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IS THERE A TRIPLE DIVIDEND EFFECT FROM A TAX ON FERTILIZER USE? A COMPUTABLE GENERAL EQUILIBRIUM APPROACH

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Abstract

Although the existence of an environmental dividend to green taxes is beyond dispute, the same is not true for the efficiency or double dividend. Given the wide spread excess fertilizer use by farmers in Egypt with serious repercussions for water pollution and contamination of agriculture goods, using a static CGE model, this research attempts at assessing the magnitude of the double dividend from the imposition of a tax on fertilizer use. The paper further assesses whether there is a triple dividend affect from improved market access to agricultural goods following the reduction in fertilizer use.

ملخص

على الرغم من أن وجود عائد الضرائب البيئية غير قابلة للجدال، الا ان الأمر نفسه لا ينطبق على الكفاءة أو الفائدة المزدوجة .ونظرا للانتشار الواسع لاستخدام الأسمدة من قبل المزارعين في مصر ومع التداعيات الخطيرة لتلوث المياه وتلوث السلع الزراعية،يحاول هذا البحث تقييم حجم الأرباح المضاعفة من فرض ضريبة على استخدام الأسمدة وذلك باستخدام نموذج CGE،وتواصل الورقة تقييم ما إذا كان هناك تأثير أرباح ثلاثي من تحسين الوصول إلى الأسواق للسلع الزراعية في أعقاب خفض استخدام الأسمدة.

1. Introduction

The incidence of overuse of fertilizer by farmers is one among many other problems adversely affecting the quality of the environment cited in the literature. Several reasons underlie this phenomenon. Among the most important is cheap water. Farmers that have access to cheap water do not invest in water efficient irrigation systems. If water and fertilizer are complements, as is the case with corn (Vickner et al 1998), the over use of water leads to an overuse of fertilizer. More water also means more nutrient run-off and percolation, and therefore the farmer will have to increase the amount of fertilizer to insure that the target amount reaches the plant. Uncertainty about weather and soil characteristics for both risk averse and risk neutral farmers is cited as one of the main reason contributing to over use of fertilizers. (Sheriff 2005)

The latest Egypt state of the environment report prepared by the Ministry of the Environment in 2008 revealed that farmers overuse fertilizers and pesticides. A lack of awareness regarding the negative repercussions of overusing fertilizers is presumably the main factor responsible for this phenomenon. Furthermore, the fact that farmers receive water for free and given the widespread practice of flood irrigation can, as discussed above, also serve as a plausible explanation for the excessive use of fertilizers by farmers in Egypt. One problem with such practices is that large amounts of waste water is unnecessarily generated that finds its way back into the river Nile, but loaded with the residue of fertilizers and pesticides, contributing to a sever water pollution problem. (EEAA 2006). The high residue of fertilizers in agricultural goods has also been detected. Not only is this hazardous to human health but has also adversely affected Egypt's agricultural exports. Meanwhile and as argued by Blottnitz et al (2006), both the production and application of fertilizers results in the emission of powerful green house gases, leading to global warming.

There are a number of different approaches that can be distinguished for inducing farmers to reduce their use of fertilizers. The first is based on inducing farmers to voluntarily reduce their use of fertilizers by using better technology or new techniques of production through education, technical assistance and cost sharing. Nevertheless, this approach can be effective only if it is profitable for the farmer to adopt it, and is long term in nature. The second approach involves imposing regulations, such as setting limits on the amount of fertilizers a farmer can use. However, as with regulations, in general they can be ineffective in the absence of strong enforcement, which is usually the case in Egypt. The third and most popular approach is that of imposing a tax on the use of fertilizers. Apart from making fertilizers more expensive, and thus forcing farmers to use less of it, taxes results in lower transaction costs and higher efficiency relative to regulations. Moreover, the institutional requirements are not different from those needed for sales taxes. A uniform input tax has the added advantage of achieving the desired reduction in input use at the lowest cost. However, imposing input taxes can be politically infeasible since it increases the costs facing farmers. (Sheriff 2005). Tradeable permits are also commonly used, but one disadvantage lies in the high cost of monitoring and verification. (Blottnitz et al 2006). Another alternative is taxes on agricultural crops (Taheripour 2006).

Environmental taxes can create a double dividend effect. It is argued that taxes on polluting inputs can generate revenue for the government that can in turn permit the reduction of other distorting income and sales taxes, (Perman et al 2003) rendering the imposition of such taxes, at least to some extent, politically feasible. The double dividend effect is, nonetheless, subject to a lot of controversy, and the empirical literature, which mainly focuses on pollution from the burning of fossil fuel and carbon taxes have, at best, produced mixed results regarding its magnitude. In light of this background -and given the dearth of research in the area of the environment in Egypt in general, and water pollution in particular, the current research seeks to explore the economy-wide and equity implications of imposing a tax on the use of fertilizer for the Egyptian economy while concurrently reducing other distortive taxes. In other words, the aim of the research is to assess whether this creates a double dividend effect and thus higher welfare in addition to a triple dividend given the added benefits of the improved market access to agricultural exports that is likely to occur in response to the reduction of the use of fertilizers. Implications for output, employment in and exports of fertilizers will be also assessed.

This paper utilizes a static General Equilibrium Model for an open economy, which will be calibrated using the 2006/2007 Social Accounting Matrix for Egypt. It is important to note that the focus will be on the non-environmental welfare effect of the efficiency dividend of the tax rather than the less controversial green dividend. The rest of this paper is organized as follows: Section II provides a review of the literature, Section III outlines the special features of the CGE model, Section IV presents model results and finally Section V concludes.

2. Relationship to the Literature

Environmental taxes are considered to be one of the most effective tools for 'getting prices right' in the sense of aligning them to social marginal costs, leading to an improvement in environmental quality and an increase in welfare; the so called first or green dividend. Welfare can further increase if the revenue raised through green taxes is recycled, leading to a reduction in other distortionary taxes, including income, payroll or sales taxes. This is the Second or efficiency dividend. According to Pearce (1991), Green taxes then can create a double dividend. While the ability of green taxes to enhance welfare as environmental quality improves the first dividend is beyond dispute, the magnitude of welfare improvement is highly uncertain. On the other hand, the second dividend can be disputed if there are costs, measured as welfare sacrifices, associated with the introduction of green taxes. (Goulder 1995a).

