Dangers of Using Political Preference Functions in Political Economy Analysis: Examples from U.S. Ethanol Policy

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Summary

Rausser and Freebairn (1974) proposed a method for empirically measuring the political power of interest groups competing in real-world political economies. In the first half of the 1990s, staunch criticism of PPF methodology appeared. Von Cramon-Taubadel (1992) obtained counter-intuitive results in PPF simulations using a simple model of EU wheat and barley policy instrument use. Bullock (1994) emphasized that PPF methodology requires that observed policy be Pareto efficient policy, which requires researchers to manipulate the dimensions of their models so that the number of interest groups is exactly one more than the number of policy instruments. He concluded "[PPF methods] need not reveal anything meaningful about interest group political power, and may incorrectly measure the direction of transfers" (Bullock 1994, p. 347). The criticisms of the PPF approach were cogent, published in leading agricultural economics journals, and deserved carefully argued response from anyone wishing to continue publishing PPF research. None came forth, even though many PPF studies appeared since.

In the present article we provide a step-by-step demonstration of the potential pitfalls of the PPF approach. For our purpose in this article is to once again critique PPF methodology, but this time in a more methodical and less abstract fashion, in hopes of catching and keeping the attention of the upcoming generation's agricultural political economists. For concreteness, we have chosen a model of U.S. ethanol policy for our simulations. We build the model so that its economic agents can be aggregated or divided into various groups of different sizes, and its several policy instruments can be included or excluded from the model. In these ways, our model is flexible enough for us to use it to illustrate the various issues of model dimension that confront the potential PPF modeler.

JEL Classification codes: Q18, Q16, Q48

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1. Introduction and Background

In 1974, Gordon Rausser and John Freebairn published an article that proposed a method for empirically measuring the political power of interest groups competing in real-world political economies (Rausser and Freebairn 1974). This method is often referred to as the political preference function (PPF) approach. Many researchers employed PPF methodology over the two decades following its publication. For example, attempts were made to measure the relative political powers of U.S. consumers, livestock feeders, private stockholders of wheat, taxpayers, and wheat farmers (Paarlberg and Abbott 1986); of Greek cotton farmers and taxpayers (Lianos and Rizopoulos 1988); and of U.S. wheat producers, wheat consumers, and taxpayers (Oehmke and Yao 1990). (For a survey, see Swinnen and van der Zee (1993).)

Staunch criticism of PPF methodology was published in the first half of the 1990s. Von Cramon-Taubadel (1992) argued that PPF weights should change not only when "political preferences" change, but also when market parameters change, and therefore that changes in the measured weights cannot be attributed solely to changes in political preferences. He also argued that PPF methodology leaves key aspects of real-world political economy not considered, such as institutions and the interactions between different policy instruments. He illustrated his arguments by obtaining counter-intuitive results in simulations using a simple model of EU wheat and barley policy. A key result was that his model's estimated PPF weights varied greatly from year to year, even though relative transfers among interest groups did not. Von Cramon-Taubadel concluded that "the revealed PPF approach has been studied and applied without scrutiny and has been found to generate results which are difficult to interpret" (1992, p. 382). Swinnen and van der Zee (1993, p. 266) criticized the PPF approach for over-simplifying the political-economic process that it claims to summarize: "The abstract policy-maker is an artificial concept to circumvent the modeling of the political market." *Reference withheld* continued the critique of PPF methodology, emphasizing that it required that observed policy be Pareto efficient policy, which often requires researchers to manipulate the dimensions of their models so that the number of interest groups is exactly one more than the number of policy instruments. He drew a conclusion similar to von Cramon-Taubadel's: "[PPF methods] need not reveal anything meaningful about interest group political power, and may incorrectly measure the direction of transfers" .

The criticisms of the PPF approach were cogent, published in leading agricultural economics journals, and deserved carefully argued response from anyone wishing to continue publishing PPF research. None came forth, even though many PPF studies have been published since, also in leading agricultural economics journals (Rausser and Goodhue 2002; Redmond 2003; Burton, Love, and Rausser 2004; Atici 2005; Atici and Kennedy 2005; Lence et al. 2005; Lee and Kennedy 2007; Francois, Nelson, and Pelkmans-Balaoing 2008, Rausser and Roland 2008; Ahn and Sumner 2009), and an important and insightful new book on political economy has recently been published which has PPF methodology as a central focus (Rausser, Swinnen, and Zusman 2011). That the critiques of the PPF approach have had little impact is understandable--discussions in *Reference withheld* were arcane and easily ignored. In an attempt to compensate, in the present article we provide a step-by-step, methodical demonstration of the potential pitfalls of PPF approach. For concreteness, we have chosen to work with a model of U.S. ethanol policy. Several similar models have recently appeared in the agricultural economics literature, so many agricultural policy analysts and political economists will be familiar with the model's policy instruments and interest groups. We build the model so that its economic agents can be aggregated or divided into various groups of different sizes, and its several policy instruments can be included or excluded from the model. In these ways, our model is sufficiently flexible for us to use it to illustrate the various issues of model dimension that confront the potential PPF modeler.

2. A FRAMEWORK FOR THE DISCUSSION

Following Harsanyi (1963; 1977), Zusman (1976), *Reference withheld* and *Reference withheld*, we now briefly present a framework for our discussion of the PPF approach and model dimension. Let a model's "government" have available m policy instrument variables[1], $x_1, \ldots, x_m$. We define a *policy* as a value of the vector of policy instruments variables $\mathbf{x} = (x_1, \ldots, x_m) \in \mathbb{R}^m$. Let the model feature n interest groups. Call $\mathbf{b} = (b_1, \ldots, b_z)$ the vector of the model's parameters. (These parameters might represent supply and demand elasticities, for example.) The welfare of each interest group i is a function of government policy, as well as of the model's parameters: $u_i = h_i(\mathbf{x}, \mathbf{b})$, where $h_i: \mathbb{R}^m \rightarrow \mathbb{R}$, $i = 1, \ldots, n$. Then the vector of welfare functions is $\mathbf{h}(\mathbf{x}, \mathbf{b}) = (h_1(\mathbf{x}, \mathbf{b}), \ldots, h_n(\mathbf{x}, \mathbf{b}))$, where $\mathbf{h}: \mathbb{R}^{m+z} \rightarrow \mathbb{R}^n$. We assume that the parameters of the economic model do not change--that is, that $\mathbf{b}$ is constant. We will suppress $\mathbf{b}$ for notational convenience, and denote the vector of utility functions $\mathbf{h}(\mathbf{x})$. Letting $X \subseteq \mathbb{R}^m$ be the set of policies from which the government might choose, then $\mathbf{h}$ and X parametrically define a *manifold* in $\mathbb{R}^n$ (Weisstein 2012), a type of "utilities possibilities" or "feasible welfare" set.

[1] Our model and the political preference function (PPF literature) which we will discuss, have several terms and concepts in common with the very large literature on the "number of policy instruments and number of policy objectives," begun by Tinbergen (1952; 1956), and greatly influenced by Theil (1964). But the two literatures are very different. The literature following Tinbergen's approach addresses how the number of policy instruments affects the pursuit of multiple policy objectives (e.g., keeping inflation low and keeping unemployment low). The PPF literature concentrates on the positive analysis of political economy, and in particular on the empirical measurement of interest groups' political power.

Definition. A policy model's *welfare manifold* is,

$$H(X)=\{\mathbf{h}(\mathbf{x}):\mathbf{x}\in X\}.$$

The welfare manifold is the set of all welfare outcomes that government policy can bring about through policy.

Definition. For generic subsets $S\subseteq X$ and $T\subseteq W$, one of the policy model's *welfare submanifolds* is,

$$H_T(S)=\{\mathbf{h}_T(\mathbf{x}):\mathbf{x}\in S\}.$$

Any of a model's welfare submanifolds is a subset of its welfare manifold.

We can use the framework just introduced to discuss the PPF literature. PPF studies assume that the policy-making process can be adequately described (in "reduced form" (Rausser and Foster 1990, 642; Grossman and Helpman 1994, 840–841) as a government choosing policies to maximize a weighted average of the welfare levels of interest groups (Gardner 2007). Many PPF studies try to measure the "political weights," α_i, of the interest groups.

