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EXTENDED ABSTRACT

Title: Analyzing the impact of reducing food waste in Europe throughout budget-constrained multipliers

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Abstract:

About one-third of food produced for human consumption is lost or wasted, becoming a major global issue that threatens a sustainable food system and generates negative externalities in environmental terms. In view of this situation, European Commission has set the target of cutting down food waste to one-half by 2020 throughout the European Union (EU). Accordingly, national campaigns against food waste have been launched and governments have led to research to get a deeper understanding of food waste within its borders (Monier et al., 2010; Viel and Prigent, 2011). As a result, most economic reports and studies aim to estimate the amount of food wasted (Göbel et al., 2012; Hanssen and Moller, 2013), whereas fewer attempt to estimate its monetary value (Segrè and Falasconi, 2011; Williams et al., 2011) and to a much lesser extent to monetize its social and environmental cost (ARC, 2012; BCFN, 2012).Avoiding this wastage has an economic impact on national economies, which has been traditionally assessed in terms of resource savings. However, calculating the economic impact of food waste reduction involves more than just a one-to-one translation in savings, it should take into account the interactions between actors and sectors in the food system and in the whole economy (Rutten, 2013). The Computable General

Equilibrium (CGE) framework becomes a powerful tool for assessing the economic impact of food waste reduction, such as in the works on selected countries or regions made by Britz et al. (2014), Irfanoglu et al. (2014), Rutten et al., (2013), Rutten and Kavallari (2013) or Rutten and Verma (2014) . Within the CGE framework, Campoy et al. (2017) employ a CGE linear model to address the economic impact of reducing avoidable food waste on a sample of EU countries with different economic structures (Spain, Poland and Germany), and, especially, on their agri-food sector.

This work aims to extend the work of Campoy et al. (2017) by using a multiplier model which capture the effect of reallocating those resources saved by avoiding food waste. To do so, budget-constrained expenditure multipliers are computed upon a Social Accounting Matrix (SAM) with highly disaggregated agricultural and food industry accounts (AgroSAMs) for the corresponding country member. The AgroSAM database was constructed based on the National Supply and Use Tables (SUT) from Eurostat and information on agricultural from CAPRI database (Britz and Witzke, 2012) for each member state of the UE. Each AgroSAM has eighty seven activities and ninety six commodities, of which twenty corresponds to primary agriculture , twenty one to primary sector, ten to food industry, twenty nine to manufacturing industry , one to construction and twenty five are commodities of the service sector. In addition, the AgroSAMs contain two production factors (capital and labor), trade and transportation margins, eleven types of taxes and five accounts for institutions (a single representative household, corporation, central government, investments-savings account and rest of the world). This structure has been tailored to the scope of the study with greater emphasis on those accounts that will be analyzed. The original AgroSAMs are for year 2000 (Müller et al., 2009), whereas the ones employed in this work are updated to the year 2007 (Philippidis et al., 2014). From the complete database, AgroSAMs for Spain, Poland and Germany were choosen to analyze and compare the economic impact of reducing food waste on these member states, representative of different economic structures.

Based on the multiplier theory initiated by Stone (1962) and Pyatt and Round (1979) and Leontief's model (1941) , budget-constrained multiplier are derived following the same procedure to calculate the extended multipliers matrix from $Y_m = (I- A_{mm})^{-1} Z$, where Z is the vector of exogenous accounts[1] ($A_{mk}\ Y_k$) and $M = (I- A_{mm})^{-1}$ is the extended multipliers matrix in the SAM. These multipliers can be interpreted as the input requirements by unit increases

[1] Submatrix A_{mk} represents how the income flows from the exogenous accounts are distributed among the endogenous accounts.

of expenditure or income (depending on whether columns or rows are considered) in an account, as in the so-called inverse Leontief matrix, with the difference that this matrix reflects the relation between production, the factors' income, income distribution and final demand. It is important to point out that the selection of *m* (i.e., the decision regarding which accounts are endogenous) usually depends on the type of analysis undertaken, which determines which accounts (exogenous) are the ones explaining the variation of the income in other accounts (endogenous). If changes in the vector of exogenous accounts are denoted as *dZ*, changes in the income of the endogenous accounts will be expressed as

$$dY_m = MdZ = Md\left(A_{mk}Y_k\right) = MA_{mk}dY_k \qquad (1)$$

The j^{th} column in *M* indicates the total income generated in each of the endogenous accounts when a unit of income flows from the exogenous institutions towards endogenous account *j*. These are the standard multipliers $\mu_j = \sum_{i=1}^{m} m_{ij}$.