A survey of the literature on the double dividend conducted by Goulder, (1995a) reveals that there is strong, albeit theoretical, evidence that the introduction of taxes on dirty goods is not costless. For example, unless the labour supply is backward bending a tax on a dirty commodity, the revenue of which is used to reduce taxes on labour income, can lead to lower after-tax wages, creating distortions in the labour market that can be as severe as those due to labour income taxes,which largely distort the labour leisure decision,- known as the labour tax marginal efficiency cost. In general, the presence of prior taxes leads to larger gross costs (again measured in welfare sacrifice) from environmental taxes even if the revenue is used to finance cuts in distortionary taxes. This is called the tax interaction effect. A green tax on dirty commodities also distorts the choice between different commodities. Moreover, if consumers substitute the taxed dirty good for other none taxed goods, this will lead to an erosion of the tax base, limiting the possibility of financing a cut in labour income taxes. This is known as the tax erosion effect. The fact that revenues from a green tax can be recycled, causing a reduction in gross distortionary costs, is termed the revenue recycling effect. Partial equilibrium analysis would thus overstate the cost of green taxes while the tax interaction effect implies that partial equilibrium analysis will understate the cost of green gases. It is therefore imperative to study the effect of green taxes within a general equilibrium framework as asserted by Goulder (1995a). It is important to mention that the above results extends to the taxation of dirty inputs.

It is important to note that assessing the double dividend empirically is imperative in the absence of complete generalization from theory (Goulder 1995b). A substantial body of empirical literature on double dividend exists. Focusing on the efficiency dividend and with the aid of an inter-temporal General Equilibrium model of the U.S. economy, Goulder (1995b) shows that the introduction of a carbon tax, the revenue of which is used to reduce distortionary taxes like income taxes and corporate profit taxes, results in positive overall costs. One explanation for such results lies in the fact that the base for the carbon tax is narrower than that of other distortionary taxes. Such results provide support for insights drawn from the theoretical literature on taxes which confirm that taxes on intermediate inputs lead to higher welfare costs, compared to taxes on primary factors or final goods. Also, simulation results show that the welfare cost of a carbon tax is more, the higher are pre existing taxes. Goulder's (1995) results show that one cannot advocate carbon taxes based only on efficiency grounds without assessing the environmental benefits.

Utilizing a dynamic general equilibrium for an open economy calibrated to Turkish data show that taxes on emissions of NOx can create double dividend even if the revenue from the taxes is not recycled to reduce distortionary taxes. Because NOx emissions arise from the use of imported fuels, which decline significantly following the introduction of the tax, leading to an increase in GDP as output of sectors that uses imported petroleum decline while that of the less intensive sectors increase (Kumbaroglu 2003).

Using a dynamic general equilibrium model for a closed economy calibrated to U.S. data, Glomm et al (2006) show that imposing a revenue neutral tax on gasoline and reducing capital income taxes produces a double dividend effect. The form of the utility function used where health, which is affected by pollution from the use of gasoline, is an argument along with the consumption of goods allows for assessing the environmental welfare effect (the green dividend) as well as the efficiency dividend. The results from the simulations indicate that the green dividend is much smaller than the efficiency dividend so that the welfare effect of imposing the tax can be well approximated by the efficiency dividend. A striking result of the model is that the quality of the environment deteriorates in the new steady state, as opposed to over the transition path, after the fuel tax is imposed. Such results arise as lower tax on capital income leads to higher levels of capital accumulation and thus more fuel consumption, since fuel goes into the production of capital goods.

With the aid of a static regional CGE model of Spain Andre et al (2005), show that a tax on emissions of CO_2 and SO_2, which is recycled by reducing income or payroll taxes, leads to an employment double dividend as unemployment falls as falling labour costs, because lower payroll taxes increases the demand for labor. Moreover, the non-environmental welfare increase, i.e. there is double dividend also in the case of a CO_2 tax.

It is needless to mention that distributional concerns play a key role in environmental tax reform for two reasons: Firstly, if it wasn't for these concerns, the government would have raised revenue through lump sum taxes instead of distortionary taxes. Secondly, the revenue from environmental taxes can be used to compensate the poor (Bovenberg 1999). Following a standard approach in public finance, which tend to analysis the welfare impact of tax policy without considering its impact on changes in investment or government expenditure, Devarajan et al (2009), use a static general equilibrium model to study the effect of a tax on carbon emissions or a sales tax on energy inputs on pollution, equity and welfare. The revenue generated is used to reduce pre-existing distortionary sales, excise taxes and import tariffs, or is used as transfers to poor households. The equity impact of a sales tax on energy inputs is superior to other types of taxes as poor households do not bear its burden. Recycling is found to benefit the poor. In general recycling the revenue from carbon taxes or energy taxes to reduce distortionary taxes reduces the welfare costs of such green taxes significantly. Removing labour market distortions arising from labor market segmentation or unemployment leads to negligible costs for carbon taxes.

Due to substantial water pollution caused by nitrogen fertilizer run off, Taheripour et al (2005) uses a static analytical and numerical open economy general equilibrium model of the U.S. to study the effect of a tax on nitrogen fertilizer run off, a fertilizer reduction subsidy, a tax on crop production on welfare in the presence of distortive agricultural support subsidies, which are financed through distortive taxes including income taxes. All three policies were found to create a double dividend because they raise revenue that can be used to finance subsidies and because part of the burden of green taxes can be passed to the foreign consumer in the form of higher agricultural goods prices, given that the U.S. is a large exporter of these goods. In a second best setting, the tax on fertilizer run-off is more efficient than a fertilizer reduction subsidy. The tax on agricultural goods generates higher costs than a tax on fertilizer run-off because the former reduces consumer surplus. However, it also reduces output leading to higher prices and thus larger gains through the trade.

While the theoretical literature does not provide generalization as to the double dividend effect of green taxes as mentioned above, the empirical literature shows that the mere presence of a double dividend as well as its magnitude can vary given the differences between the economies under investigation with regards the type, incidence and level of pre-existing distortions whether these are related to distortionary taxes, distorted labour markets etc. Therefore even with so much empirical research available, exploring the existence of double dividend cannot be undertaken without considering the unique features of the economy under study along with the type of distortions present. Only this would make it possible for policy makers to decide whether to undertake green policy reform. The variety of channels through which double dividend materializes only serves to highlight the importance of searching for new channels. The survey of the empirical literature shows that the focus has been on exploring whether there is an efficiency dividend or not given the difficulty in measuring the environmental welfare effect of green taxes.

Besides, the bulk of the empirical literature almost exclusively focuses on energy when run-off from fertilizers and the water pollution it creates poses equally hazardous health problems in addition to the threat it poses for aquatic life. Moreover, residues of fertilizers can lead to crop contamination which further increases health risks associated with the consumption of agricultural goods and can reduce agricultural exports. This latter trade effect can be a potentially important channel though which a triple dividend can materialize.

