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Abstract

This paper describes the construction of a social accounting matrix with disaggregated agricultural and food industry sectors for Ireland for the purpose of agri-food policy simulations. The base year for the AgriFood–SAM is 2005 and it draws on a recently constructed 2005 SAM for Ireland. Its unique features include a high level of disaggregation of the agricultural and food industry sectors as well as the integration of individual household data for the purposes of micro-simulation analysis. The AgriFood–SAM documented here can be used as a tool to analyse the inter-sectoral linkages between the agri-food sectors and the Irish economy. Multiplier effects for exogenous changes in final demand for different agri-food activities are presented. Finally, the economy-wide effects of a simulation of a reduction in greenhouse gas emissions from the agricultural sector are calculated using these multiplier values.

Keywords: social accounting matrix, input-output table, agriculture, multiplier analysis, Ireland
JEL Classification: C67, D57, Q12, Q18

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1 Introduction

A social accounting matrix is an internally consistent accounting framework within which the full circular flow of income and expenditure is captured. Its structure should correspond to the modelling framework and policy questions which it will be used to address. This paper describes the construction of a social accounting matrix with disaggregated agricultural and food industry sectors for Ireland for the purpose of agri-food policy simulations. The 2005 AgriFood-SAM for Ireland documented here makes use of the 2005 Input-Output Tables (CSO, 2009e) on which the 2005 SAM for Ireland was constructed (Miller et al., 2011). It uses the 2005 National Farm Survey (NFS) to disaggregate the agricultural sector. Given the link between the NFS and the 2004-2005 Household Budget Survey (HBS 04/05) (CSO, 2005b) it integrates all individual households available in both surveys. These new features facilitate the link of the AgriFood-SAM with the NFS and HBS 04/05 at the micro level for the purpose of micro-simulation analysis.

Henry (1972, 1980, 1986) was the first to construct SAMs for Ireland for economic analysis. Subsequently, O'Toole and Matthews (2002) constructed a SAM for the year 1993 based on the published Input-Output table from 1993, with particular emphasis on the agricultural and food processing sectors. Dixon (2006) produced a 2003 SAM for Ireland with a disaggregated agrifood sector using the 1998 Input-Output table and a type of RAS procedure to scale different data from various sources to match the aggregates for the macro-economy in 2003. Wissema (2006) also built a 1998 SAM for Ireland with a disaggregated energy sector. O'Herlihy (2004) developed a regional SAM for the Border, Midland and Western Region of Ireland. Müller et al. (2009) carried out a study at the European Commission's Joint Research Centre (JRC) to build a common social accounting matrix database for the EU-27. The JRC team constructed 27 Social Accounting Matrices for each EU member state including Ireland with a disaggregated agricultural sector for the year 2000. The disaggregation of the agricultural sectors in the 27 SAMs is based on the Common Agricultural Policy Regional Impact Analysis (CAPRI, 2008) system data. The AgriFood-SAM documented in this paper advances on that exercise by: (i) using more recent data; (ii) explicit disaggregation of the value added account and external accounts; (iii) provide a more careful treatment of the taxes and subsidies account for agriculture; and (iv) explicit disaggregation of the household account. This paper starts with the unbalanced SAM in constructing the AgriFood-SAM. Balancing takes place when the disaggregation of various accounts is complete.

According to the Environmental Protection Agency (EPA, 2010), agriculture is the largest source of emissions, representing 30 percent of total national emissions in 2010, a 4 percent increase since 2007, followed by the energy sector with 22 percent. EPA projections show that Ireland can comply with its Kyoto obligations regarding the reduction in GHG emissions, but the emissions from agriculture are projected to increase by 7 percent by 2020, on 2010 levels, given the projected impact of Food Harvest 2020. A 20 percent reduction in the GHG emissions from the agricultural sector could be achieved through a reduction in animal numbers. The partial equilibrium FAPRI-

Ireland model assumes that the 20 percent reduction in emission is achieved through a reduction in the number of beef cattle. The base year for the partial equilibrium model is 2005. In this paper, a SAM-FAPRI Ireland GHG emission model is used to simulate the effects of a 20 percent reduction in GHG emissions from the agriculture sector. The results from Donnellan and Hanrahan, (2011) GHG emission model of a 20 percent reduction in the GHG emission from the primary agriculture cattle sector are used in a SAM-multiplier model to estimate its economy-wide impact.

