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An Inquiry into Double Dividend Effects of Carbon Taxes

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An Inquiry into Double Dividend Effects of Carbon Taxes

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Abstract

For my undergraduate thesis, I conducted research on the topic of carbon taxes. Specifically, I was interested in the possible existence of a double dividend effect as a method for making this public policy option more palatable to a broader audience. To that end, I first conducted a literature review on the subject, then did an empirical analysis. I chose Nebraska as the subject of my analysis because it is my home state and I experienced heated debates over tax policy firsthand as a Page for the State Legislature. To see whether a double dividend would exist in Nebraska, I used a simple computable general equilibrium model to model three different scenarios for offsetting a carbon tax: lump-sum payments, reductions in taxes on labor, and reductions in taxes on capital. While my knowledge and resources presented some large limitations, I still found interesting results. Lump-sum payments and reductions in taxes on labor show the same increase in welfare, but the latter is much less distortionary. However, reducing taxes on capital shows by the far the best outcome, as I find a larger increase in welfare, and very limited distortionary effects.

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1 Introduction

We constantly hear in the news about how climate change is beginning to wreak havoc on almost all aspects of human life. Longer-lasting droughts, more frequent flooding, stronger storms, and crop failure—these are just a few of the current and future ramifications of climate change, especially if it continues unabated. Climate scientists are unanimous in the consensus that the planet is warming. Since 1880, global temperature has risen 1.9 degrees Fahrenheit. Not only that, they also agree that this change is mostly anthropogenic, or caused by humans. Cook et al. (2016) found in a wide-ranging review of literature and surveys that 90-100 of climate scientists agree that climate change is anthropogenic. Warming temperatures could have a devastating impact on the species that have driven them, if left unchecked.

As this paper is focused on the economics of climate change, it is appropriate to look at the some of the predicted economic effects. If the current situation continues, the future could be quite bleak for humanity. Some key areas of risk resulting from warming temperatures are agriculture, natural disasters, and human health. Probably most relevant to the state of Nebraska—the focus of this analysis—is agriculture. This sector is undoubtedly the most critical in the Nebraskan economy, with the state placing in the top echelon nationwide for production of corn, soybeans, beef, and other agricultural products. While Deschenes and Greenstone (2007) find little net effect for U.S. agriculture as a result of climate change, there is considerable variability by state. They project Nebraska to be one of the biggest losers after California, to the tune of 670 million loss in annual profits. Increased flooding and severe weather activity could also become problems for the state in the future.

Given these facts, many people are naturally interested in what can be done to stymie, if not reverse the Earth's rising temperature. Proposed solutions run the gambit of public and private, feasible and infeasible. Groups in both Europe and the United States have proposed sweeping legislation to completely re-work economies and gear them toward the challenge of fighting climate change. World governments signed the Paris Accords in 2016 with the goal of limiting the global temperature rise to 2 degrees Celsius. Private enterprises have come up with ideas to technologically alter Earth's atmosphere or deal with the effects. What all of these solutions have in common is grand notions about the ability of a single idea to wildly alter the course of history, either through the ingenuity of an as-yet-undiscovered entrepreneur or the wisdom of government planners. There is a third way, however, that is widely endorsed by economists. That way is a tax on carbon emissions. With a tax on carbon emissions, governments could subtly nudge industry and consumers to alter their behavior in ways that reduce emissions of greenhouse gas, while being as non-disruptive as possible.

Not only would a carbon tax alleviate greenhouse gas emissions, it would also have the potential to be revenue neutral. Economists call this phenomenon the double dividend effect. Basically, policymakers would impose a carbon tax, while also reducing some other, more distortionary tax. This policy move should lead to an increase in efficiency, as carbon taxes are an example of a Pigouvian tax, which are levied on markets that produce negative externalities, in this case, carbon dioxide. Scholars might study any large number of issues relating to carbon taxes. These include regressiveness, implementation, and whether the carbon tax does indeed reduce carbon emissions (its chief aim). For the purposes of this paper, I assume that the carbon tax will not be regressive and that it does indeed reduce carbon emissions. Different implementations will be considered when simulating the tax's effects. The primary goal is to assess whether a double dividend effect exists for a carbon tax implemented in the state of Nebraska.