3. A MULTI-MARKET MODEL OF U.S. ETHANOL POLICY

The structure of an economic model of U.S. ethanol and tax policy is represented in figure 1.[2] There are six basic resource markets: (1) grain-specific resources (think of farmland owners and human capital

[2] This model shares much with various recent models of ethanol policy, including Gardner (2007), Martnez-Gonzalez, Sheldon, and Thompson (2007), Schmitz, Moss, and Schmitz (2007), Babcock (2008), Du, Hayes, and Mallory (2009), and Elobeid and Tokgoz (2008). Due to space limitations, we do not offer a review of these works, nor do we compare our model to theirs in detail. We do not intend to offer a definitive model of U.S. ethanol policy, but rather have developed our model for the purposes illustrating our discussions of Pareto efficiency and PPF methodology.

owned by corn farmers), (2) crude oil, (3) refinery-specific capital and labor (think of Exxon-Mobil, Conoco-Phillips, etc.), (4) ethanol-specific capital and labor (think of Archer-Daniels Midland, Aventine, etc.), (5) (non-feed) livestock inputs (ranchers and feedlot owners' sector-specific human and physical capital), and (6) (non-sector-specific) labor. These are indexed by *c* ("corn"), *o* ("oil"), *r* ("refinery"), *a* ("ADM and others"), *l* ("livestock"), and *ws* ("work supply"). The supply of each basic resource is upward-sloping with respect to the suppliers' price. Grain-specific resources and ethanol-specific resources are used to produce an intermediate product, ethanol, indexed by *b* ("biofuel"). Crude oil and refinery-specific resources are the inputs to the other intermediate product, gasoline, indexed by *g*. The two intermediate products are the inputs to the production of a consumer good, fuel (indexed by *f*). Livestock inputs and grain-specific resources are used to produce the second consumer good, meat (indexed by *m*). The non-sector-specific labor market is taxed as much as necessary to meet a requirement for government's budget to be balanced.

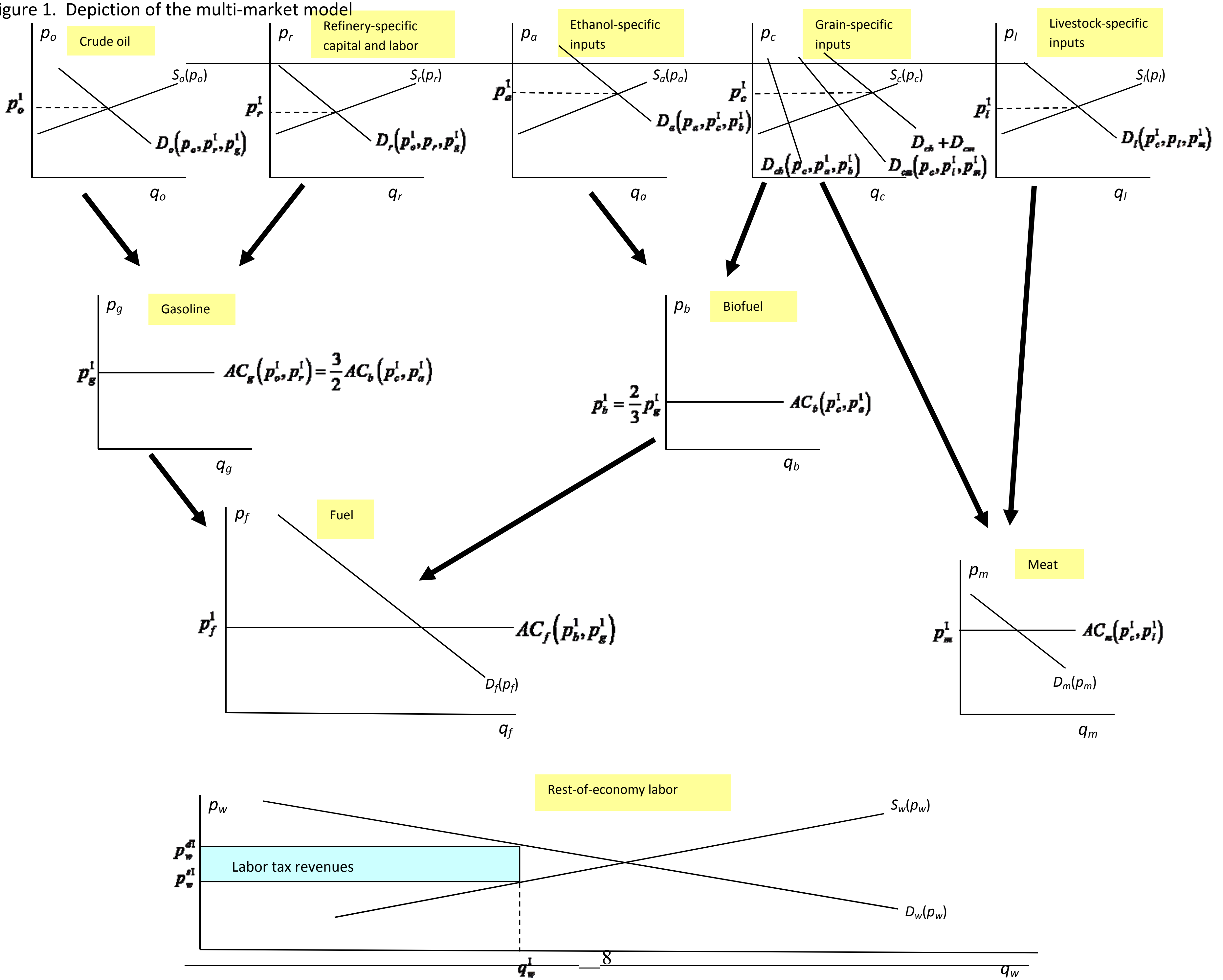
Gasoline and ethanol can be combined to make fuel using an additive production function. The additive production function implies that gasoline and ethanol are modeled as perfectly substitutable inputs to fuel production, with 3/2 gallons ethanol perfectly replacing a gallon of gasoline, and 2/3 gallons of gasoline perfectly replacing a gallon of ethanol. Meat, ethanol, and gasoline are produced according to Leontief technologies. The denominations of units of ethanol-specific resources, refinery-specific resources, and livestock-specific resources are adjusted so that one unit of refinery-specific resource is combined with one unit of crude oil to produce one gallon of petroleum-based fuel, one unit of ethanol-specific resources is combined with 0.444 bushels of corn to produce one gallon of ethanol, and one unit of livestock-specific resources is combined with 0.120 bushels of corn to produce one pound of meat.[3] Industry-level constant returns to scale are assumed in ethanol, fuel, and meat production.[4]

We define two types of equilibria: the first does not and the second does involve an ethanol consumption mandate. Details of the derivations of these equilibria appear in on-line Appendix 1. The *Mathematica* program written to create the figures and simulation results reported in this article appears in on-line Appendix 2. We use **t** to denote a vector of tax/subsidy instrument variables, with one such variable for each market. We denote the no-mandate equilibrium function as $\mathbf{e}^*(\mathbf{t})$, a vector of equilibrium quantity and price functions dependent on taxes and subsidies. In a more general case, the ethanol mandate may or may not be imposed. The use mandate forces the producers of "fuel" to use some minimum amount of ethanol. With the mandate available, the government has ten instruments with which to affect economic equilibria: the taxes/subsidies **t** and the biofuel use mandate q_{bman}. We use notation similar to that above to denote the economic equilibrium function by $\mathbf{e}'\left(\mathbf{t}, q_{bman}\right)$, a vector of equilibrium quantities and price functions dependent on taxes, subsidies, and the ethanol use mandate.

[3] 66.6 billion pounds of meat consumed in the U.S. in 2007 (retail cut basis), with about 8 billion bushels of corn going to feed gives 66.6/8 = 8.325 pounds of meat per bushel of corn fed, or 0.120 bushels of corn per pound of meat.

[4] The idea is that ethanol production could be increased by 10% by simply increasing the number of ethanol factories by 10%. The new factories could just replicate the production methods of the previously existing factories. The reason infinitely many ethanol factories are not built after a rise in the price of ethanol is because the supply curves of the basic resources are upward-sloping. Therefore increased demands for corn ("grain-specific resources") and for expertise in ethanol production ("ethanol-specific resources") cause the prices that the ethanol-producing firms pay for these to rise to the point at which all profits for ethanol producing firms are choked off in equilibrium.

Figure 1. Depiction of the multi-market model



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The model can accommodate the measure of the welfare of a maximum of nine interest groups. Six of these groups are suppliers of basic resources: group *c* (land owners/corn suppliers), group *o* (crude oil producers), group *r* (refiners), group *a* (suppliers of non-corn inputs to ethanol), and group *ws* (employees). Three of the groups are demanders: group *wd* (employers), group *f* (fuel consumers), and group *m* (meat consumers). Firms that produce gasoline, ethanol, fuel, or meat are assumed to operate in perfectly competitive markets, earn zero economic profits and accrue no welfare.[5]

4. EFFICIENCY AND THE DIMENSION OF THE POLITICAL ECONOMY MODEL

We will now show that conclusions about the "efficiency" of ethanol policy can depend crucially upon the assumed *dimension* of the model—that is, upon how interest groups are aggregated and upon which

[5] For example, think of fuel suppliers simply as the owners of retail service stations—it is reasonable to think that entry and exit in this market means that owners of service stations receive little economic rent.

policy instruments are assumed to be available.. Also, we have included a taxed labor market in the model to so that the theory of "second best"[6] will apply. Since in reality labor markets are taxed to fund government programs, this part of the model is realistic, and is neglected by other models of ethanol policy recently appearing in the literature (Gardner 2007; Martinez-Gonzalez, Sheldon, and Thompson 2007; Schmitz, Moss, and Schmitz 2007; Babcock 2008; Elobeid and Tokgoz 2008; Du, Hayes, and Mallory 2009).[7] We say that a model is "of dimension (*m*, *n*)" if it has *m* variable policy instruments and *n* interest groups. We start by analyzing ethanol-related policy with models of small dimensional components, and continue by increasing the dimensional components step-by-step.