This paper outlines the construction of the AgriFood-SAM which takes place in two stages. First, the construction of the 2005 SAM for Ireland which is used as the starting point for this paper is briefly recapitulated in Section 2. In the second stage, this SAM is disaggregated further to construct an AgriFood-SAM that gives a more complete representation of the agri-food sector, the value added and external accounts as well as disaggregating the household sector. This is presented in Section 3. Section 4 illustrates the use of the 2005 Irish AgriFood-SAM for multiplier analysis. The conclusions are summarized in Section 5.

2 A Social Accounting Matrix for 2005

The construction of the Irish SAM is a three step-process: (i) Building the macro-SAM: The macro-SAM has the structure shown in Table 1 but at a highly aggregated level. The basic information source for the macro-SAM is the National Accounts System (CSO, 2009b) in that almost all the flows that are part of the latter are integrated into the former. (ii) Generating the SAM: This involves the disaggregation of the macro-SAM. Each cell of the macro-SAM corresponds to a matrix of accounts in the SAM. The activity account is disaggregated among 55 activities producing 55 commodities, according to the symmetric 2005 Supply and Use and Input-Output Tables for Ireland constructed by CSO and published by Eurostat (2009).[2]

For a better understanding of the distribution of income from primary factors to households, government and the external sector, the factors of production account is disaggregated into labour and capital. This disaggregation was done using the information provided by the Input-Output Tables (CSO, 2009e) and the National Account System (CSO, 2009b).

The taxes account is split into direct and indirect taxes and custom duties. Direct taxes are paid by the households and enterprises, while the indirect taxes represent: payments by activities for such items as business licenses, departure charges, motor vehicle taxes, road tolls, stamp duty, and other non-tax revenue, and commodity tax entry, such as excises and value-added tax. Import tariff and export tax rates by commodity category were derived from trade information from Revenue

[2]The 2005 Supply and Use and Input-Output Tables for Ireland (CSO, 2009e) are published using a 53 sector commodity disaggregation. Eurostat (2009) published the full 55 sector commodity disaggregation which is used in this paper.

Table 1: Numeric 2005 Irish macro SAM (million euro)

		PRODUCTION			INSTITUTIONS						
		1. ACT	2. COMM	3. FACT	4. HH	5. ENT	6. GOV	7. TAX	8. ROW	9. SAV	Total
PRODUCTION	1. ACT		Marketed output (331,630)		Own consumption (0.92)						ACT income (331,361)
PRODUCTION	2. COMM	Intermediate inputs (188,169)	Trade and transport margins (0)		Private consumption (73,778)		Gov consumption (24,905)		Exports (132,368)	Investments (43,937)	Demand (463,157)
PRODUCTION	3. FACT	Value Added (143,083)							Factor from ROW (42,657)		Factor income (185,740)
INSTITUTIONS	4. HH			Factor income to HH (89,275)	Inter-HH transfer (955)	Surplus to HH (3,941)	Transfers to HH (16,974)		Transfers to HH from ROW (2,970)		HH Income (114,115)
INSTITUTIONS	5. ENT			Factor income to ENT (27,710)	Transfers to ENT (5,893)	Transfers to ENT (1,383)	Transfers to ENT (1,591)		Transfers to ENT from ROW (1,518)		ENT Income (38,095)
INSTITUTIONS	6. GOV			Factor income to GOV (1,179)				Taxes (50,179)	Transfers to GOV from ROW (454)		GOV Income Income (51,830)
INSTITUTIONS	7. TAX	Producer Tax, value added tax (108)	Sales Taxes, tariffs, export taxes (18,977)		Transfers to GOV, direct HH taxes (23,711)	Direct ENT taxes (7,233)	Custom Duties (150)				Taxation (50,179)
INSTITUTIONS	8. ROW		Imports (112,820)	Factor Income to ROW (67,558)	Factor Income to HH (109)	Surplus to ROW (3,948)	GOV transfers to ROW (527)			Capital transfers from ROW (76)	ROW Income (185,038)
	9. SAV				HH Savings (9,669)	ENT Savings (21,590)	GOV Savings (7,683)		ROW Savings (5,071)	Capital Transfers (2,864)	Savings (46,877)
	Total	ACT Expenditure (331,360)	Supply (463,157)	Factor Expenditure (185,740)	HH Expenditure (114,116)	ENT Expenditure (38,086)	GOV Expenditure (51,830)	Taxes (50,179)	ROW (185,038)	Investment (46,877)	