2 Literature Review

As a result of extensive reading on the topic, I have compiled a brief literature review which summarizes the main points of research into double dividends. The most important distinction that I found is the concept of "weak" and "strong" versions. The second is that different policy offsets of carbon taxes give widely varied results with respect to the double dividend. Goulder (1994) explains that in the weak form, cost savings are realized if the government uses revenue from the carbon tax to cut other, more distortionary taxes. He also recognizes an intermediate form, in which there exists a distortionary tax, which, when offset by the carbon tax, allows zero or negative gross costs. Finally, the strong form occurs when a zero or negative gross cost is realized for an "average" distortionary tax. For purposes of my later analysis, I mostly combine the intermediate and strong forms together, since lack of precision does not allow me to decompose all the way down to specific taxes. The rest of this literature review will be broken down into three sections: general research on carbon taxes, research on enacted or proposed carbon taxes in countries, and research on carbon taxes in NUTS-1 regions of countries (e.g. states, provinces).

First, we have some broad overview. Freire-González (2018) analyzed 66 different simulations from 40 studies on this topic. They found that in 55% of these simulations, a strong double dividend was found. Importantly, they also noted that offsetting environmental taxes with cuts in capital taxes was the most likely scenario to exhibit the double dividend. Haites et al. (2018) found that, while carbon taxes do have an effect in mitigating emissions, a double dividend is often not seen, although this could be partially down to implementation issues. These two studies bring up another important concept in my reading—that taxes on capital tend to be more distortionary than those on labor, and therefore we are more likely to see the double dividend effect if we offset carbon taxes with capital taxes.

Many scholars have also looked at the specific results of carbon taxes which have been implemented or could be implemented in different countries. Certain of these results are reported here. First, I look at some studies of large contries and political unions. Proost and Regemorter (1992) analyzed the introduction of a carbon-energy tax in the European Community. They found that the strong form of the double dividend did not exist, and also that efficiency losses actually occurred, if one does not take into account the environmental benefits. Babiker et al. (2002) looked into the possiblility of a double dividend in the U.S. and European countries. They found that labor must be extremely elastic for the strong form to be present, while also noting that since European countries already have high energy taxes, a double dividend is less likely there. Glomm et al. (2005) investigated the potential effects of a carbon tax in the United States. They concluded that the increase in welfare resulting from green taxes is small, but that there is a large efficiency gain as a result of reducing capital taxes. Takeda (2007) conducted a study for Japan, noticing a weak double dividend effect in all scenarios, but a strong effect when the carbon tax was offset by reductions in capital taxes. Orlov et al. (2013) studied a possible carbon tax in Russia. They found, unlike some of these other studies, that a strong double dividend could exist when labor taxes were reduced, but that this depends heavily on labor supply elasticity. Finally, a recent paper by Metcalf and Stock (2019) detailed through a regression analysis how a carbon tax could be implemented and not significantly impact the economy in a negative way. These studies in large countries (or groups of countries, in the case of the European Community) are instructive, but it is possible that they are not as relevant as we might wish to a small, open economy like Nebraska.

This next section will look at carbon tax studies in several countries, as well as two Canadian provinces. First of all, Robson (2014) holds up Australia as an example of what *not* to do when implementing a carbon tax. Conefrey et al. (2013a) studied a possible carbon tax in the country of Ireland. They found that a double dividend would exist if income taxes were reduced, but not in the case of lump sum payments to the populace. A very similar situation was found by Allan et al. (2014a) with Scotland, with the important caveat the revenue would need to be recycled within Scotland, rather than the United Kingdom as a whole. Looking at Taiwan, Bor and Huang (2010) found a double dividend in the scenarios where a carbon tax was combined with a personal income tax or business income tax reduction. Kiuila and Markandya (2009) write that in their research on Estonia, the best economic outlook resulted when they recycled the revenue from a theoretical carbon tax to environmental protection programs, leading to increased employment, and thus, consumer welfare. Closer to home, Landa Rivera et al. (2016) find that both environmental benefits and economic growth can be achieved when recycling revenues from an energy tax in Mexico. In the Canadian province of Saskatchewan, Liu et al. (2018) found that a carbon tax could be beneficial for the environment, but that it would be bad for resource-driven economy of that province. On the other hand, British Columbia's law has been shown by Murray and Rivers (2015) to have reduced carbon emissions and provided some form of double dividend.