Finally, and aside from the double dividend, it is worthwhile mentioning that taxes on fertilizer input is rather popular compared to taxes on emissions due to the diffuse nature of these emissions from agriculture. The experience of several European countries, includingSweden, Finland and Austria showed that fertilizer use has decreased following the implementation of a tax and at the same time production did not decline. Some of the reasons underlying this phenomenon are that the tax raised the awareness of farmers as to the negative environmental effects of the overuse of fertilizers while improvements in technology increased the efficiency of nitrogen use. Moreover, farm income did not fall as the revenues from the tax were recycled through export subsidies. (Rougoor et al 2001)

3. The Model

The model used in this paper is based on a static open General Equilibrium model for Egypt developed by Lofgren (1993), but modified by incorporating two skill categories for labor: skilled labor which is sectorally mobile, and unskilled labor, which along with capital is sector specific. In each sector, value added is produced using a cobb Doglass production function with capital and the two labor skill categories as inputs. All other inputs including fertilizer are used in fixed coefficients (Leontief technology). The model differentiates between 17 sectors of economic activity (See Table 6) and between rural and urban households, each further disaggregated into five income quintiles to better capture the equity implications of the fertilizer tax. Welfare is measured as Equivalent Variation. Markets are perfectly competitive.

Following the standard approach in public finance, where analyzing the welfare effect of tax policy takes place without considering its impact on most macroeconomic aggregates, investment and government consumption in the economy are assumed fixed (Devaragan et al 2009). Foreign savings adjust to maintain equality between savings and investment in the economy. The exchange rate is the numeraire. The model is calibrated using the 2006/2007 Social Accounting Matrix for Egypt which is initially disaggregated to allow explicit modeling of the fertilizer sector. Complete model equations are presented in the appendix to this paper.

4. Model Results

Before discussing simulation results, it is helpful to highlight some intrinsic features of the economy as portrayed in the SAM. Agricultural output constitutes 9% of total output produced in the economy. Of total expenditure on intermediate inputs by the agricultural sector, expenditure on fertilizer accounts for 15%. A tax on fertilizer input will no doubt induce farmers to use less of it, but it is not expected to compensate entirely for the removal of all other taxes whether direct or indirect. On the other hand, such a tax should not lead to lower agricultural output, especially since the amount of fertilizer used is already in excess of what is technically needed. The contribution of the fertilizer sector to total output is marginal, amounting to 0.4% of total output. There are no imports of fertilizers and output is mainly consumed domestically. Indirect tax on fertilizer is very small amounting to 0.7%.

Given that farmers over-use fertilizer, as the amount of fertilizers applied is in excess of agronomically recommended amounts by 10-20%, (CAPMAS 2005) the first question that comes into anyone's mind is what is the magnitude of the tax that can force farmers to reduce fertilizer use to the recommended levels while the second is concerned with the economy wide as well as the welfare implications of this tax. A third question is related to the type of taxes that should fall as a result of recycling the fertilizer tax revenue.

As to the first question, the magnitude of the tax is determined endogenously in the model. To be more precise, we seek to calculate the level of the tax that will force farmers to reduce fertilizer use by 15% so as to keep the amount of money spent on fertilizer, per unit of output, before the tax equal to that after the tax. Mathematically, the following equation is added to the CGE model

$$P^q_{1f} * 0.85 * \iota_{of} * (1 + \tau_f) = P^q_{of} * \iota_{of}$$

P^q_{1f} =Composite fertilizer price after imposing the tax

ι_{of} =Fertilizer input output coefficient for the agricultural sector as appearing in the social accounting matrix

τ_f =Fertilizer tax

P^q_{of}=Composite fertilizer price in the base run

Since prices in the base run are set equal to 1, the fertilizer tax can be derived from the following equation

$$\tau_f = \{1/ (P^q_{1f} * 0.85)\} - 1$$

The main advantage of this approach, as confirmed by model results, is that the amount of fertilizer use declines more or less by the same amount regardless of the method of recycling the tax revenue from the fertilizer tax. In turn, this implies that the environmental dividend will be the same, and hence comparison between the different methods of recycling the tax revenue will be on the bases of the efficiency dividend arising from using the tax revenue to reduce other distortionary taxes or as result of the triple dividend, arising due to improved market access to agricultural goods. To a great extent, this reduces the problems of using a welfare measure that does not account directly for the environmental benefits arising from clean water and safe food that becomes possible once fertilizer use falls. Least is that the model determines endogenously the fertilizer tax necessary to realize the full environmental dividend.

The model is then used to simulate the effect of the tax along with alternative means of recycling the tax revenue on real GDP, the balance of payment, unemployment and welfare of rural versus urban consumers. Alternative methods of recycling the fertilizer tax revenue include:

1- Transfers to the lowest two rural and urban income quintiles, each receiving quarter of the revenue;

2- Using the revenue to reduce indirect taxes or tariffs on food and the fertilizer industry so as to keep government revenue constant. The food industry was chosen given that both rural and urban consumers spend the largest share of their disposable income on food.

Also, implications of each method of recycling the revenue is examined under the assumption that the reduction of fertilizer use to recommended levels will improve market access to Egyptian agricultural goods. It has been documented elsewhere that agricultural goods, specifically those destined for Europe, face strong barriers since they do not meet the specifications that make them safe to consume as set by importers. The importance of this issue stems from the fact that there is growing awareness world wide as to the health hazards of chemical fertilizers as evident from rising demand for organic food in particular. Following Maskus and Konan (1997) improved market access to agricultural goods will be modeled as a 10% increase in the world price of agricultural goods. To test the sensitivity of model results to such an assumption, the results are also examined under a 5% increase in the world price of agricultural goods. (See Table 4 and5) Furthermore, assuming that workers will resist any erosion of their real wages, the effect of each scenario on unemployment of both skilled and unskilled labor in all sectors of economic activity will be explored, by holding nominal wages fixed if there is evidence that real wages fall.

All simulation results showed falling real wages, with varying degrees across sectors of economic activity, depending on which method of recycling the tax revenue is implemented, following the introduction of the fertilizer tax. Allowing for rigid wages and unemployment affected the magnitude of the efficiency dividend particularly for the poor. The reason is that rigid wages lead to a fall in the demand for labor, creating unemployment, which reduces labor income. Since labor income accrues mainly to poor households, welfare of these lower income quintiles falls as a result. This serves to highlight the importance of accounting for imperfections in factor markets when examining the effect of introducing green tax, since the magnitude of the efficiency dividend is sensitive to such specifications. In what follows, the results of the simulations with rigid wages are presented in Tables 1, 2 and 3 and are discussed below. In Table 3 welfare is reported beginning with the lowest income quintile for urban household “Welfare.HU1” to the highest “Welfare.HU5”. The same for rural households.