Conversely, if a budget constrain is included in the model, any increase of income to an endogenous accounts will be follow by a reduction of income to the remaining ones, keeping thus that constrain (Guerra and Sancho, 2011). This implies the use of redistribution scheme (φ) that guarantees the upholding of the budget constrain $\varphi_j + \sum_{i\neq j}^{m} \varphi_i = 0$. The standard multiplier are now conditioned by the countervaling substitution effect induced by such scheme. As result, we obtain the budget-constrained multiplier matrix $\widehat{M}$, where each column of can be rewritten as follows:

$$\hat{\mu}_j = \sum_{i=1}^{m} \varphi_j m_{ij} + \sum_{i=1}^{m} \sum_{i\neq j} \varphi_i m_{ij} \qquad (2)$$

Unlike the always positive standard multipliers μ_j ,the budget-constrained multiplier $\hat{\mu}_j$ can show any sign, either positive or negative, as result of the balance between the overall positive output effects ($\sum_{i=1}^{m} \varphi_j m_{ij}$) and the negative substitution effects ($\sum_{i=1}^{m} \sum_{i\neq j} \varphi_i m_{ij}$

This model is employed to assess the economic impact of reducing avoidable food waste on a sample of European member states, such as Germany, Spain and Poland. To do this, an exogenous vector *Z* is defined for each agent along the supply chain and at household level, encompassing the corresponding demand of agrifood commodities. A new vector *Z'* is obtained by subtracting the injection of income resulting of monetize the avoidable portion of food waste[2] by each agent along the supply chain and at household level in each member state selected. The breakdown among different agents responsible for food waste is determined by Monier et al. (2010), which does not include the agricultural activities but represents the only current reference when it comes to statements about the extent of food wastage in the EU-27 (Bräutigam et al., 2014). According to this study, the Wholesale/ Retail[3] sector (WRS) generates the smallest proportion of food waste, only a 5%, followed by the Food service/Catering[4] sector (FCS), which amounts for a 14% of the waste. The bulk of food waste arisings are generated by the Manufacturing[5] sector (MFS), with a 39%, but also at Household[6] level (HH), with a 42%. The value of the avoidable food waste has been established by applying the corresponding percentage from Monier et al. (2010) to the food purchases made by each sector. Concretely, the 6.3% of the food purchases made by WRS and FCS could be avoidable, whereas this figure increase to 15% at HH level. In the FCS, 4% to 10% of food purchases are estimated to become waste before reaching a customer and this waste is 90% avoidable, whereas no data is available from WRS. Due to that, the avoidable portion of food waste for those productive sectors has been calculated by multiplying the midpoint (7%) by the avoidable portion of waste, resulting in the 6.3% of the food purchases. In MFS, food waste is largely unavoidable, so this sector has not been considered in the simulation described just below. Finally, at HH level, food waste arisings represents 25% of food purchased (by weight), of which 60% could be avoidable; therefore the percentage of avoidable waste has been established in 15%.

Considering the previous information, four different scenarios has been set out in order to assess the economic impact of reducing avoidable food waste on the member states selected, (Germany, Poland and Spain):

- Scenario 1: Impact on the member states economies analyzed as a result of reducing the avoidable food waste generated by WRS, FCS and HH.

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[2] Monier et al. (2010) defines food waste as "waste composed of raw or cooked food materials and includes food materials discarded at any time between farm and fork" whereas, food waste at househould level is considered as "waste generated before, during or after food preparation, such as vegetable peelings, meat trimmings, and spoiled or excess ingredients". In both cases the food waste can be edible or inedible.

[3] Production sector involving the distribution and sale of food products to individuals and organisations.

[4] Production sector involved in the preparation of ready-to-eat food for sale to individuals and communities; includes catering and restauration activities in the hospitality industry, schools, hospitals and businesses.

[5] Production sector involved in the processing and preparation of food products for distribution.

[6] Sector involves food waste generated in the home by consumers in household units.

- Scenario 2 and 3: Impact of reducing the avoidable food waste in WRS and FCS respectively in terms of total output, GDP and employment on the three European economies.
- Scenario 4: Impact resulting of the abatement of the avoidable portion of food which ends up as being discarded by households in terms of total output, GDP and employment on Spanish, German and Polish economies.