It can therefore be seen that the literature supports a view that carbon taxes can very well achieve a double dividend effect in certain cases. Well-implemented public policy can both protect the environment and create more efficiency in the economy, with less disruption than other solutions. But can it work everywhere?

3 Methodology

The second portion of this thesis seeks to identify whether a carbon tax, applied in the state of Nebraska, would potentially exhibit the double dividend effect. To that end, I constructed a computable general equilibrium (CGE) model. This simple model makes many assumptions about the nature of real-world economic activity but nonetheless achieves results that make good economic sense and which more experienced researchers could easily corroborate. In the next few subsections, an overview is given of the data and the equations used to construct the model. I used the free demo version of the computer software program General Algebraic Modeling System (GAMS). I also based my model off an example model available in GAMS documentation, tweaking it for my analysis and data needs.

3.1 Computable General Equilibrium Model

3.1.1 Domestic Production

The first set of equations in the Computable General Equilibrium (CGE) model is domestic production. These equations describe how intermediate inputs and factors are used to produce output across sectors of the economy.

$$Y_j = b_j \prod F_{h,j}^{\beta_{h,j}} \qquad (1)$$

(1) is the composite factor equation. Y_j represents the composite factor. b_j is the scale parameter in the production function, $F_{h,j}$ is the h^{th} factor input by the j^{th} sector, and $\beta_{h,j}$ represents the share parameter.

$$F_{h,j} = \beta_{h,j} py_j \frac{Y_j}{pf_h} \qquad (2)$$

Next, (2) shows the factor demand function. $F_{h,j}$ is the demand for the h^{th} by the j^{th} sector. py_j is the composite factor price and pf_j is the factor price.

$$X_{i,j} = ax_{i,j} Z_j \qquad (3)$$

(3) exhibits the intermediate demand function, where $X_{i,j}$ is the intermediate input into the i^{th} sector by the j^{th} sector. Furthermore, $ax_{i,j}$ is the intermediate input requirement coefficient and Z_j is the output from the j^{th} sector.

$$Y_j = ay_j Z_j \qquad (4)$$

Equation (4) shows the composite factor demand function. Y_j represents the composite factor, while ay_j shows the composite factor input requirement coefficient.

$$pz_j = ay_j py_j + \sum ax_{i,j} pq_i \qquad (5)$$

The last of the domestic production equations is (5), the unit cost function. Here, pz_j and pq_i represent the supply price of the $i^t h$ good and Armington's composite good price, respectively.

3.1.2 Government Behavior

The next set of equations we look at display government behavior in the model. This is particularly important given the subject of study.

$$Td = \tau d \sum pf_h FF_h \qquad (6)$$

Government behavior begins with equation (6). τd shows the direct tax by the government on households. FF_h is the factor endowment of the $h^t h$ factor, and pf_h is its price.

$$Tz = \tau z_j pz_j Z_j \qquad (7)$$

In equation (7), τz_j is the tax rate on capital. It includes both the existing taxes on businesses in Nebraska, as well as the theoretical carbon tax being assessed in the model.

$$Tm = \tau m_i pm_i M_i \qquad (8)$$

Equation (8) shows revenue from tariffs. It is not really used in the model, as U.S. states cannot levy tariffs, but it is included for the sake of completeness.

$$Xg_i = \mu_i \frac{Td + \sum Tz_j + \sum Tm_j - Sg}{pq_i} \qquad (9)$$

This equation displays the government spending in the i^{th} sector. μ represents government spending in the i^{th} sector as a share of total government spending, which is then multiplied by the sum of all government revenues, minus government saving.