Model results reveal that the fertilizer tax consistent with a 15% reduction in fertilizer use hovers around 26% for almost all methods of recycling the revenue, except in the case for reducing indirect taxes on fertilizers, as will be explained later. In other words, the magnitude of the tax can be sensitive to the method of recycling the tax which shows how important it is to solve for it endogenously.

The first simulation, EXP1, is concerned with the assessing the impact of the tax before recycling the revenue. Since this tax, in general, leaves the cost of fertilizer to the farmer the same as in the base run; little if no change will occur in the agricultural sector. Any change occurring thereafter will be in response to contraction in the fertilizer sector. Although exports of fertilizer increase by 23%, output in this sector falls by 5.22% in response to falling demand for fertilizers and unemployment among production labor soars to 18%. This later result could be explained by the fact that as output falls, demand for labor falls causing nominal and in turn real wages to fall. Welfare of each of the ten income quintiles falls by a meager 0.04%. Thus in terms of welfare sacrifice, the fertilizer tax imposes direct costs on households. On the other hand, real GDP increases slightly by 0.08% mainly in response to the increase in fertilizer exports while government revenue increases by 0.22% and the trade surplus increases by 4.21%. In what follows alternative methods of recycling this revenue will be discussed.

The first method of recycling the revenue entails, under EXP2, providing the two lowest income quintiles in both rural and urban areas with a transfer payment equal to quarter of the tax revenue. As a result, welfare of the lowest urban income quintile increases by 0.55% and that of the second by 0.36%. In the case of rural sector, welfare increased by 0.57% and 0.4% respectively. Apart from the fertilizer sector, where unemployment among production labor continues to be 18%, no significant unemployment arises in any other sector.

Under EXP4 the tax revenue is recycled in the form of lower indirect taxes on the food industry such that government revenue remains constant. As mentioned before, the food industry was chosen in light of the fact that all consumers spend the largest share of their income on food. A tax on fertilizer generates revenue that permits a reduction in indirect tax rate on food by 25%. A double dividend is created, albeit very small. Welfare of all consumers increases by 0.06 %. Real GDP increases by 0.08% in response to a similar increase in output in the food industry. The trade surplus increases by 1.31% as exports of fertilizer increase by 23%. Unemployment in fertilizer continues to be 18%.

The next method for recycling the tax revenue entails using the revenue to reduce tariffs on food products while keeping government revenue constant as portrayed under EXP6. As a result, a reduction in tariffs on food products by 38% takes place. Such method creates a double dividend benefiting the poor more than rich. Apart from EXP 2 and 3, welfare for all income groups is the highest among all simulations considered so far. Real GDP and the trade surplus increase slightly. Unemployment in the fertilizer sectors continues to be equal to 18%. Unemployment arises in several other sectors, but the rise is very small.

One common aspect in all these scenarios, is that they create a major unemployment problem in the fertilizer sector. Such a problem, however, completely disappears if the fertilizer tax revenue is used to reduce indirect taxes imposed on the fertilizer sector, as in EXP8. The fertilizer tax revenue not only made possible the complete elimination of indirect taxes on fertilizers, but allowed for a very small subsidy to output. Although the magnitude of the fertilizer tax necessary to achieve the desired reduction in fertilizer use increases to 35% since prices of fertilizers falls as a result of reducing indirect taxes, welfare of all income groups increase specially for the lowest income quintiles, but is lower than the case of reducing tariffs on food. Real GDP increases by 0.1%, the highest among all simulations. The trade surplus increases by 1%, which is also relatively low. Unemployment created in other sectors is negligible.

Allowing for improved market access under all the alternative methods for recycling the tax revenue discussed above (EXP3, 5, 7 and9) reduces welfare except for the case where the fertilizer tax revenue is recycled to reduce indirect taxes or tariffs on food. One possible explanation for why the fertilizer tax does not create a triple dividend, except under these two methods of recycling the revenue, is that capacity is constrained by fixed capital stock in the short run, and thus the increase in exports following improved market access, diverts capacity away from producing for the domestic market which in turn leads to higher domestic prices and falling consumption. While such results occur because of the static nature of the model as capital stock is fixed, using a dynamic model will not change these results because of fixed agricultural land, a constraint that is especially binding in the case of Egypt.

A triple dividend, on the other hand arises in the case of reducing indirect taxes on food since output increases and in the case of reducing tariffs on food, because consumers can import if output is diverted to exports.

The inflationary pressure created as a result of improved market access reduces real wages and creates unemployment among production labor in several sectors, besides fertilizer, that is particularly significant in the case of food, ranging from 1.55% under EXP3, 2.88% under EXP7 and 1.37% under EXP 9, since agricultural goods are used as inputs in the food industry so when the prices of these inputs increase, profitability of the food industry declines and demand for labor falls.

The triple dividend however, is higher for the richest income quintiles. This can explained by the fact that labor income which accrues mainly to the poor is now lower. Improved market access to agricultural exports, however, leads to higher trade surpluses.

As mentioned earlier, to test the sensitivity of these results to the assumption that market access is modeled as a 10% increase in the world price of agricultural exports, the same experiments are run under a 5% increase in the world price of agricultural exports. Simulation results shows that a triple dividend still arises when the tax revenue is recycled to reduce indirect taxes and tariffs on food, but its magnitude is slightly lower as evident from Table 4 while the rich continue to benefit more than the poor.

Perhaps the most important implication of the simulation results presented above is that the double dividend or the triple dividend effect of a fertilizer tax is very small in magnitude. This should not be surprising given the small tax base. When trying to choose among the alternative methods of recycling the fertilizer tax revenue considered so far, results must be compared under the assumption of improved market access since this would naturally follow once fertilizer use is reduced. Using the tax revenue to provide poor households with cash transfers though benefits the poor most, is not administratively straightforward to implement compared to a reduction in tariffs on food. However, the simulation results reveal yet another challenge facing policy makers; not only is the double or triple dividend very small, but can be associated with very high rates of unemployment in the fertilizer sector in the short run. Choosing to eliminate unemployment in the fertilizer sector through recycling the fertilizer tax revenue in order to reduce indirect taxes in the fertilizer sector is a viable option, but produces even smaller double dividend and no triple dividend at all.

It is also useful to compare a tax on fertilizer input to a tax on agricultural output, which is supposed to lead to less fertilizer use by inducing farmers to reduce output. To reduce fertilizer use by 15%, model results shows that the indirect tax on agriculture must reach a ridiculously high level, close to 75% reducing agricultural output by 15% compared to no change under all scenarios involving the fertilizer tax. On account of these numbers, a tax on agricultural output is not by all means an attractive tool, at least compared to a tax on fertilizer input, to reduce fertilizer use in a country that is struggling to feed its rapidly growing population.