4.1. One Variable Policy Instrument and Two Interest Groups: A Model of Dimension (1, 2)

Policy models that feature one variable policy instrument and two interest groups have appeared frequently in the agricultural policy literature. Often but not always, these models have been meant simply to be illustrative—real political economies are much more complicated than a model of dimension (1, 2) can portray. Classic and seminal examples of such illustrative models of dimension (1, 2) are Josling (1974) and Gardner (1983). These divide the agricultural political economy, modeled in a single

[6] Bovenberg and Goulder (1996) helped begin a large and important literature on this topic of a "double dividend," and other issues of "second best" in ethanol policy have appeared in the literature. Gardner (2007), Schmitz, Moss, and Schmitz (2007) and others have pointed out that because government policy already distorts corn markets, it is possible the intervention in the ethanol market could increase aggregate welfare. In addition, there is a wide discussion in the literature about the relative environmental effects of producing and burning ethanol instead of petro-fuels. Of course, in the presence of externalities it is possible that government intervention can raise the aggregate welfare an otherwise competitive economy.

[7] Also, without labor markets the competitive, non-intervention equilibrium of our model would be Pareto efficient, and we can demonstrate our points more readily if it is not.

market, into "consumers-taxpayers" and "producers." We now examine three different models of dimensions (1, 2): one in which the biofuel tax/subsidy is available to be changed while other policy instruments are constant, one in which the gasoline tax/subsidy is available to be changed while the other the other policy instruments are held constant, and one in which the ethanol use mandate is available to be changed while the other policy instruments are held constant. Because our model contains multiple markets, the two groups we create cannot simply be "producers" and "consumers-taxpayers," since multiple goods are produced and consumed, and various taxes and subsidies may be paid or received. In our models of dimension (1, 2) we aggregate groups *a* and *c* (owners of ethanol-specific inputs and corn farmers/landowners) into one group, indexed *ca*, and aggregate the other groups: crude oil suppliers, refiners, livestock capital and labor owners, employers, employees, fuel consumers, meat consumers into a group we call "everybody else" and index with *orlwfm*.

To analyze welfare impacts, first we assume that only t_b is available to the government. We ignore the potential of changing t_c, t_o, t_r, t_a, t_l, t_f, and t_m, and we suppress them in the notation. Throughout we maintained t_g and q_{bman} at their "current" levels of 0.494 and eight billion. We take as the baseline the welfare levels under the current policy

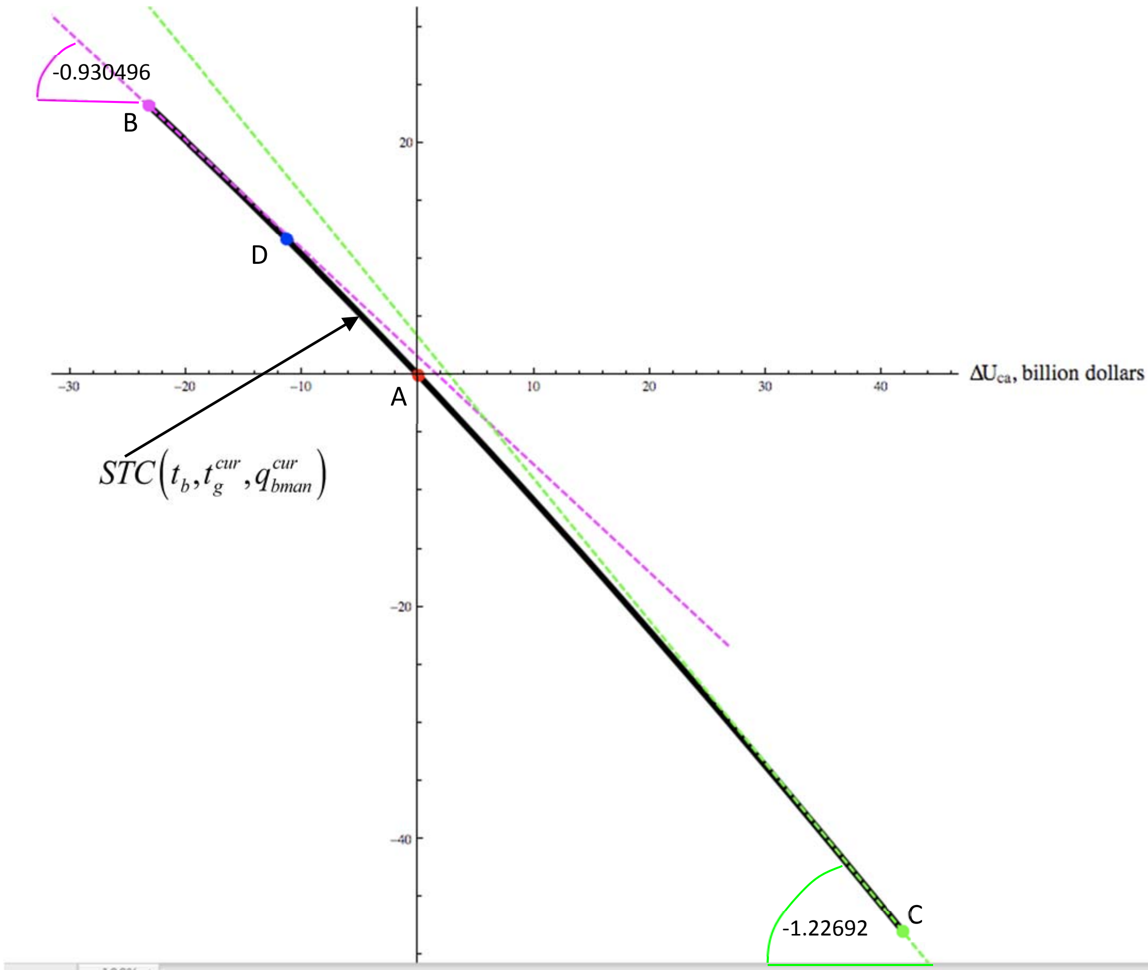
$$\left(U_{orlwfm}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right), U_{ca}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right)\right), \text{ denoted } \mathbf{U}^{cur} = \left(U_{orlwfm}^{cur}, U_{ca}^{cur}\right).$$

Define two functions:

$$\Delta U_{orlwfm}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) = U_{orlwfm}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) - U_{orlwfm}^{cur} \tag{1}$$

$$\Delta U_{ca}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) = U_{ca}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) - U_{ca}^{cur} \tag{2}$$

Figure 2. Surplus transformation cure plotted by changing the ethanol tax/subsidy level and not imposing an ethanol mandate



Equations (1) and (2) define two change-in-welfare (from the baseline level) functions, one each for group *orlwfn* and group *ca*. Given these two functions, the curve in figure 2, labeled $STC\left(t_b, t_g^{cur}, q_{bman}^{cur}\right)$, was traced parametrically by changing the ethanol tax/subsidy from -\$1.50 to \$1.00, and tracing out the movement of the point $\left(\Delta U_{orlwfm}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right), \Delta U_{ca}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right)\right)$ at the different ethanol tax levels. (All simulations were conducted using the *Mathematica* (Wolfram Research 2007) program appearing in the on-line Appendix 2.) Figure 2 shows that the ethanol tax/subsidy can be used to redistribute large amounts of income between interest groups. The diagram shows how imposing a continuum of ethanol taxes/subsidies changes interest group welfare away from the model's measure of welfare under the "currently observed" policy (a gasoline tax of \$0.494/gallon and an ethanol tax of \$0.044/gallon). The origin in the diagram, labeled A, is the point obtained when the current policy is imposed, which maintains the gasoline tax at its observed level of \$0.494/gallon, maintains the use mandate at its current (ineffective) level and sets the ethanol tax/subsidy instrument at its current level of \$0.044/gallon. Point B is (41.8521, -48.0457), meaning that the change in the policy that changed the ethanol instrument from a \$0.044 tax to a \$1.50 subsidy raises the (dollar-denominated) welfare of ethanol-specific income owners and corn growers by \$41.8521 billion and lowers everybody else's welfare by \$48.0457 billion. Point C is (-23.2724, 23.2109), and illustrates that changing the policy from a \$0.044/gallon ethanol tax to a \$1.00/gallon ethanol tax lowers the welfare of ethanol-specific factor owners and corn growers by \$23.27 billion and raises everybody else's by \$23.21 billion.