Source:Authors' calculation

Commissioners (2006). The government receives income from taxes (direct and indirect) and transfers from the external sector and import duties.

The external account is split into three based on the export and import main destinations: UK, Rest of the EU and Rest of the World, according to the external account chapter in the Statistical Yearbook of Ireland 2008 (CSO, 2009d). Trade and transport margins were directly taken from the 2005 Supply Table (CSO, 2009e) and represent the cost of managing and transporting commodities. This account row distributes the margins from the trade sectors over all other sectors and the column is the total margins for the trade sectors identified as the retail, wholesale and motor transport sectors.

The above disaggregation results in a 124x124 2005 Irish Social Accounting Matrix, with 55 activities producing 55 commodities, 2 factors of production, 3 institutions (households, enterprises and government), 3 tax-related accounts (direct, indirect tax and custom duties), one savings/investments account and 3 external accounts (UK, REU and ROW). However, this process of disaggregation results in an unbalanced but complete SAM which requires the third step of (iii) Balancing the SAM. The method used is the cross-entropy (CE) approach based on Robinson et al. (2001). A brief discussion of the cross-entropy balancing method is described in section 3 (a more detailed discussion is presented in Miller et al., 2011). This paper starts with the unbalanced SAM in constructing the AgriFood-SAM. Balancing takes place when the disaggregation of various accounts is complete.

3 A 2005 Agriculture-Food SAM (AgriFood-SAM) for Ireland

In the 2005 SAM for Ireland, the agriculture, hunting and related services (NACE code 01) and manufacture of food and beverages (NACE code 15) sectors are treated as single industries, following the 2005 Input-Output Table (Eurostat, 2009). The household sector is represented by a single account and there are two factors of production. We now proceed to disaggregate the agri-food sectors in the SAM as well as the household sector to construct what we call the AgriFood-SAM. This AgriFood-SAM differs in four major respects from the 2005 SAM for Ireland just described. First, using information from the Economic Accounts for Agriculture (EAA) (CSO, 2005a), the National Farm Survey (NFS) (Teagasc, 2004 and Teagasc, 2005b) and the input-output table, 12 separate agricultural industries are constructed producing 13 commodities. Second, the food-processing sector is disaggregated into 10 industries producing 10 commodities, thus providing greater detail about the downstream activities of the food system and its relationship with the agricultural sectors. Third, for the newly formed agricultural sectors labour is split between paid and family labour as well as introducing the return to land as another factor of production for these sectors. Fourth, the household sector is replaced by 6,866 households constructed using the NFS 2004 and the HBS 2004-2005.

The disaggregation of both agricultural, hunting and related services (AG) and manufacture of food and beverages (FD) industries presupposes the construction of a new Input-Output table giving details of the inputs required and uses for each of the disaggregated activities.

3.1 Agriculture, hunting and related services breakdown

3.1.1 Disaggregation of intermediate inputs

In this section the disaggregation of the agriculture, hunting and related services sector NACE 01 is described. The main source of agricultural data was the Output, Input and Income in Agriculture 2009 (OIIA 2009) (CSO, 2009c), with additional information from the Compendium of Irish Agricultural Statistics 2008 (CIAS 2008) (DAFF, 2008), Economic Accounts for Agriculture 2005 (EAA 2005) (CSO, 2005a), National Farm Survey 2005 (Teagasc, 2005b), Annual Review and Outlook for Agriculture and Food 2007 (AROAF 2007) (DAFF, 2007) and various Teagasc publications including Management Data for Farm Planning (MDFP 2005) (Teagasc, 2005a) and Situation and Outlook in Agriculture 2008/2009 (SOA 2008/2009) (Teagasc, 2009).