A final note with respect to the interpretation of the results of the model given the assumption of perfect competition in input and output markets is warranted. With regards to the fertilizer tax, one would expect that its magnitude would be bigger if there are elements of imperfect competition in the fertilizer market since firms will have to lower their prices as demand for fertilizer falls. The magnitude of the tax documented in this paper will then serve as a lower bound. Meanwhile, if the tax is higher, tax revenue will be higher and consequently, the efficiency dividend will be also higher. However, the ranking of alternative means of recycling the tax revenue will remain unchanged so are the results pertaining to the existence of a triple dividend.

5. Conclusion and Policy Implications

Green taxes have become increasingly attractive as a device to force polluters to internalize the cost of the environmental damage they create, not only because they are successful in reducing pollution, but also because they create a double dividend, and as revealed here a triple dividend, effect as the tax revenue is recycled to reduce other distortionary taxes. Given the wide spread excess use of fertilizer in Egypt which has resulted not only in a severe water pollution problem, but also has acted to reduce export demand for agricultural goods, a fertilizer tax can be a potentially powerful tool capable of forcing farmers to use less fertilizer.

With the tax rate determined endogenously in the model, alternative methods of recycling the tax revenue including transfers to the poor, lowering indirect taxes and tariffs on the food industry were examined using a static CGE model. Although the tax which ranged from 12% to 40% - depending on the method of recycling the revenue, is quite high, in general, the double dividend was found to be very small in magnitude across these methods, being highest in the case of lowering tariffs on food with the rich benefiting more than the poor. A triple dividend was created only in the case of reducing indirect taxes and tariffs on food with the rich, again, benefiting more than the poor.

Very high rates of unemployment amounting to 18% in the fertilizer sector arises upon the imposition of the tax, except when the revenue is used to reduce indirect taxes in the fertilizer albeit leading to even smaller double dividend and no triple dividend. On the positive side, the economy experiences increasing trade surpluses as exports of fertilizer increase. Although it is well documented in the literature that the magnitude of the environmental dividend is big, the benefits from a fertilizer tax must be reevaluated given the rising unemployment, especially in light of the small magnitude of the double and triple dividend reported here.

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Table 1: % Change from Base Run

	ÈXP1	EXP2	EXP3	EXP4	EXP5	EXP6	EXP7	EXP8	EXP9
Trade surplus	4.21	0.85	6.15	1.31	1.30	1.13	0.89	1.03	0.35
RGDP	0.08	0.09	0.12	0.08	0.09	0.05	0.01	0.10	0.11
GOV Revenue	0.22	0.31	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Fertilizer Tax	26.24	26.23	26.10	26.23	26.07	26.26	26.14	35.15	40.32

Table 2: Unemployment

	ÈXP1	EXP2	EXP3	EXP4	EXP5	EXP6	EXP7	EXP8	EXP9
AGR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIL	0.00	0.02	0.03	0.03	0.03	0.00	0.03	0.00	0.00
.FOOD	0.06	0.00	1.55	0.00	0.00	0.51	2.88	0.00	1.37
TEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
.FER	18.67	18.68	18.49	18.68	18.50	18.67	18.47	0.00	0.00
O-CHE	0.00	0.02	0.09	0.02	0.23	0.00	0.00	0.07	0.28
PET	0.00	0.00	0.27	0.00	0.00	0.00	0.43	0.00	0.24
N-MET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
IRON	0.00	0.01	0.13	0.00	0.22	0.00	0.00	0.10	0.41
O-MET	0.00	0.00	0.13	0.00	0.21	0.00	0.05	0.08	0.38
ENG	0.00	0.01	0.06	0.00	0.08	0.00	0.04	0.02	0.11
O-IND	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.03
.CON	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
.ELE	0.04	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
TRAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HOTELS	0.00	0.00	0.21	0.00	0.33	0.00	0.06	0.11	0.56
O-SER	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00

Note: RGDP= Real GDP

Table 3: Welfare

	Equivalent Variation as Percent of Base Run Expenditure								
	EXP1	EXP2	EXP3	EXP4	EXP5	EXP6	EXP7	EXP8	EXP9
Welfare.HU1	-0.04	0.55	0.39	0.06	0.06	0.08	0.09	0.06	0.03
Welfare.HU2	-0.04	0.36	0.21	0.06	0.07	0.08	0.09	0.06	0.04
Welfare.HU3	-0.04	-0.04	-0.18	0.06	0.09	0.07	0.09	0.06	0.06
Welfare.HU4	-0.04	-0.04	-0.15	0.06	0.11	0.06	0.10	0.06	0.08
Welfare.HU5	-0.04	-0.04	-0.05	0.06	0.20	0.04	0.14	0.06	0.17
Welfare.HR1	-0.04	0.57	0.39	0.06	0.07	0.10	0.13	0.06	0.02
Welfare.HR2	-0.04	0.40	0.24	0.06	0.07	0.09	0.12	0.06	0.03
Welfare.HR3	-0.04	-0.05	-0.20	0.06	0.07	0.08	0.10	0.06	0.04
Welfare.HR4	-0.04	-0.05	-0.19	0.06	0.07	0.08	0.09	0.06	0.04
Welfare.HR5	-0.04	-0.04	-0.12	0.06	0.15	0.08	0.18	0.05	0.10

Notes: HU1 = Lowest income urban quintile; HU5 = Highest income urban quintile; HR1 = Lowest income rural quintile; HR5 = Highest income rural quintile; All experiments are conducted under the assumption that the fertilizer tax will lead to a 15% reduction in fertilizer use and Rigid wages whenever real wages fall; EXP1= A fertilizer tax is imposed with no recycling of the revenue; EXP2 = A fertilizer tax is imposed and revenue is recycled in the form of transfers to the poorest two household; In rural and urban areas each receiving quarter of the tax revenue; EXP3 =A fertilizer tax is imposed and revenue is recycled in the form of transfers to the poorest two household; In rural and urban areas each receiving quarter of the tax revenue. In addition there is improved market; Access to agricultural exports modeled as a 10% increase in the world price of agricultural goods; EXP4 =A fertilizer tax is imposed and revenue is recycled in the form of lower indirect tax for food industry; EXP5 = A fertilizer tax is imposed and revenue is recycled in the form of lower indirect tax for food; Industry. In addition there is improved market access to agricultural exports modeled as a 10% increase in the world price of agricultural goods; EXP6 = A fertilizer tax is imposed and revenue is recycled in the form of reduced tariffs on food industry; EXP7 = A fertilizer tax is imposed and revenue is recycled in the form of reduced tariffs on food industry. In addition there is improved market to agricultural exports modeled as a 10% increase in the world price of agricultural goods; EXP8 = fertilizer tax is imposed and revenue is recycled in the form of reduced indirect tax on the fertilizer industry; EXP9 = fertilizer tax is imposed and revenue is recycled in the form of reduced indirect tax on the fertilizer industry. In addition there is improved market to agricultural exports modeled as a 10% increase in the world price of agricultural goods