A number of traditional policy questions can be addressed using this model of dimension (2,1). The first question is "which policy maximizes the economy's aggregate welfare?" Several studies examining various policy contexts have addressed this question. (*Reference withheld* and *Reference withheld* offer reviews.) To answer the question for the model under discussion, the following problem must be solved:

$$\underset{t_b}{Max}\left\{U_{orlwfm}\left(t_b,t_g^{cur},q_{bman}^{cur}\right)+U_{ca}\left(t_b,t_g^{cur},q_{bman}^{cur}\right)\right\}.$$

Since for $i\in\{orlwfm, ca\}$, $U_i\left(t_b,t_g^{cur},q_{bman}^{cur}\right)$ and $\Delta U_i\left(t_b,t_g^{cur},q_{bman}^{cur}\right)$ vary only by a constant, the aggregate utility-maximizing biofuel tax/subsidy must also solve

$$\underset{t_b}{Max}\left\{\Delta U_{orlwfm}\left(t_b,t_g^{cur},q_{bman}^{cur}\right)+\Delta U_{ca}\left(t_b,t_g^{cur},q_{bman}^{cur}\right)\right\}. \quad (3)$$

Call the solution to the problem in (3) t_b^*. The first-order condition is:

$$\frac{\dfrac{\partial \Delta U_{ca}\left(t_b^*, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}}{\dfrac{\partial \Delta U_{orlwfm}\left(t_b^*, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}} = -1. \tag{4}$$

The term on the left-hand side of (4) is the slope of $STC\left(t_b, t_g^{cur}, q_{bman}^{cur}\right)$ at the point $\left(\Delta U_i\left(t_b^*, t_g^{cur}, q_{bman}^{cur}\right), \Delta U_i\left(t_b^*, t_g^{cur}, q_{bman}^{cur}\right)\right)$ = (-11.4046, 11.7461), point *d* in figure 2. The biofuel tax that solves (4) is t_b^* = 0.50213. That is, the model estimates that, if the only ethanol-related policy instrument that could be changed were the ethanol tax/subsidy, national income could be raised by (11.7461 – 11.4046) billion, which is $341.5 million, by raising the current ethanol tax (which is the gasoline tax of 49.4 cents per gallon, minus the ethanol tax credit of 45 cents per gallon, for a net ethanol tax of 4.4 cents per gallon) to 50.2 cents per gallon, slightly more than the current gasoline tax.

4.2. Difficulties with Political Power Measures in the (2, 1)-Model

As an example of difficulties that can arise from PPF methodology, let us use it in an attempt to answer the following question: "What are the relative political power weights of the interest groups that are revealed by the observed policy?" In more mathematical terms, "Which values of α_{ca} and α_{orlwfm} would cause the solution to this problem:

$$\underset{t_b}{Max}\left\{\alpha_{orlwfm}\Delta U_{orlwfm}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) + \alpha_{ca}\Delta U_{ca}\left(t_b, t_g^{cur}, q_{bman}^{cur}\right) : \ \alpha_{orlwfm} \geq 0, \alpha_{ca} \geq 0, \ \alpha_{orlwfm} + \alpha_{ca} = 1\right\} \tag{5}$$

to be the observed actual value of the ethanol tax/subsidy?" The first-order condition is

$$\frac{\dfrac{\partial \Delta U_{orlwfm}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}}{\dfrac{\partial \Delta U_{ca}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}} = -\frac{\alpha_{ca}}{1-\alpha_{ca}}. \tag{6}$$

The numerator on the left-hand side of (6) can be calculated to be 26.8912, and the denominator to be 25.4. Dividing, the left-hand side of (6) is calculated as -1.05871. This is the slope of the surplus transformation curve at the origin in figure 2. Substituting this value into the left-hand side of (6) and then solving for α_{ca}, we obtain,

$$\alpha_{ca} = \frac{\dfrac{\partial \Delta U_{orlwfm}\left(t_b^{*}, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}}{\dfrac{\partial \Delta U_{orlwfm}\left(t_b^{*}, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b} - \dfrac{\partial \Delta U_{ca}\left(t_b^{*}, t_g^{cur}, q_{bman}^{cur}\right)}{\partial t_b}} = \frac{26.8912}{26.8912+25.4} = 0.514259, \tag{7}$$

$$\alpha_{orlwfm} = 1-\alpha_{ca} = 0.485741. \tag{8}$$

The interpretation of the "revealed preference" weight typically made in the PPF literature would be as follows: "Corn farmers/landowners and owners of ethanol-specific factors of production form an interest group that possesses roughly the same amount of political power as does the interest group formed by everyone else in the economy, with the former group's power weight being 0.514259, and the latter's 0.485741."

Figure 2 also illustrates a fundamental weakness of the PPF methodology: *the calculated power weights may tell very little about the sizes of transfers that interest groups pay for or receive*. It is intuitively unappealing that a small change in political power weight can lead to a huge change in the size and direction of income transfer. But the surplus transformation curve in figure 2 is nearly linear. Its slope at point B, achieved by a $1.50 per-gallon ethanol subsidy, is -0.930496. This implies that point B would be the political economic result of a government that assigned at weight of approximately 1/(1 + 0.930496) = 0.518002 to group *ca* (corn farmers/landowners and ethanol-specific capital and labor), and a weight of 0.930496/(1 + 0.930496) = 0.481998 to everyone else in the economy. On the other hand, at point C, which is achieved by one-dollar ethanol tax, the slope of the STC is about -1.22692. This implies that point C would be the political economic result of a government that assigned a weight of 1/(1 + 1.22692) = 0.449051 to group *ca* and a weight of 1.22692/(1 + 1.22692) = 0.550949 to groups *orlwfm*. Notice how very different are points B and C. The PPF model predicts a relatively small change in the political power of group *ca*: at point B, over twenty billion dollars is being transferred to corn farmers/landowners and ethanol input suppliers; at point C, over forty billion dollars is being transferred from them. It should be emphasized that no attempt has been made here to come up with a "special case" with these properties. The model used is quite representative of those used in most PPF studies.

4.3. The Welfare Effects of the Gasoline Tax in the (2, 1)-Model

Next we assume that the only policy instrument that government can change is t_g, the gasoline tax. The ethanol tax/subsidy and the ethanol use mandate are assumed constant at their baseline levels, and the other seven tax/subsidy instruments are maintained at their non-intervention levels. We take as the baseline the welfare levels $\mathbf{U}^{cur} = \left(U_{ca}^{cur}, U_{orlwfm}^{cur}\right)$ as previously defined. Taking steps similar to those we took to examine the effects of the ethanol subsidy/tax, we can obtain a vector of two functions that are dependent on the gasoline tax: $\left(\Delta U_{ca}\left(t_b^{cur}, t_g, q_{bman}^{cur}\right), \Delta U_{orlwfm}\left(t_b^{cur}, t_g, q_{bman}^{cur}\right)\right)$, and we can define a surplus transformation curve $STC\left(t_b^{cur}, t_g, q_{bman}^{cur}\right)$ by tracing out the points generated by continuously varying t_g between 0 and \$4.00/gallon. The resultant curve is presented in figure 3.

It is immediately apparent from figure 3 that the model predicts that raising gasoline taxes can raise the welfare of both groups. That is, beginning at the origin point A, it is possible (by raising gasoline taxes above the current level), to move to a point like E, at which both groups have higher utility levels than at point A. (At E the gasoline tax is $1.50/gallon.) This may seem surprising since the gasoline tax looks to distort the market since it creates a wedge between the marginal cost and marginal willingness to pay for gasoline (the supply and demand curve). But raising the gasoline tax generates government income. Since by assumption the size of the government deficit or surplus must remain constant, increasing the distortion in the agricultural sector allows for a reduction in the distortion in the labor sector, with the aggregate result being that both interest groups are made better off.

Given this model of dimension (2,1), it is not possible to calculate PPF weights given the observed policy, since this can only be done when the observed policy is "Pareto efficient" ((*Reference withheld*). We put this term in quotation marks because Pareto efficiency depends on the dimensions of the model. Comparing figures 2 and 3 demonstrates that changes in the number or types of policy instruments assumed available can easily change whether a modeled policy is Pareto efficient. In figure 2, only the ethanol tax is available for change, and the observed policy outcome at point A is Pareto efficient—there is no available policy that makes all interest groups better off. But in figure 3, the same policy, leading to the same point A, is no longer Pareto efficient, since points like E are obtainable. This all seems rather obvious when discussed with the framework used in this article. But how model dimension affects policy analysis is not well understood in the literature.[8] For if only the ethanol tax/subsidy is available, then the question is, "Which values of α_{ca} and α_{orlwfm} would cause the solution to

$$\underset{t_g}{Max}\left\{\alpha_{orlwfm}\Delta U_{orlwfm}\left(t_b^{cur},t_g,q_{bman}^{cur}\right)+\alpha_{ca}\Delta U_{ca}\left(t_b^{cur},t_g,q_{bman}^{cur}\right):\ \alpha_{orlwfm}\geq 0,\ \alpha_{ca}\geq 0,\ \alpha_{orlwfm}+\alpha_{ca}=1\right\} \quad (10)$$