The first step in disaggregating the agriculture, hunting and related services sector was to use the Output, Input and Income in Agriculture 2009 (OIIA 2009) which identifies 18 types of commodities: cattle, pigs, sheep, horses, poultry, milk, other products, barley, wheat, oats, potatoes, sugar beet, mushrooms, other fresh vegetables, fresh fruit, turf, other crops and forage plants. These were aggregated into the 12 industries used in the AgriFood-SAM as shown in Table 2. Each industry produces one commodity, generating a one to one relation between the SAM sectors, apart from the Cattle and Milk industries which produce cattle and milk/cull cows respectively, but also calves. Calves are the main link between the Cattle and Milk industries in the agricultural sector. Hence, the 12 agricultural industries generate 13 agricultural commodities.

The output matrix represents the industry - commodity relationship. Total output of the Agriculture, hunting and related services sector for the year 2005 is €5,303 million at producer prices (OIIA 2009). The output for each of the 12 industries is calculated using OIIA (2009) and EAA (2005) which reports the total output value at basic prices and producer prices and the shares of other products (i.e. wool output in the case of sheep industry) using Eurostat specifications. The value of output is reported at basic prices, as the AgriFood-SAM reports the subsidies and taxes on production in separate accounts.

The Milk and Cattle industries are closely related as both industries produce calves. In order to estimate the total output for those industries we use the total number of cattle and calves in 2005 reported by the CSO (2009c). There were 2,637,400 cows in the December 2005 census, out of which 1,150,000 were dairy cows, 1,101,100 suckler cows, and 1,693,300 domestically bred calves. The output of calves was attributed to both the Milk and Cattle industries. Given the

Table 2: Concordance between SAM and OIIA 2009 accounts

SAM Activities Accounts	**OIIA 2009 Accounts**	**SAM Commodities Accounts**
Milk	Milk	Milk &Calves
Cattle	Cattle	Cattle &Calves
Sheep-Wool	Sheep, share of the other products using EuroStat specification	Sheep & Wool
Pigs	Pigs	Pigs
Poultry - Eggs	Poultry, share of the other products using EuroStat specification	Poultry & Eggs
Horses	Horses	Horses
Cereals	Barley, Wheat, Oats	Cereals
Fruit - Vegetable	Mushrooms, Other Fresh Vegetable, Fresh Fruit	Fruit - Vegetable
Sugar	Sugar Beet	Sugar
Potatoes	Potatoes	Potatoes
Forage Plants	Forage Plants	Forage Plants
Other Crops	Other Crops, Turf	Other Crops

relatively equal number of cows in both industries, we assume that each industry produces half of the total number of calves. Out of the total number of calves 885,700 head are male and 807,700 head are female, therefore of the calves produced in the Milk industry half are assumed to be female. Sufficient dairy calves for replacement are assumed to be retained within the Milk industry. Surplus heifer and bull calves from the Milk industry are transferred to the Calves activity, while cull cows are sold to the Beef processing industry. According to Management Data for Farm Planning (MDFP) 2005 and National Farm Survey 2005, a dairy cow has a milking period of approximately five years; therefore 20 percent of the milking cows must be replaced with new calves each year. The calves born in the Cattle industry are transferred to the Calves activity and then purchased as an input at the same price. The prices for cattle and calves per head are used to calculate the value of output for the cattle and calves industry. According to the Irish Farmers Journal 2005, the average price of a cull cow was €553, heifers €526, suckler cows €490, dairy cows €787 and calves €201. The output for each agricultural sectors is reported in the Output, Input and Income in Agriculture 2009 (OIIA 2009) prepared by the CSO. Hence, the output matrix is a diagonal matrix with the exception of those two industries that register a separate output of calves. The explicit treatment of calves means that the gross value of agricultural output in the AgriFood-SAM exceeds the value of gross output in OIIA (2009) by this amount, with a corresponding additional expenditure on calves as part of intermediate input expenditure.