Table 4: Improved Market Access Modeled as 5% increase in the world price of agricultural exports

	EXP3A	EXP5A	EXP7A	EXP9A
FSAV	3.40	1.30	1.02	0.71
RGDP	0.10	0.08	0.03	0.10
GREVENUE	0.47	0.00	0.00	0.00
FERTAX	26.17	26.15	26.20	37.98
	EXP3A	**EXP5A**	**EXP7A**	**EXP9A**
AGR	0	0	0	0
OIL	0.02	0.03	0.00	0.00
.FOOD	0.67	0.00	1.63	0.60
TEX	0.00	0.00	0.00	0.00
.FER	18.59	18.60	18.58	0.00
O-CHE	0.06	0.12	0.00	0.17
PET	0.13	0.00	0.25	0.10
N-MET	0.00	0.00	0.00	0.00
IRON	0.06	0.11	0.00	0.25
O-MET	0.06	0.10	0.00	0.22
ENG	0.03	0.04	0.00	0.06
O-IND	0.00	0.00	0.00	0.02
.CON	0.00	0.00	0.00	0.00
.ELE	0.00	0.00	0.00	0.00
TRAN	0.00	0.00	0.00	0.00
HOTELS	0.08	0.16	0.00	0.33
O-SER	0.00	0.00	0.00	0.00

Notes: Experiments 3A,5A,7A,9A are the same as experiments 3,5,7,9except that improved market access to agricultural exports is modeled as 5% increase in the world price of agricultural exports.

Table 5

	EXP3A	EXP5A	EXP7A	EXP9A
Welfare.HU1	0.48	0.06	0.09	0.04
Welfare.HU2	0.29	0.06	0.08	0.05
Welfare.HU3	-0.11	0.07	0.08	0.06
Welfare.HU4	-0.09	0.08	0.08	0.07
Welfare.HU5	-0.04	0.12	0.08	0.11
Welfare.HR1	0.48	0.06	0.12	0.04
Welfare.HR2	0.33	0.06	0.10	0.05
Welfare.HR3	-0.12	0.06	0.09	0.05
Welfare.HR4	-0.11	0.06	0.08	0.05
Welfare.HR5	-0.08	0.10	0.13	0.08

Table 6: Sectoral Disaggregation in 2006/2007 SAM

- Agriculture
- Oil
- Food&Tobacco
- Textiles
- Fertilizer
- Other Chemicals
- Petroleum Products
- Nonmetals
- Iron & Steel
- Metals Industry
- Engineering and Machinary
- Other Industries
- Construction
- Electricity
- Transportation &Communication
- Hotels & Restaurants
- Other Services

APPENDIX: The Model

Assuming perfect competition in product and factor markets for simplicity, the *benchmark* model distinguishes between twenty different economic activities and 14 institutions including rural and urban households, public and private companies, government and the rest of the world. In order to capture the distributional impact of green and other taxes, each type of households – according to 2006/2007 SAM for Egypt- is further divided into five categories. So there is a total of ten households in the model The SAM is also disaggregated to allow for explicit modeling of the fertilizer sector. The model equations are presented below

Price Block

$$p_s^m = \left[1+\tau_s^m\right] r\pi_s^{wm} \qquad s \in ST \qquad (1)$$

p_s^m = domestic import price (L.E)

τ_s^m = tariff rate

r = foreign exchange rate (L.E./$)

π_s^{wm} = world import price

$s \in ST$ =the set of tradable sectors

Under the small country assumption, Egypt takes world prices for its imports as given so that the domestic price equals the world price adjusted for tariffs.

$$p_s^e = \left[1+\sigma_s^e\right] rp_s^{we} \qquad s \in ST \qquad (2)$$

p_s^e = domestic export price (L.E.)

σ_s^e =export subsidy rate

p_s^{we} =world export price

Again given the small country assumption, Egypt takes the world prices for its exports are given so that the domestic price equals the world price adjusted for the subsidy

$$p_s^q = p_s^d \frac{d_s}{q_s} + \left[p_s^m \frac{m_s}{q_s} \right]\Bigg|_{s\in ST} \qquad s \in S \qquad (3)$$

p_s^q =domestic supply price (L.E.)

p_s^d =domestic price of domestic output (L.E.)

d_s =domestic output sold domestically

q_s =domestic supply (from domestic output and imports

m_s =imports

$s \in S$ =set of sectors (tradables and nontradables)

according to equation 3, the domestic supply price is a weighted average of the domestic price of domestic output and the domestic import price with the weights being the shares of domestic output sold domestically and imports in domestic supply

$$p_s^x = p_s^d \frac{d_s}{x_s} + \left[p_s^e \frac{e_s}{x_s} \right]\Big|_{s \in ST} \qquad s \in S \qquad (4)$$

p_s^x =market price of domestic output

x_s =domestic output

e_s =exports

Similarly, equation 4 shows that the domestic price of domestic output is a weighted average of the domestic price of domestic output and domestic export price the weights being the shares of domestic output sold domestically and exports in domestic output.

$$p_s^{va} = \left[1 - \tau_s^i\right] p_s^x - \sum_{s' \in S'} \iota_{s's} p_{s'}^q \qquad s \in S \qquad (5)$$

p_s^{va} = value added price (L.E.)

τ_s^i = indirect tax rate

$s' \in S'$ =the set of sectors (=S)

$\iota_{s's}$ =quantity of input s' per unit of output s

Output, Supply and Demand Block

Domestic output and factor demand

$$x_s = \alpha_s^{xp} \prod_{f \in F} \Big|_{(f,s) \in MFS} c_{fs}^{s\ \beta_{fs}} \qquad s \in S \qquad (6)$$

α^{xp} = shift parameter in the production function

$f \in F$ =set of factors (Labor, Capital)

$(f,s) \in MFS$ =mapping between factors and sectors

c_{fs}^f =quantity demanded of factor f for sectors (Capital and labor)

β_{fs} =share parameter for factor f in sectors

Labor is further dissagregated to production (unskilled) and non Production (skilled) labor

$$c_{LS}^L = c_{LSP}^{L^{\alpha_{LSP}}} c_{LSNP}^{L^{\alpha_{LSNP}}} \qquad (7)$$