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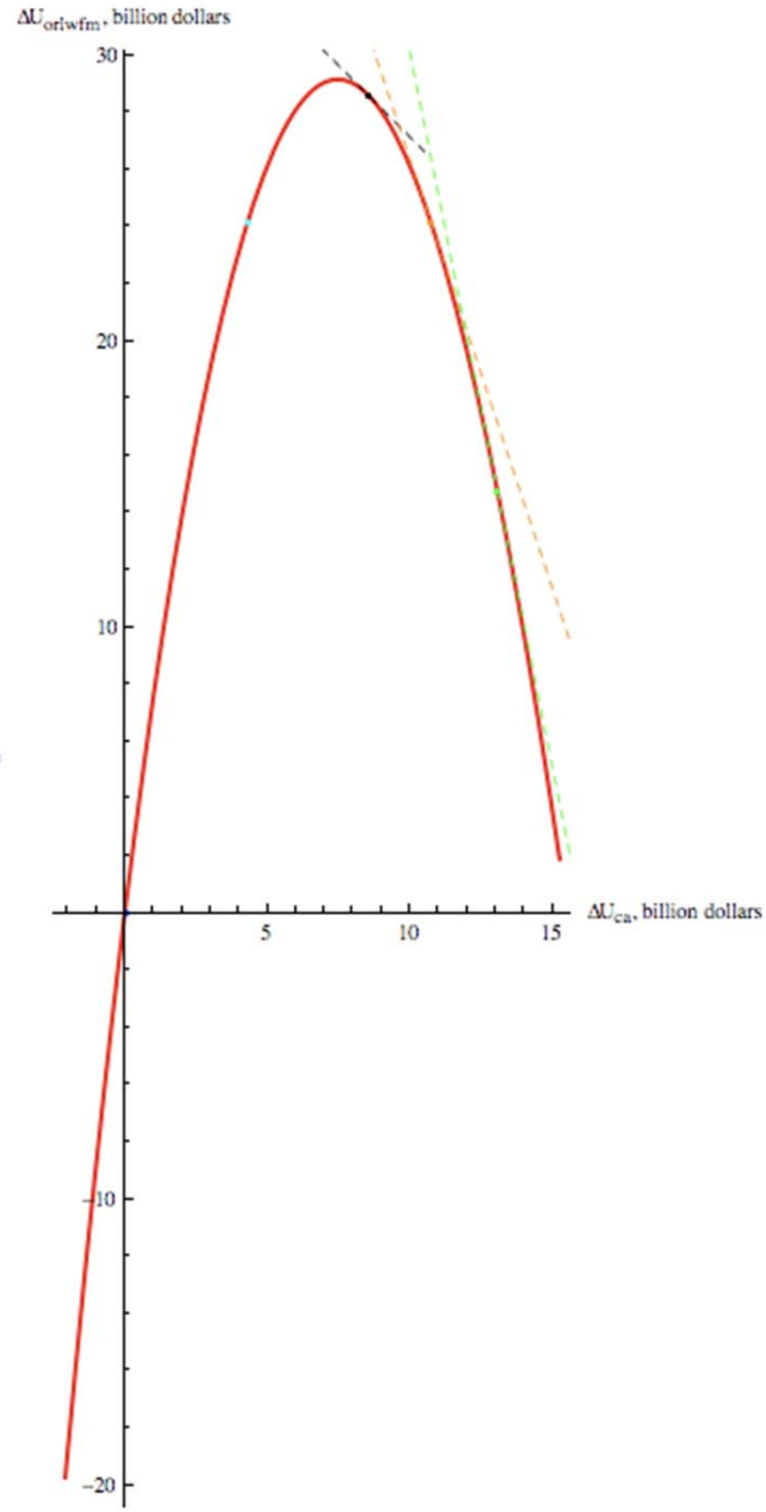
[8] See Appendix 1 for a discussion of how Rausser and Goodhue (2002) misuse Nash's (1950) irrelevant alternative axiom by misstating how removal of policy instruments affects a model's feasible welfare manifold.)

to be the observed actual value of the gasoline tax, t_g^{cur}?" There are no such values. If the weights are non-negative, then any point like E, which is northeast of A, will result in a higher weighted aggregate welfare than will point A. Since points like B are feasible, the answer to the question is that if the observed policy is not Pareto efficient, then the assumption of the PPF model that a problem like (9) is being solved, must be mistaken.

Figure 3. Surplus transformation cure plotted by changing the gasoline tax, holding the ethanol tax/subsidy at its baseline level and not imposing an ethanol mandate



4.4. The Welfare Effects of the Ethanol Use Mandate in the (2, 1)-Model

Now we assume that the only policy instrument that government can change is q_{bman}, the ethanol use mandate. The ethanol tax/subsidy and the gasoline tax are assumed constant at their baseline levels, and the other tax/subsidy instruments are assumed not to be available to government. Again $\mathbf{U}^{cur}$ = $\left(U_{ca}^{cur}, U_{orlwfm}^{cur}\right)$ is the baseline welfare point. Taking steps similar to those we took to look at the effects of the other two policy instruments, we can obtain a vector of two functions that are dependent on the use curve $STC\left(t_b^{cur}, t_g^{cur}, q_{bman}\right)$ by tracing out the points generated by continuously varying q_{bman} between zero and thirteen billion gallons. The resultant curve is presented in figure 4, which shows that increasing the ethanol use mandate raises the welfare of corn farmers and owners of ethanol-specific resources (group *ca*), but lowers the welfare of "everybody else." Another interesting feature of figure 4 is that as we move along the curve towards the southeast, the slope of the curve becomes *less* steep—the curve is concave to the horizontal axis. At point A, the slope of the curve is -0.650313. At point M, the slope of the curve is -0.5549. This shape of the curve has important implications for PPF analysis. For the problem

$$\underset{q_{bman}}{Max}\left\{\alpha_{orlwfm}\Delta U_{orlwfm}\left(t_b^{cur}, t_g^{cur}, q_{bman}\right) + \alpha_{ca}\Delta U_{ca}\left(t_b^{cur}, t_g^{cur}, q_{bman}\right) : \ \alpha_{orlwfm} \geq 0, \alpha_{ca} \geq 0, \ \alpha_{orlwfm} + \alpha_{ca} = 1\right\} \quad (10)$$

has a corner solution. For the sake of an example, let us say that the use mandate can be set no higher than thirteen billion gallons. Then the policy $\left(t_b^{cur}, t_g^{cur}, 13 \text{ billion}\right)$ takes us to point M (43.7047, -26.1931) in figure 4. The slope of the line through A and M is -26.1931/43.7047 = -0.599319. From this number we can derive the PPF weights that make government indifferent between point A and point M: α_{ca} = 0.599319/(1 + 0.599319) = 0.374734, and α_{orlwfm} = 1 - α_{ca} = 0.625266. For any α_{ca} greater than 0.374734, government would choose point A. For any value less than 0.374734, government would choose point M. That is, because of the shape of $STC\left(t_b^{cur}, t_g^{cur}, q_{bman}\right)$, *a very small change in the PPF weights would lead to a very large change in policy from one of no ethanol use mandate to a very large ethanol use mandate.*

$STC\left(t_b, t_g^{cur}, q_{bman}^{cur}\right)$, $STC\left(t_b^{cur}, t_g, q_{bman}^{cur}\right)$, and $STC\left(t_b^{cur}, t_g^{cur}, q_{bman}\right)$ all appear in figure 5. The slopes of the STCs at point A are approximately -0.65, -1.06, and 8.13. Therefore, the measurement of the political power weights would highly depend on which policy instrument is modeled as changing. If only the ethanol tax/subsidy is modeled, the conclusion is that the "everybody else" group is 1.06 times more powerful than the corn farmer and ethanol factories coalition. If only the ethanol mandate is modeled, the "everybody else" group is only 0.65 times as powerful as is the corn farmer and ethanol factories coalition. Finally, if only the gasoline tax is modeled, the basic assumption behind the PPF methodology that government can be modeled as using policy to maximize a weighted sum of interest group welfare levels, is violated.

4.5. Two Policy Instruments and Two Interest Groups: A Model of Dimension (2, 2)

Next we again increase the dimension of the model, continuing to examine the welfare levels of the two interest groups indexed *ac* and *oralwfm*, but now allowing that two policy instruments, the ethanol tax/subsidy and the gasoline tax, are available to the government for simultaneous use. Increasing the number of policy instruments available to two results in a feasible welfare set that is a two-dimensional submanifold (as opposed to the surplus transformation curves we have examined, which are one-dimensional submanifolds). In R^2, two-dimensional submanifolds have interior points, but one-dimensional submanifolds do not. In figure 4 we display the "surplus transformation submanifold" generated by (i) not using the ethanol use manifold instrument, (ii) letting the ethanol tax t_b move continuously from t_b^{lo} = -1.50 to t_b^{hi} = 1.00 while (iii) also letting the gasoline tax move continuously from $t_g^{lo} = 0$ to $t_g^{hi} = 4.00$, and then (iv) plotting the resultant $\left(\Delta U_{orlwfm}\left(t_b, t_b, q_{bman}^{cur}\right), \Delta U_{ca}\left(t_b, t_b, q_{bman}^{cur}\right)\right)$ welfare points. The point $\Delta U^{cur} = \left(\Delta U_{orlwfm}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right), \Delta U_{ca}\left(t_b^{cur}, t_g^{cur}, q_{bman}^{cur}\right)\right)$ reflects use of the observed policy, and is shown at point A in figure 6, as in figures 2 through 5.