The main source of data for the intermediate consumption matrix is the OIIA 2009 and the EAA 2005. In the OIIA 2009 there are 11 intermediate consumption factors: Feeding stuffs, Fertilizers, Seeds, Energy and Lubricants, Maintenance and Repairs, Services, Crop protection products, Veterinary pharmaceutical products, Other Goods (detergents, small tools, etc.), Forage Plants and Contract work. Table 3 describes the association of the intermediate consumption factors with the sectors of the SAM. Total intermediate consumption in the agriculture sector according to EAA 2005 is €3,675 million at basic prices and €4,060 million at purchasers' prices in the 2005 Use Table for Ireland. The difference of €385 million represents the difference between the basic

Table 3: Intermediate Consumption in Agriculture

Intermediate Consumption	**NACE codes**	**Value (€million)**
Seeds & Planting stock	01	85.9
Energy & Lubricants	40	283.5
Electricity	*40*	*60.5*
Gas	*40*	*0.0*
Other fuels	*40*	*223.0*
Fertilisers - outside	24	363.3
Plant Protection	24	55.9
Veterinary Expenses	24	114.6
Feeding stuff		1,649.4
Feed outside	*15*	*874.6*
Feed inside	*01*	*774.8*
Maintenance Materials	45	278.6
Maintenance Buildings	45	70.6
Agricultural Services	01	270.1
Financial Services	65	91.0
Other goods & services	74	411.0
Total Intermediate Consumption		3,674.5

Source: Economic Agricultural Accounts 2005
& Output, Input and Income in Agriculture 2009

price reported by EAA 2005 and the purchaser price recorded in the 2005 Use Table. The total intermediate consumption within the NACE 01 agriculture industry amounts to €1,282 million at purchasers' prices in 2005, according to the 2005 Use Table for Ireland (CSO, 2009e). The total value of intermediate consumption between the 12 newly created agricultural sectors amounts to €1,131 million at basic prices, according to the EAA 2005. The 2005 Use Tables for Ireland used in constructing the AgriFood-SAM reports €1,061 million as inputs from food processing sectors (e.g. from animal feed sector), compared with the EAA 2005 that estimates €875 million feed input into agriculture sectors, resulting in a difference of €186 million in tax between the basic price reported by EAA 2005 and the purchaser price recorded in the 2005 Use Table. Hence, €1,717 million (€4060 - €1282 - €1061) at purchaser's prices or €1,670 million (€3675 - €1131 - €875) at basic prices, represents intermediate consumption from the other sectors in the AgriFood-SAM.

The NFS 2005 is used to calculate, for each activity, the shares of intermediate goods used. The NFS is a nationally representative survey and thus its results can be aggregated to national numbers. It distinguishes between six farm systems: dairy, dairy and other, cattle, cattle and other, mainly sheep and tillage. The systems refer to the dominant activity in each farm. The farms falling into pigs/poultry system are not represented in the NFS, due to the inability to obtain a representative sample.

Inputs used only in livestock production are first differentiated from those used in cereals production and those used in both. The NFS reports for each farm system the value of pasture, winter forage, animal feed, fertilizer, seed, and other intermediate inputs used. As a farm can produce multiple products, we use the livestock units (number of live animals, i.e. beef cows, dairy cows, sheep, horses, weighted by the basic grazing livestock unit, which is a dairy cow) reported by each farm in order to calculate the shares of intermediate inputs used in producing livestock products. Specific inputs to livestock industries are identified first, e.g. feeding stuff, concentrates, veterinary services and medicine. If a particular input is produced on the farm (i.e. most commonly seeds and feed) and is not reported as sold, we consider the input as being consumed inside the farm and allocated, together with the purchased input, between the sectors according to the calculated livestock unit share.