α_{LSP} = share parameter for production labor in sector s

α_{LSNP} =share parameter for nonproduction labor in sector

Assuming that producers maximize profits, equation 6 shows that output is produced using a Cobb Douglas production function. Skilled Labor is assumed to be sectorally mobile while unskilled labor and capital are sectorally immobile. The demand for both types of factors are given below

$$c_{LSP}^{L} = \frac{p_s^{va} x_s \beta_{LS} \alpha_{(LSP)}}{w_{LSP}^{S}} \qquad (8)$$

$$c_{LSNP}^{L} = \frac{p_s^{va} x_s \beta_{LS} \alpha_{LSNP}}{w_{LNP}} \qquad (9)$$

c_{LSP}^{L} = demand for production labor

c_{LSNP}^{L} = demand for nonproduction labor

w_{LSP}^{S} = wage for production labor in sectors

w_{LNP} = wage for nonproduction labor

While the demand for Capital is given by

$$c_{ks}^{k} = \frac{p_s^{va} x_s \beta_{ks}}{w_{ks}^{s}} \qquad (10)$$

c_{ks}^{k} = demand for capital in sectors

w_{ks}^{s} = price of capital in sectors

Intermediate demand

$$v_s = \sum_{s' \in S'} \iota_{ss'} x_{s'} \qquad s \in S \qquad (11)$$

v_s =intermediate demand for good s

demand for intermediate inputs is determined by multiplying fixed input coefficients by output under the standard Loentief formulation. In contrast to the case of primary inputs, this implies that there is no substitution possibilities between intermediate inputs.

Domestic supply aggregation and import demand

$$q_s = \alpha_s^q \left[\delta_s m_s^{-\rho_s^q} + (1-\delta_s) d_s^{-\rho_s^q} \right]^{\frac{-1}{\rho_s^q}} \qquad s \in ST \ (12)$$

α_s^q =shift parameter in the composite domestic supply function

δ_s =share parameter in the domestic supply function

ρ_s^q =substitution parameter in the domestic supply function

given the Armington specification, imported goods and goods produced domestically are imperfect substitutes and combined to produce domestic supply using the above CES function. Minimizing the costs of using imports and domestically produced costs subject to the CES function gives rise to the following equation for import demand

Domestic output transformation and export supply

$$m_s = d_s \left[\frac{p_s^d}{p_s^m} \frac{\delta_s}{1-\delta_s} \right]^{\frac{1}{1+\rho_s^q}} \qquad s \in ST \qquad (13)$$

$$x_s = \alpha_s^{xt} \left[\gamma_s e_s^{\rho_s^x} + (1-\gamma_s) d_s^{\rho_s^x} \right]^{\frac{1}{\rho_s^x}} \qquad s \in ST \qquad (14)$$

α_s^{xt} =shift parameter in the output transformation function

γ_s =share parameter in the output transformation fuction

ρ_s^x =substitution parameter in the output transformation function

Assuming imperfect transformability between domestic output for exports and domestic sales, exports and domestically output sold domestically are combined using a CET function. To determine how output will be allocated to exports or sold domestically, producers are assumed to maximize sales revenue subject to the above CET equation yielding the following equation for export supply:

$$e_s = d_s \left[\frac{p_s^e}{p_s^d} \frac{1-\gamma_s}{\gamma_s} \right]^{\frac{1}{\rho_s^x - 1}} \qquad s \in ST \qquad (15)$$

Domestic use and supply for nontradables

Since there are no imports or exports for nontradables then

$$x_s = d_s \qquad s \in SN \qquad (16)$$

domestic output is equal to domestic use of domestic output

$$q_s = d_s \qquad s \in SN \qquad (17)$$

and domestic supply is equal to domestic use of domestic output.

$s \in SN$ = Sectors producing nontradables {electricity and construction}

Factor and Institution Block

Factor income and transfers

$$y_k^k = \sum_{s \in S} \Big|_{(k,s) \in MKS} c_{ks}^k w_{ks}^s \tag{18}$$

y_k^k =income of capital (L.E.)

$$y_L^L = \sum_{s \in S} w_{LSP}^s c_{LSP}^L + w_{LNP} \left[\sum_{s \in S} c_{LSNP}^L \right] \tag{19}$$

y_L^L = labor income

In turn each factor of production passes its income to institutions in fixed proportion

$$t_{if}^f = \psi_{if}^f y_f^f \qquad \text{f = Labor, Capital} \tag{20}$$

ψ_{if}^f =share to institution i from income of factor f

t_{if}^f =income transfer to institution i from factor f

$i \in I$ =set of institutions

$(i, f) \in MIF$ =mapping between institutions and factors

Given that the total income of each factor has to be paid to some institution, then

$$\sum_{i \in I} \psi_{if}^f = 1$$

Income and transfers for households and companies

Incomes of households and companies are determined through this equation

$$y_i^i = \sum_{f \in F} \Big|_{(i,f) \in MIF} t_{if}^f + \sum_{i' \in ID} t_{ii'}^i + \bar{\pi} \phi_i^{ig} + r \phi_i^{iw} \qquad i \in ID \tag{21}$$

y_i^i =income of institution i

$t_{ii'}^i$ =income transfer to institution i from institution i’

$\bar{\pi}$ =price index

ϕ_i^{ig} =transfer to institution i from the government (L.E.)

ϕ_i^{iw} =transfer to institution i from the rest of the world ($)

$i \in ID$ =set of domestic non government institution

(Households, private and public companies)

$i' \in ID'$=set of domestic non-government institutions (=ID).

$$t_{ii;}^i = \psi_{ii'}^i y_{i'}^i \qquad i \in I,\ i' \in ID \quad (i, i') \in MIID \tag{22}$$

$\psi_{ii'}^{i}$ =share to institution i from income of institution i,' excluding direct taxes to the government tax account

$(i,i') \in MIID$ =mapping between institutions and domestic non-government institution

Household consumption spending and demand

Consumption spending is calculated from the equation below

$$e_h^h = \left[1 - \sum_{i \in I} \psi_{ih}^{i} - \tau_h^d - \psi_h^s\right] y_h^i \qquad h \in H \qquad (23)$$

$h \in H$ =households

e_h^h =consumption spending by household

τ_i^d =rate of direct tax for institution i

ψ_i^s =income shares for institution i to savings

It is assumed that households maximize a stone Geary utility function and marginal budget shares of each good consumed is equal to average income shares. This implies LES demand functions of the form

$$c_{sh}^h = \frac{\psi_{sh}^e e_h^h}{p_s^q} \qquad h \in H,\ s \in S \qquad (24)$$

c_{sh}^h =quantity demanded of good s from household h

ψ_{sh}^e =expenditure share for good s for household h

Government revenue and expenditure

According to the SAM, government revenue consists of the different types of taxes in addition to transfers from other institutions

$$\begin{aligned} y^g &= \sum_{i \in ID} t_{govt,i}^{i} + \sum_{i \in ID} \tau_i^d y_i^i \\ &+ r\phi_{government}^{iw} + \sum_{s \in S} \tau_s^i p_s^x x_s + \sum_{s \in ST} \tau_s^m r \pi_s^{wm} m_s \end{aligned} \qquad (25)$$

y^g =government revenue (L.E.)