Figure 4. Surplus transformation cure plotted by changing the ethanol use mandate, holding the ethanol tax/subsidy and the gasoline tax at their current levels

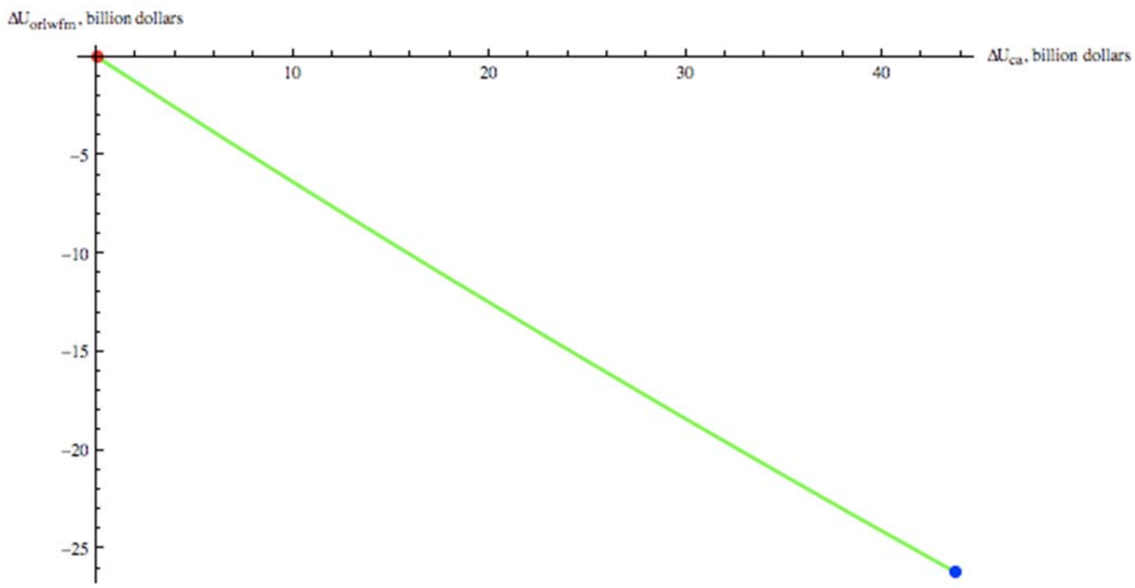


Figure 5. Three surplus transformation curves through the baseline policy outcome

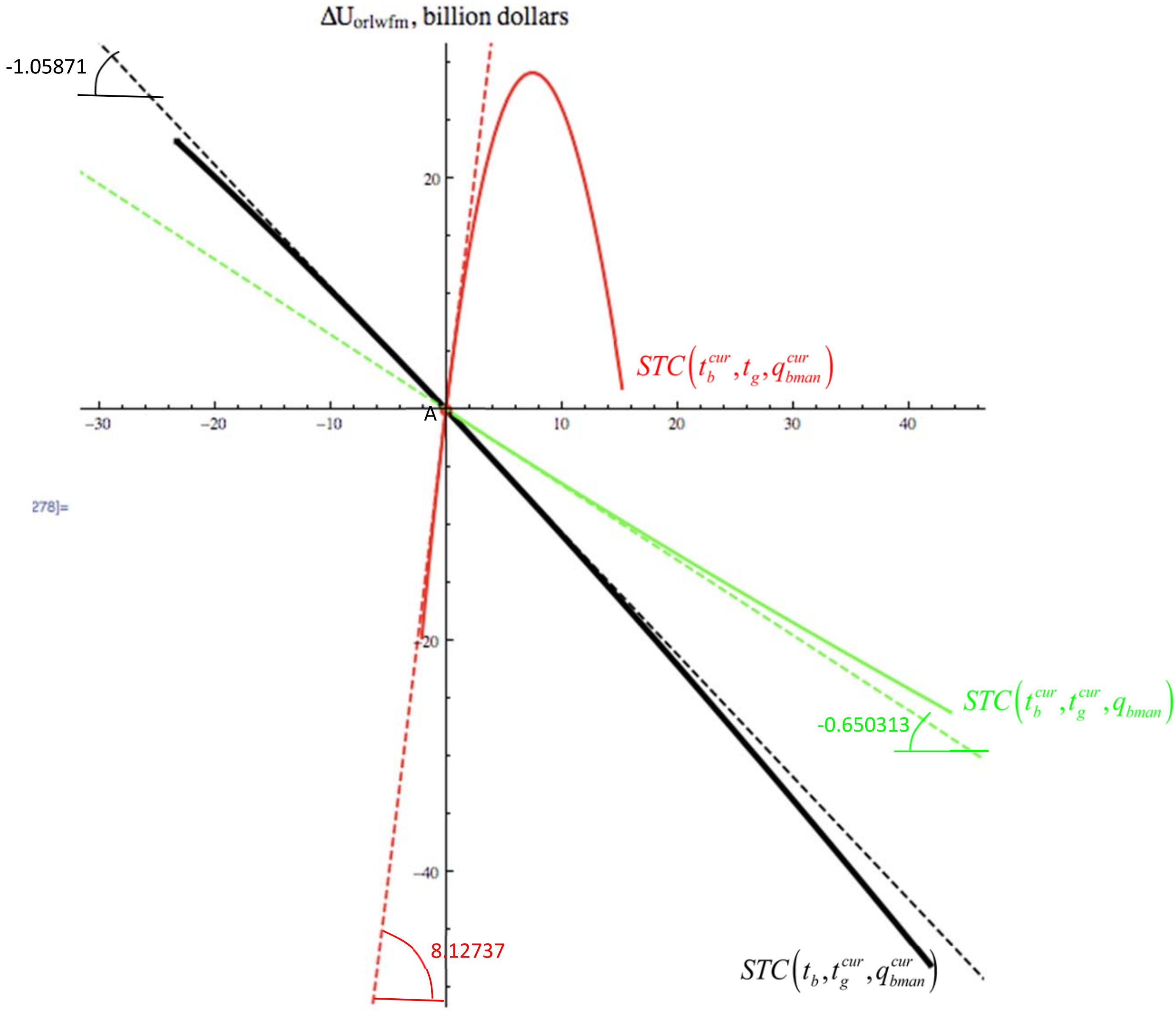
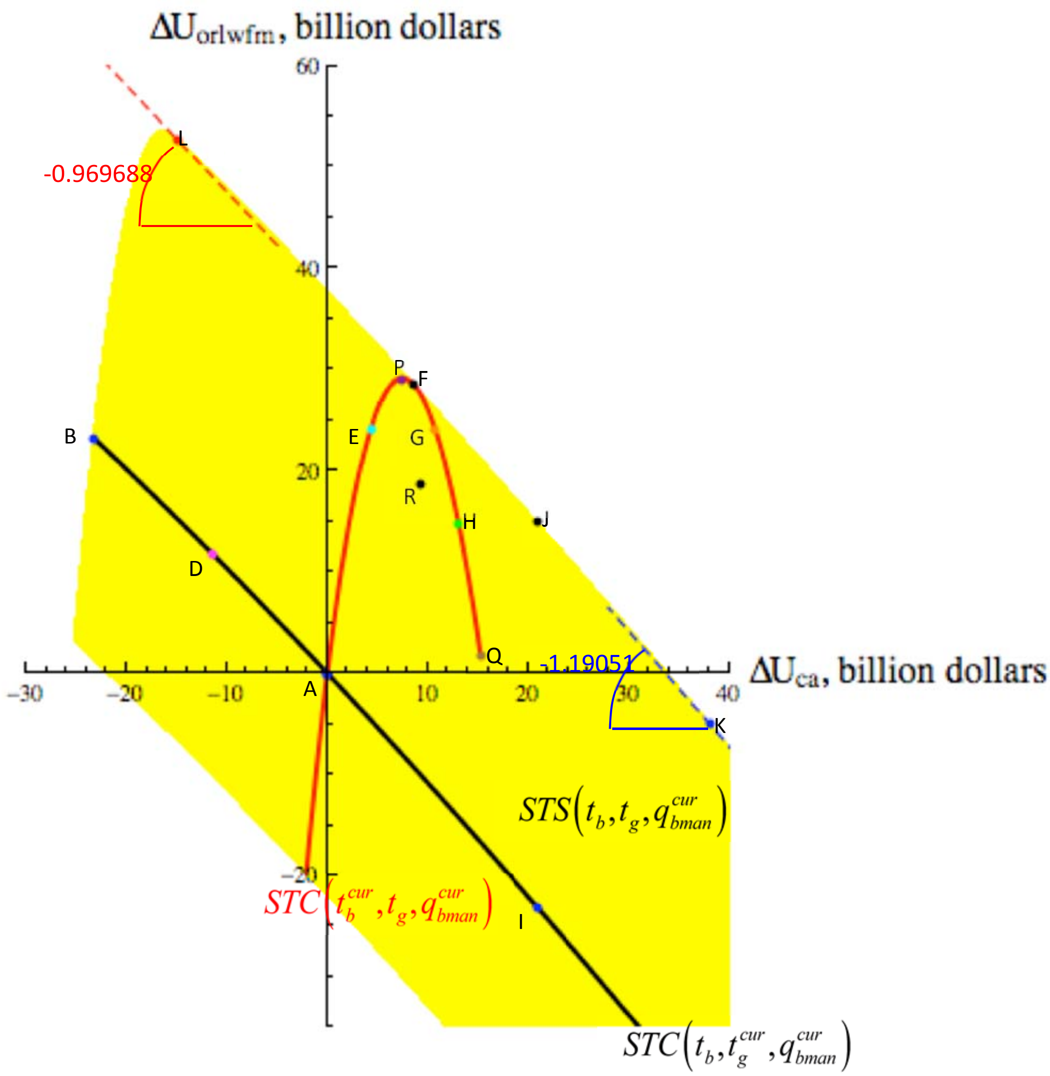