3.1.3 Investment Behavior

This next section deals with investment in the model economy. It shows the total amount of investment in different sectors, as well as government and private saving.

$$Xv = \lambda_i \frac{Sp+Sg+\epsilon Sf}{pq_i} \qquad (10)$$

Equation (10) models the total investment demand in the Nebraskan economy. λ_i is the share of total investment in the economy in the i^{th} sector. λ is then multiplied by the sum of all saving in the economy, divided by the price of Armington's composite good (see page 14).

$$Sp = ssp \sum pf_h FF_h \qquad (11)$$

Equation (11) deals with private saving. The average propensity for private saving, ssp, is multiplied by the sum of the price of the h^{th} multiplied by the endowment of that factor.

$$Sg = ssg(Td + \sum Tz_j + \sum Tm_j) \qquad (12)$$

Similarly to the previous equation, (12) deals with saving, this time that of the government. Average propensity for government saving is multiplied by the sum of all tax revenue that the government receives.

$$Xp = \alpha_i \frac{\sum pf_h FF_h - Sp - Td}{pq_i} \qquad (13)$$

Last of all in the investment behavior section, we have household consumption. Elasticity of substitution for the $i^t h$ good is multipled by the sum of the price of each factor multiplied by the endowment of said factor, minus private saving and income tax, diivided by the price of Armington's composite good.

3.1.4 International Trade

Although international trade does not figure heavily into this particular model, it is still included for the sake of completeness.

$$pe_i = \epsilon pWe_i \qquad (14)$$

The purpose of equation (14) is merely to set the export price of the i^{th} good in the local currency, pe_i, equal to the world price, pWe_i, with the help of the exchange rate ϵ.

$$pm_i = \epsilon pWm_i \qquad (15)$$

Equation (15) is similar to (14), but for the import price of the i^{th} good, rather than the export price.

$$\sum pWe_iE_i + Sf = \sum pWm_iM_i \qquad (16)$$

Equation (16) merely ensures that the sum of the value of all exports E_i, plus foreign saving Sf, is equal to the sum of the value of all imports.

3.1.5 Armington Function

The elasticity of substitution in this model is based on the Armington function. It is a constant elasticity of substitution (CES) model that says the only difference between local and foreign goods for consumers is that they were produced in different places (CITE). While this is quite simplistic, it is not so important when making such a simple model, especially of an individual U.S. state.

$$Q_i = \gamma_i(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i})^{\frac{1}{\eta_i}} \qquad (17)$$

Equation (17) determines the Armington composite good for the i_th sector. γ_i denotes the scale factor for the i_th sector. δm_i and δd_i show, respectively, the share parameter in the Armington function for the foreign M_i and local D_i goods. M_i and D_i are raised to η_i, the parameter for elasticity of substitution.

$$M_i = \frac{\gamma_i^{\eta_i} \delta m_i pq_i}{(1+\tau m_i) pm_i}^{\frac{1}{1-\eta_i}} Q_i \qquad (18)$$

Equation (18) shows the calculation for the value of imports in the i^{th} sector.

$$D_i = \frac{\gamma_i^{\eta_i} \delta d_i pq_i}{pd_i}^{\frac{1}{1-\eta_i}} Q_i \qquad (19)$$

Similarly to above, (19) shows the calculation for the value of domestic goods in the i^{th} sector.