The economic impact derived from this negative shock described in each scenario is given in absolute terms and in percentage of change over the baseline data encompassed in the corresponding AgroSAM, using both standard and budget-constrained multipliers. Under the latter, while the overall output effect will be negative, the substitution effects will be positive due the negative shock. It means that the corresponding agent employs the money saved by avoiding food waste in purchasing other goods or services. The redistribution scheme employed for each agent follows a simple homothetic pattern that assume an increase proportionate to the initial outlays.

Under the Scenario 1, Polish economy exhibits the smallest size for the shock (€6,868 MM), whereas this shock is nearly double on Spanish economy (€12,742 MM) and more than four time on the German economy (€29,968 MM). However in relative terms, countries show a reverse order and the differences among them are not so pronounced under the standard multiplier approach. Thus, the effects on German economy are the smallest, with change on production and GDP of -1.42 % and -1.21% respectively. The impact on Spanish economy is slightly higher, with figures of -1.57% and -1.49 %, and greater on Polish economy, with a reduction of -2.32% in production and -2.15% in GDP. Employment does not follow the previous pattern since Spain and Poland exhibits lower and quite similar figures in terms of labour shedding compared with Germany, nearly doubling the job lost due to reduce the production of the commodities demanded by WRS, FCS and HH. That picture changes where the same shock is analysed under the budget-constrained multiplier approach. As expected, all the variables become less negative. In addition, while Germany continues to be the economy with the smallest effects and Poland the one with the largest, the difference among both country is smaller. However, the employment pattern remains.

In Scenarios 2 and 3, the portion of avoidable food waste established was the same (6.3% of food purchases) but the monetary size of the shock is quite different for each sector, such as the shock is much smaller within WRS than within FCS. In the case of WRS, Germany exhibits the smallest shock (€73 MM) and thus the impact in terms of production and GDP is barely -0.02%, whereas the reduction in labour reaches 6,400 employments. These figures are slightly higher for the Spanish economy, where the shock amounts for €108 MM, therefore the production and GDP decrease -0.07% and the labour falls in 11,378 employments. The Polish economy is the most affected by reducing the food waste within the WRS, the shock is €246 MM more than three times the size of the shock in Germany. The impact is also much higher compared to German economy since the production and GDP decreases -0.33% and the labour falls 36,580 employments, fifteen and sixteen times the Germany figures. Conversely, if budget-constrain is applied, all the economies turns their figure to positive, that is, the overall output effect is overcame by the substitution effects. This could indicate the promoter capacity of WRS on the corresponding economies.

The size of the shock due to reducing food waste by German and Spanish FCS is much greater than in the corresponding WRS. For those countries, the monetary value of the avoidable food waste is over one thousand millions of euros. Although the shock in German economy is greater in absolute terms (€1,602 M) compared to Spanish economy (€1,165 M), the effects on production and GDP are higher for the latter. The same does not apply for labour, for which labour decreases 75,989 employments in Germany compared to 54,616 in Spain. It is noteworthy that the smallest shock in Poland, almost nine time less than in Germany, generates a similar impact in terms of production and GDP, but the impact is much less severe on the labour force, with a reduction of 29,915 employments. Although the substitution effects greatly reduces the negative impact of the shock, they are not enough to turn the figures in to positive ones, as in the WRS case. This group of activities has lesser influence on the economy compared with WRS

The Scenario 4 reflects the impact of reducing the avoidable food waste generated by HH. As pointed out by Monier et al. (2010), HH are responsible for the most part of waste arising. Germany exhibits the greatest shock (€28,293 M), Spain is in the midpoint (€11,468 M) and Poland the smallest one (€6,434 M). However, the effects in term of production and GDP are quite similar for the first two countries (between -1.3% and -1.5%), whereas they are slightly higher on Polish economy (around -2.5%). Turning attention to labour, the pattern again differs, that is, Germany exhibits the largest reduction of employment, followed at some distance by Poland and in lesser extent by Spain. In this case, the budget-constrain assumption leads to the best situation for Spain, with the highest decrease on the negative impact. And, this time, Poland exhibits better results than Germany. Thus, with a quite close change on production and GDP after the impact, the effects on employment are quite different.

Keywords: Linear Multiplier Models, Social Accounting Matrix, Food Waste.
JEL codes: C67, D57, Q18.

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