Figure 6. $STS\left(t_b, t_g, q_{bman}^{cur}\right)$: Surplus transformation submanifold plotted by changing the gasoline tax and the ethanol tax, while not using the ethanol mandate policy instrument.



Examination of figure 6 demonstrates that a model's conclusions about welfare redistribution possibilities and outcomes depend crucially on its dimension. For example, if one only looks at the possibility of changing the ethanol tax/subsidy, one might conclude that if it is socially desirable to transfer income from "everybody else" to corn farmers and ethanol factory owners, that a reasonable way to do so would be to leave other energy policies in their present states, and to raise the ethanol subsidy to

$0.75 per gallon. This policy would have the welfare outcome shown by point I in figure 6, which is (20.8643, -23.0762). But this conclusion ignores the possibility of changing the gasoline tax and the ethanol tax/subsidy simultaneously. By using the instruments simultaneously, point *J* = (20.8643, 14.9589) is obtainable. At *J*, the same level of corn farmer/ethanol factory owner welfare is achieved as is achieved at *I*, except at *J*, instead of having "everybody else" lose over 23 billion dollars in comparison to their observed welfare outcome A, we see that "everybody else" has gained almost 15 billion dollars relative to A. Clearly, failing to consider that multiple policy instruments can be used simultaneously can result in very poor policy recommendations.

Second, Figure 6 illustrates that *when the number of policy instruments in the model is greater than or equal to the number of interest groups, the probability is zero that the observed policy will be Pareto efficient, and therefore in general it will not be possible to derive PPF weights from the data*, at least without taking further steps to somehow find a welfare outcome and policy that are "close" to the originals yet are Pareto efficient (Zusman and Amiad 1977; Beghin 1990; Beghin and Karp 1991; Rausser, Swinnen, and Zusman 2011, pp. 397-403). (For a full discussion, see *Reference withheld*.) This is a generalization of the result shown in figure 3. There the surplus transformation manifold is of order one (it's a curve). While it is possible for policy outcomes not to be Pareto efficient (such as at points A or E), because any feasible point on the submanifold is not interior, it is quite "likely" that the welfare outcome will be on the Pareto frontier, which is the part of the $STC\left(t_b^{cur}, t_g, q_{bman}^{cur}\right)$ between P and Q. But because $STS\left(t_b, t_g, q_{bman}^{cur}\right)$ is created by varying two policy instruments, it is of dimension 2, and has an interior. Roughly speaking, it is "less likely" that an arbitrary policy will be Pareto efficient, because "most" points in $STS\left(t_b, t_g, q_{bman}^{cur}\right)$ are in its interior, and therefore not Pareto efficient.

Third, *even if an observed policy should lead to a point on the Pareto frontier of* $STS\left(t_b, t_g, q_{bman}^{cur}\right)$*, the PPF weights measured may not be intuitively appealing*. As in figure 4, a small change in weights can lead to a very large change in transfers. This is illustrated by points K and L in figure 6, at which the slopes of the Pareto frontier are -1.19051 and -0.969688. The interpretation at point K would be that group *orlwfm* is approximately 0.97 times as powerful as group *or*, whereas at point L group *ca* is about 1.19 times as powerful as group *or*—even though the transfers at points K and L are very different from each other, with 53 billion more dollars going to group *ca* and 58 billion fewer dollars going to group *orlwfm* at point K than at point L.

4.6. Three Policy Instruments and Two Interest Groups: A Model of Dimension (3, 2)

Now again we increase the dimension of the model, continuing to examine the welfare levels of the two interest groups indexed *ac* and *oralwfm*, but now allowing that three instruments: the ethanol tax/subsidy, the gasoline tax, and the ethanol use mandate may all be used simultaneously. The resulting feasible welfare set appears in figure 6, which shows once again how the determination of what is a "good" policy depends critically upon the dimension of the model. A policy that looks Pareto efficient when two instruments are available may no longer be Pareto efficient when three instruments are available. For example, a policy leads the Pareto efficient outcome J in figure 6. But in figure 7, that same policy again leads to point J, but J is no longer on the Pareto frontier. Furthermore, using PPF methodology here has similar problems to those discussed with figure 4: solutions to the PPF maximization problem are corner solutions, and therefore in equilibrium transfers can be very different under similar weights.

Figure 7. Surplus transformation submanifold when three instruments can be used simultaneously

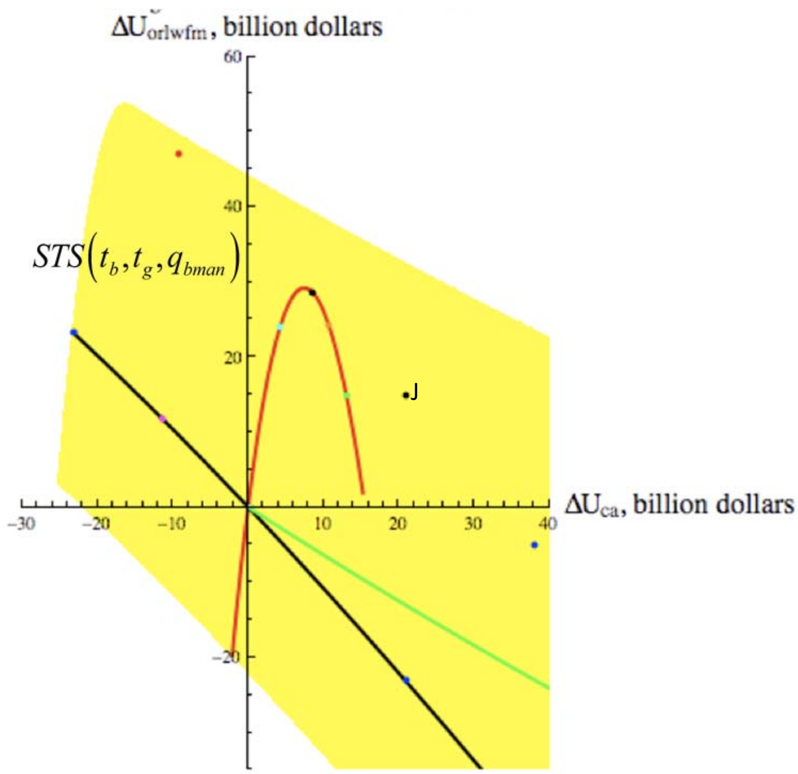
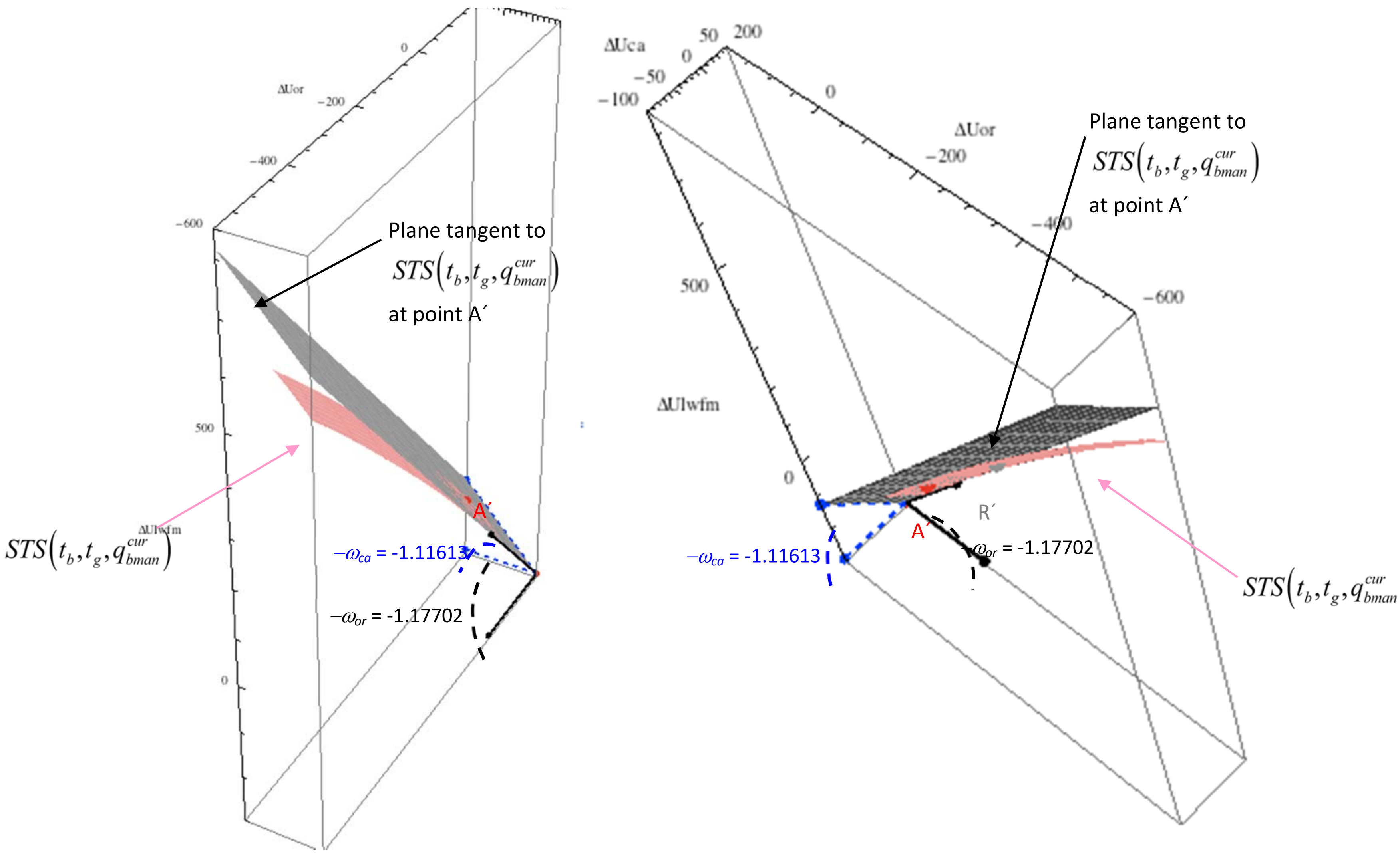