$\phi_{government}^{iw}$ = transfers from rest of the world to government

Government expenditure is given by the following equation

$$e^g = r\phi^{wg} + \overline{\pi} \sum_{i \in ID} \phi_i^{ig} + \sum_{s \in S} p_s^q \overline{\gamma}_s^g + \sum_{s \in ST} \sigma_s^e r p_s^{we} e_s \qquad (26)$$

e^g =government expenditure (L.E.)

$\overline{\gamma}_s$ =government demand for good s

ϕ_i^{ig} =transfer from the government to institution i

ϕ^{wg} =transfer from government to the rest of the world

System Constraint Block

Factor and domestic good markets

Assuming full employment and flexible prices, equilibrium in the markets for factors of production imply that demand for each factor equals fixed supply. For sector specific factors

$$c_{Ks}^{k} = \lambda_{ks}^{s} \tag{27}$$

λ_{ks}^{s} = fixed supply of capital

$$c_{LSP}^{L} = \lambda_{LSP}^{s}$$

λ_{LSP}^{s} = fixed supply of production labor

As for sectorally mobile skilled labor , equilibrium implies

$$\sum_{s\in S} c_{LSNP}^{L} = \lambda_{LNP} \tag{28}$$

λ_{LNP} = fixed supply of nonproduction labor

Assuming that investment are fixed exogenously, equilibrium in the goods market implies

$$q_s = v_s + \sum_{h\in H} c_{sh}^{h} + \overline{\gamma}_s + \overline{\iota}_s \qquad s \in S \tag{29}$$

$\overline{\iota}_s$ = investment demand

Current Account

$$\sum_{i\in I}\phi_i^{iw} + \sum_{s\in ST} p_s^{we} e_s + s^w = \phi_i^{wg} + \frac{1}{r}\left[\sum_{i\in ID}\Big|_{(row,i)\in MIID} t_{row,i}^{i}\right] + \sum_{s\in ST}\pi_s^{wm} m_s \tag{30}$$

s^w =foreign savings (\$)

ϕ_i^{iw} =transfers from the rest of the world to institutions i

The current account equation imposes equality between income and expenditure of the rest of the world

Welfare : Measured as equivalent Variation

EV(h)=Π(p_s^q 1/ p_s^q o) ψ_{sh}^e e_h^h 1- e_h^h o

p_s^q 1 = domestic supply price resulting from the implementation of the shock

p_s^q o = domestic supply price in the base run

e_h^h 1 = consumption expenditures for household h resulting from implementation of the shock

e_h^h o = consmption expenditures for household h (LE) in the base run

Mathematical Statement In Summary Form

Sets - - One-Dimensional

$f \in F$	= factors(labor and capital)
$h \in H \ (\subset I)$	= households
$i \in I$	= institutions
$i \in ID \ (\subset I)$	= domestic non-government institutions
$i' \in ID'$	= ID
$s \in S$	= sectors/goods
$s \in S'$	= S
$s \in SN \ (\subset S)$	= non-tradable sectors/goods
$s \in ST \ (\subset S)$	= tradable sectors/goods

Sets - - Two-Dimensional

$(f, s) \in MFS$	= mapping between factors and sectors
$(i, f) \in MIF$	= mapping between institutions and factors
$(i, i') \in MIID$	= mapping between institutions and domestic non-government institutions

Parameters

α^{xp}	= shift parameter in the production function
α_s^{xt}	= shift parameter in the output transformation function
α_s^q	= shift parameter in the composite supply function
α_{LSP}	= share of production labor

α_{LSNP} = share of nonproduction labor

β_{fs} = share parameter for factor f in sector s

γ_s = share parameter in the output transformation function

$\bar{\gamma}_s$ = government demand

δ_s = share parameter in the composite supply function

$\iota_{s's}$ = quantity of input s' per unit of output s

$\bar{\iota}_s$ = investment demand

λ^g_{LNP} = government demand for nonproduction labor

λ^s_{ks} = fixed supply of capital in sector s

λ^s_{LSP} =fixed supply of production labor

λ_{LNP} = fixed supply of nonproduction labor

π^{wm}_s = world import price($)

$\bar{\pi}$ = price index (LE)

ρ^x_s = substitution parameter in the output transformation function

ρ^q_s = substitution parameter in the composite supply function

σ^e_s = export subsidy rate

τ^d_i = rate of direct tax for institution i

τ^i_s = indirect index rate

τ^m_s = tariff rate

ϕ^{ig}_i = transfer to institution i from the government (LE)

ϕ^{iw}_i = transfer to institution i from the Row ($)

ϕ^{gw}_i = transfer from the rest of the world to the government

ϕ^{wg} =transfer from the government to the rest of the world

ψ^e_{sh} = expenditure share for good s for house hold h

ψ^f_{if} = share to institution i from the income of factor f (labor, capital)

$\psi^i_{ii'}$ = share to institution i from the income of institution i' (excluding direct taxes to the government)

ψ^s_i = income share for institution i to savings

ω_s = weight in price index for good s

Variables

c_{fs}^{f} = demand for factor f from sector s (Labor, capital)

c_{LSP}^{L} = demand for production labor

c_{LSNP}^{L} =demand for nonproduction laobr

c_{sh}^{h} = consumption demand for good s from household h

d_s = domestic output sold domestically

e_s = exports

e^g = government expenditures (LE)

e_h^h = consumption expenditures for household h (LE)

m_s = imports

p_s^d = domestic price of domestic output (LE)

p_s^e = domestic export price (LE)

p_s^m = domestic import price (LE)

p_s^q = domestic supply price (LE)

p_s^{va} = value-added price (LE)

p_s^{we} = world export price ($)

p_s^x = market price of domestic output (LE)

q_s = domestic supply (from domestic output and imports)

r = foreign exchange rate (LE/$)

s^w = foreign savings ($)

t_{if}^{f} = income transfer to institution i from factor f (LE)

$t_{ii'}^{i}$ = income transfer to institution i from institution i' (LE)

v_s = intermediate demand for good s

w_{LNP} = price of nonproduction labor (LE)

w_{LSP}^{s} = price production labor (LE)

w_{Ks}^{s} = price of capital (L.E)

x_s = domestic output

y_f^f = income of factor f (LE)

y_i^g = government income (LE)

y_i^i = income of institution i (LE)