3.1.6 Transformation Function

The transformation function equations are very similar to the Armington function, except that they deal with the supply of goods, rather than the demand.

$$Z_i = \theta_i (xie_i E_i^{\phi_i} + xid_i D_i^{\phi_i})^{\frac{1}{phi_i}} \qquad (20)$$

Equation (20) deals with the output of the $i^t h$ sector, Z_i. xie_i is the export share parameter in the transformation function, while xid_i is the parameter for the domestic good. ϕ is the transformation elasticity parameter.

$$E_i = (\frac{\theta_i^{\phi_i} xie_i (1+\tau z_i) pz_i}{pe_i})^{\frac{1}{1-\phi_i}} Z_i \qquad (21)$$

Next is the calculation for exports. θ_i is the scale parameter for the transformation function. Without going too much into details, equation (21) determines what fraction of the total output of the i^{th} sector is exported.

$$D_i = (\frac{\theta_i^{\phi_i} xid_i (1+\tau z_i) pz_i}{pd_i})^{\frac{1}{1-\phi_i}} Z_i \qquad (22)$$

Just like equation (21), equation (22) is the fraction of the total output that remains in state for domestic consumption.

3.1.7 Market Clearing Conditions

$$Q_i = Xp_i + Xg_i + Xv_i + \sum (X_{i,j} \qquad (23)$$

The purpose of the market clearing condition in equation (23) is to make sure that there is no excess demand or supply for the goods produced by the i^{th} sector.

$$\sum F_{h,j} = FF_h \qquad (24)$$

The purpose of the market clearing condition in equation (24) is to make sure that there is no excess demand or supply for the factors supplied by the household.

3.1.8 Utility Function

$$Utility = \prod Xp_i \alpha_i \qquad (25)$$

Equation (25) details a fictitious utility objective that is useful for determining if some change to the economy will increase or decrease the well-being of its members.

3.2 Data

Finding good data constituted one of the most difficult aspects of this research. In the end, I used data supplied by an adviser. It represented the Nebraskan economy in a social accounting matrix (SAM) with twenty-six production sectors, two factors of production, nine household brackets, one investment sector, twenty tax sectors (local, state, and government), thirteen government services sectors, and a rest of world sector. In order to fit this data into the constraints of the GAMS demo version and my beginner CGE knowledge, I aggregated this data into seven production sectors, two factors of production, one household bracket, one investment sector, one indirect tax sector, one government services sector, and a rest of the world sector. The seven production sectors are as follows: manufacturing, utilities, transportation, private services, commercial, and miscellaneous-non-emissions-producing. Another issue with this data is that it is dated (from 2004).

	Production Sectors	Factors	Household	Investment	Government	Rest of World
Production Sectors	Intermediate Inputs		Household Consumption	Investment	Government Spending	Purchases by Rest of World
Factors	Payments to Factors of Production					
Household		Factor Possession				
Investment			Household Saving		Government Saving	Foreign Saving
Government	Taxes on Capital		Taxes on Labor		Transfers from Federal Government	
Rest of World	Transfers to Rest of World					

Figure 1: Social Accounting Matrix (SAM) for Nebraska

This constraint is unfortunate, but something I had to work with due to constraints on resources. I think that my findings are certainly interesting enough to justify more research on the topic in the future. Below is a representation of the SAM I used for my analysis.

4 Results

In order to assess whether a double dividend effect would be seen if Nebraska levied a carbon tax, I modelled three different scenarios. In each, the government imposes a relatively modest carbon tax of $10 per ton of carbon emissions. However, I made the tax revenue-neutral in a different way for each scenario. In the first, the state merely sends the revenue from the carbon tax to households in the form of lump sum payments. In the second, I offset the carbon tax with an equal cut in direct labor taxes on households. Finally, in the third scenario, the state cuts taxes on capital in order to offset the new carbon tax. In the following tables, I summarize the results of these simulations. Some key indicators are observed: change in production, household consumption, government spending, investment demand, exports, and imports in each sector of the economy, as well as changes in government and private saving, and the overall increase or decrease in consumer welfare.

4.1 Scenario One

The first scenario to be assessed is lump-sum payments. In this simulation, the government assesses the \$10 per ton carbon tax on every sector of the economy. The state offsets this gain in revenue by an equivalent cut in labor taxes on the household. Tables 1 and 2 summarize the results of this simulation in selected indicators.