Figure 8. From two points of view, the surplus transformation submanifold when there are three groups and two policy instruments available, the biofuels tax/subsidy and the gasoline tax, are available.

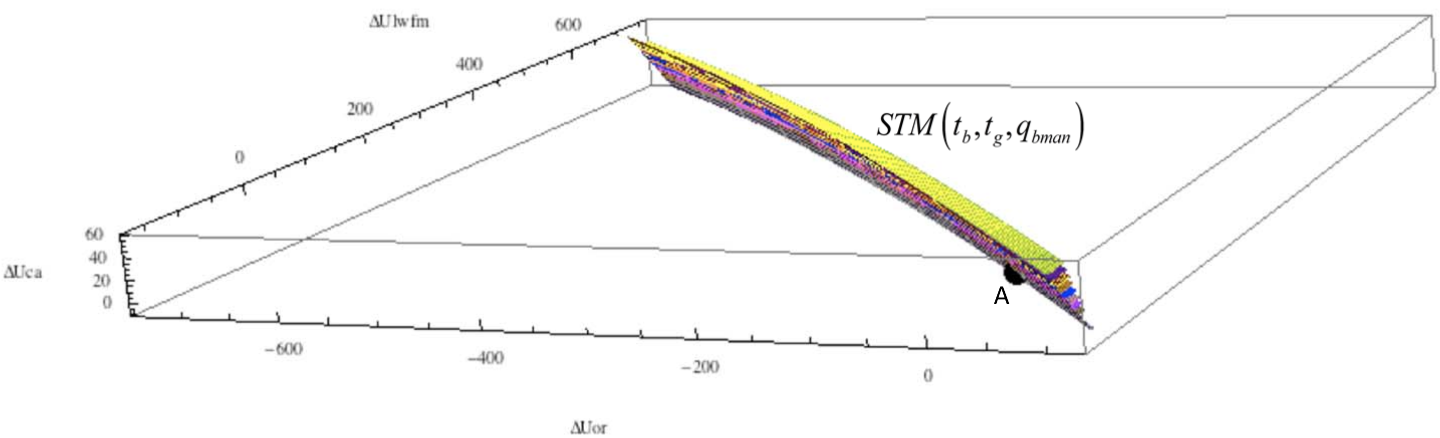


That all policies in this model of dimension (2, 3) are Pareto efficient means that Pareto efficiency cannot be used as a criterion by which to judge among the model's available policies. But it also means that now we can use PPF methodology to derive political power weights for any policy, and therefore for any policy that is observed. As discussed, the particular policy observed was a (net) ethanol tax of t_b^{cur} = \$0.044 per gallon and a gasoline tax of t_g^{cur} = \$0.494 per gallon, this policy leads to a welfare outcome of (0, 0, 0), since the changes in welfare measured on the axes in figure 8 are changes from the utility levels resultant from the current policy. This outcome (0, 0, 0) is shown as point A′ in figure 8. Because this "observed" welfare outcome is on the Pareto frontier, we can find and we show the hyperplane tangent to the Pareto frontier at that point, its slopes tell us the implied political power weights. These slopes are -1.11613 and -1.17702, and their interpretation is that crude oil producers and refiners are "revealed" by the observed policy to be about 1.18 times as politically powerful, and corn farmers and ethanol factories are revealed to be about 1.11 times as politically powerful, as are the group comprised of livestock input owners, employers, employees, and meat consumers, and fuel consumers. These slopes can be converted to PPF weights to obtain α_{lwfm} = 0.30366, α_{or} = 0.357414, and α_{ca} = 0.338925, implying that the observed policy reveals that the three groups exert approximately equal political power. Letting point R′ be the outcome of the policy (-0.15, 1.50, 0) that brought about point R in figure 6, we can measure what the PPF weights would be were this the observed policy: α_{lwfm} = 0.311885, α_{or} = 0.339099, and α_{ca} = 0.349016. Notice that these weights are very near to the weights derived from the observed policy, even the point R′ and point A′ show welfare outcomes that are very different. Once again, because the surplus transformation manifold is nearly planar, the PPF measures of political power tell us little.

4.7. Three Policy Instruments and Threee Interest Groups: A Model of Dimension (3,3)

Figure 9 illustrates the political economy model in the case of three policy instruments three interest groups. Much as in figure 6, where the model dimension is (2, 2), the welfare outcome of the "observed" policy is in the interior of the surplus transformation manifold, and therefore is not Pareto efficient, and PPF methods cannot be used to measure political power weights.

Figure 9. Surplus transformation submanifold with three policy instruments and three interest groups.



5. CONCLUSIONS

Our study demonstrates the probable pitfalls of using PPF methods to measure the political power of interest groups. These measures depend crucially on model dimension, but PPF modelers almost never spend significant effort explaining why the interest groups included in their model were included, nor why the coalitions assumed where assumed. Far too many studies have conveniently developed models with the number of policy instruments being one fewer than the number of interest groups. Because this causes the implicit surplus transformation manifold to have no interior, then the angles of the hyperplane tangent to the surplus transformation manifold are measurable. But in the application of this method, often interest groups have to be aggregated or disaggregated in rather arbitrary ways, and policy instruments that are important and observed used must be left out.

This article makes it clear that the best way to measure the "political power" of interest groups is by examining the sizes of the transfers brought about by policy, not by measuring the slopes of a contrived surplus transformation manifold at a contrived "observed" point. Surely, studies that report "Group A received \$*x*, which was taken from group B, which lost \$*y*" provide the reader with a more intuitively appealing measure of the political power of the interest groups than does "Group A's political power weight is 0.*xx* and group B's is (1 – 0.*xx*)." Once the changes in welfare for the model's different groups are estimated, it is always tempting to sum them to calculate the dead weight loss (or social gain) derived from the policy change. There is nothing wrong with calculating dead weight loss, but this measure has been over-emphasized in the literature. More important are the distributional issues. When poor and middle class people subsidize rich, politically connected people—a fair categorization of those who benefit most from U.S. ethanol policy--concerns about the overall health of a political economy should dwarf concerns about losses in national income that work out to a handful of dollars per-capita. A main accomplishment of the ethanol and corn farmer lobby has been to argue successfully with little evidence that there are significant environmental and national security benefits to be gained from fueling our cars with corn. We agricultural policy analysts need to straighten our priorities, and spend more effort studying these economic, social, and political issues.

Our discussion has been largely a type of warning, a critique of a currently frequently used methodology. Of course, "how not to" discussions are inevitably easier to write than "how to" discussions. Still, "how not to" discussions can serve a purpose: they can steer research resources away from non-profitable pursuits, such as attempting to estimate interest groups' political power weights using PPF methodology.

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