unskilled workers will only benefit this group. Thus, in spite of a small negative aggregate employment dividend, the scheme can be of interest to policy makers searching for a way to generate employment for unskilled workers.

We find no trade-off between welfare and unemployment concerns in choosing among the recycling alternatives. All of the schemes analysed produce nearly the same positive welfare effects. However, the welfare dividend is weak; i.e., the gains from recycling revenue cannot offset the welfare cost of introducing market prices on CO2 emissions. That said, we do not calculate the welfare gain obtained in terms of a better environment and a positive contribution to climate stabilization.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.eneco.2009.01.003.

References


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13 A supplement with more detailed results is available from the authors upon request.