Table 1: \$10 per ton carbon tax with lump-sum payout

	Misc.	**Manuf.**	**Trans.**	**Utilit.**	**Commer.**	**Services**
$\%\Delta Labor$	-0.429	-0.665	-0.565	0.944	0.370	0.395
$\%\Delta Capital$	-0.271	-0.507	-0.407	-0.786	0.530	0.555
$\%\Delta Production$	-0.298	-0.615	-0.512	-0.835	0.417	0.446
$\%\Delta HouseholdConsumption$	1.537	1.503	1.478	1.510	1.489	1.495
$\%\Delta GovernmentSpending$	-7.120	-7.151	-7.173	-7.144	-7.163	-7.158
$\%\Delta InvestmentDemand$	-0.037	-0.070	-0.095	-0.063	-0.084	-0.078
$\%\Delta Exports$	-0.214	-0.584	-0.495	-0.764	0.430	0.465
$\%\Delta Imports$	-0.552	-0.704	-0.556	-0.948	0.402	0.417

Table 2: Saving, \$10 per ton carbon tax with lump-sum payout

	Change
$\%\Delta PrivateSaving$	0.061
$\%\Delta GovernmentSaving$	0.153

First of all, this scenario shows consumers realizing a 1.51% increase in welfare. Therefore, it does seem to meet the threshold for a weak double dividend. In the usage of factors of production the miscellaneous non-carbon sector, manufacturing, and transportation experience decreases, while factor usage in the commercial and services sectors increases. Most interestingly, payments to labor increase by almost an entire percentage point and payments to capital decrease slightly less in utilities. This could reflect a reality in which the carbon tax causes less capital to be used in the production of electrical power, but more labor is needed to meet demand. Following on from the trends in payments to factors, production in the first four sectors also falls, while production in services and commercial increases. The same is true for exports and imports. This results makes sense for exports, but it would seem like the opposite should be true for imports. Household consumption rises across the board—likely a result of the lump-sum tax putting more disposable income in consumers' pockets. Government spending, on the other hand, drastically decreases for some reason. This could possibly be due to the model not adequately capturing the effect of the policy change on government behavior. Investment demand slightly falls for all sectors as well.

4.2 Scenario Two

Under scenario two, the government assesses the \$10 per ton carbon tax on every sector of the economy. Instead of recycling revenue by a one-time payment to consumers, there will be a cut in labor taxes, the most obvious of which would be state income tax. Tables 3 and 4 summarize the results of this simulation in selected indicators.

Table 3: $10 per ton carbon tax with labor tax reduction (all percentages)

	Misc.	**Manuf.**	**Trans.**	**Utilit.**	**Commer.**	**Services**
$\%\Delta Labor$	-0.457	-0.866	-0.748	-0.431	0.325	0.531
$\%\Delta Capital$	-0.324	-0.733	-0.615	-0.298	0.459	0.666
$\%\Delta Production$	-0.347	-0.824	-0.703	-0.339	0.363	0.574
$\%\Delta HouseholdConsumption$	1.530	1.501	1.479	1.504	1.489	1.495
$\%\Delta GovernmentSpending$	-3.385	-3.413	-3.434	-3.409	-3.424	-3.419
$\%\Delta InvestmentDemand$	-2.419	-2.448	-2.469	-2.444	-2.459	-2.454
$\%\Delta Exports$	-0.268	-0.790	-0.681	-0.271	0.384	0.600
$\%\Delta Imports$	-0.586	-0.923	-0.762	-0.447	0.342	0.535

Table 4: Saving, $10 per ton carbon tax with labor tax reduction

	Change
$\%\Delta PrivateSaving$	-0.051
$\%\Delta GovernmentSaving$	-3.541

There is an increase in consumer welfare under this scenario, and oddly enough, it is the exact same as that in scenario one: 1.51%. In fact, many of the results of this simulation line up closely to the lump-sum payment method. Payments to labor and capital decrease in the non-carbon miscellaneous, manufacturing, transportation, and utilities sectors. They increase in the commercial and services sectors. These changes correspond again with those of production, exports, and imports. The increase in household consumption is about the same as in Scenario One. Similarly to Scenario One, government spending decreases, but although they are significant decreases, they are still about half of those in Scenario One. On the other hand, the decrease in investment demand is more severe in Scenario Two.

4.3 Scenario Three

Under scenario three, the government assesses the $10 per ton carbon tax on every sector of the economy. This time, the carbon tax is offset with reductions in capital taxes, with each sector received equal relief. Tables 5 and 6 summarize the results of this simulation in selected indicators.

Table 5: $10 per ton carbon tax with capital tax reduction (all percentages)

	Misc.	**Manuf.**	**Trans.**	**Utilit.**	**Commer.**	**Services**
$\%\Delta Labor$	-0.004	-0.005	-0.008	-0.006	-0.006	0.007
$\%\Delta Capital$	-0.003	-0.004	-0.007	-0.005	-0.005	0.009
$\%\Delta Production$	-0.003	-0.005	-0.008	-0.005	-0.006	0.008
$\%\Delta HouseholdConsumption$	-0.021	-0.016	-0.034	-0.037	-0.014	-0.009
$\%\Delta GovernmentSpending$	0.077	0.082	0.064	0.061	0.084	0.089
$\%\Delta InvestmentDemand$	-0.015	-0.010	-0.028	-0.032	-0.009	-0.003
$\%\Delta Exports$	-0.003	-0.009	-0.007	-0.009	0.003	0.021
$\%\Delta Imports$	-0.005	0.005	-0.009	0.000	-0.016	-0.012

Table 6: Saving under the capital tax scenario

	Change
$\%\Delta PrivateSaving$	0.000
$\%\Delta GovernmentSaving$	0.005

Consumers realize the largest gain in welfare under the capital tax scenario: 4.86%. Furthermore, most of the increases and decreases across the different sectors were very small, indicating that the tax reform is not too disruptive. With regard to payments in labor and capital, all sectors but services see a decrease. A similar situation is seen with production. For exports and imports, the same trends are seen as in the previous scenarios although, again, with much smaller changes. Household consumption descreases slightly, which makes sense since the household does not see any direct gain from the policy change. Government spending rises across the board, and these are the largest increases of the simulation, although still much smaller than those seen earlier. Investment demand also has small decreases in all sectors, which is a little strange, considering the greater availability of capital. Finally, there zero change in private saving and a very small increase in government saving.

5 Conclusions

Somewhat surpringly, all of the scenarios in this analysis exhibited an increase in welfare, and therefore a double dividend effect. However, Scenarios One and Two also show some more distortionary effects on different areas of the economy. In a reflection of what I find in the literature on the topic, offsetting a new carbon tax with decreases in capital-based taxes seems to be the smartest move. In Nebraska it could be possible to specifically offset a new carbon tax with reductions in property taxes, a perennial source of angst. Naturally, more study would be required before the Unicameral would enact any such legislation. There is also the problem of education—making people realize that climate change *is* a serious issue that we must address. Even better would be a nationwide carbon tax that could probably reduce more emissions that occur in more industrialized states. Nevertheless, it would be helpful if Nebraska took the lead on the issue, especially with the federal government so immoveable on environmental policy.

I find in my study that carbon taxes are most likely to exhibit the double dividend effect when they are offset with a reduction in taxes on capital. This situation holds even in a relatively small U.S. state like Nebraska. This is a great public policy option that adjusts incentives for the private sector to better reflect a socially optimal equilibrium, rather than dictating massive projects from above. The problem of climate change is very great. I believe that one part of the solution has to be carbon pricing and taxes on a worldwide, or at least nationwide, scale. Additionally, the U.S. government ought to pour funding into research on radical technologies that have the potential to make a big difference. We have waited too long to put all of our hopes in things like wind and solar energy. Carbon taxes, therefore, are just a piece of the puzzle, but a very important one.

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