Overall, the allocation of specific inputs to livestock sectors is done by using the calculated livestock units shares, while the allocation of other inputs used by both types of sectors (tillage and livestock), such as fertiliser, energy, etc, was done according to the sectoral output share and based on information provided by Teagasc 2011. Inputs in the pig and poultry sectors were allocated using the limited information from the NFS 2005 and other external sources such as the Pig Survey conducted by CSO 2005c. The allocation of the intermediate inputs in the other sectors (i.e. cereals, fruit and vegetable, sugar, potatoes, other crops and fodder crops) was done according to its sectoral output share. The Compendium of Irish Agricultural Statistics, (CIAS 2008) provides information about the intermediate demand for agricultural sector products in value and quantity terms (i.e. feeding stuff, fertilizers) and was used as a secondary type of data source to construct the intermediate demand matrix between the 12 agricultural sectors but also in allocating the flows between the agricultural and food sectors. In order to determine the intermediate demand matrix of the agricultural accounts we normalize the input coefficients taking into account the aggregated value of the intermediate consumption given by the OIIA 2009. For example, compound feedingstuffs are allocated between the livestock sectors using the CIAS 2008 quantitative data for the production of feeding stuff and the number of animals as reported in the December 2005 census as well as the value of feeding stuff reported by the OIIA 2009. Based on information provided by Teagasc 2011, a dairy cow consumes on average 700 kg of feed per year, hence the feeding stuff input into the milk sectors is €208 million.

Table 4 shows the transformation for gross output from purchaser prices to basic prices and the intermediate inputs expenditures as reported by the OIIA 2009 excluding agricultural services that are part of output. The second half of the table shows the aggregate intermediate inputs for each of the agricultural sectors as calculated using NFS 2005 as described in the previous paragraph. The difference in gross output for milk and cattle industries is due to the addition of calves to each of the sectors as mentioned earlier. Hence, the milk industry output increases by €124 million representing surplus dairy calves, and the cattle industry output by €170 million representing beef calves. Also, milk industry output increases by €127 million representing cull cows sold to the beef processing industry and bull calves sold to the cattle industry. Intermediate inputs for each of the two industries show the addition of calves. The difference between the intermediate input expenditure reported by the 2005 Use Table and the value reported in Table 4 is due to the use of calculated NFS 2005 shares and it amounts to €94 million.

3.1.2 Disaggregation of value added

The value added for agriculture was taken from OIIA 2009 and is used as a control total. The allocation of intermediate inputs to each activity as described in 3.1.1, taken together with the value of output in each activity, means that the value added in each activity is also set exogenously at this point (see Table 4). The next step is to disaggregate the total value added in each activity into the factor of production accounts.

Table 4: Sectoral allocation of Input, Output and Value Added for Agriculture Sector

Sectors	Gross Output Value (pp) (OIIA 2009)	Taxes less Subsidies on products (IO 2005)	Gross Output Value (bp) (IO 2005)	Intermediate Input Expenditure (IO 2005)	Taxes less Subsidies on production (adjusted)	Value Added (author) calculation)	Gross Output Value (bp) (adjusted)
Milk	1,408	59	1,349	547	-4	1,057	1,600
Cattle	1,489	-1,248	2,737	1,917	-873	1,736	2,780
Sheep	208	-24	232	72	-91	252	232
Pigs	308	6	302	292	2	8	302
Poultry	188	4	184	180	1	3	184
Horses	247	18	229	216	1	12	229
Cereals	194	20	174	154	-147	167	174
Fruit & Veg.	246	3	243	226	1	16	243
Sugar	70	9	61	24	0	37	61
Potatoes	83	3	80	62	1	18	80
Other Crops	93	31	62	44	1	18	62
Fodder Crops	769	4	764	527	-149	386	764
Total	5,303	-1,115	6,418	4,260	-1,257	3,709	6,712

Source: Author calculation using OIIA 2009, 2005 Input-Output tables and NFS 2005.
Gross Output = Gross Value Added + Intermediate Input Expenditure + Taxes less Subsidies on Production
Note: €4,060 = (€3,674.5(OIIA 2009) - €270.1(OIIA 2009)) + €656 at purchaser's price
€4,060 + €294 (surplus dairy calves + beef calves) = €4354 - €94 = €4,260 at purchaser's price (inputs in the AgriFood-SAM)

The factor of production account in the AgriFood-SAM consists of four components: labour, family labour, land and capital. The 2005 Input-Output Table reports the value of wages and salaries and the value of operating surplus for the agriculture sector. The allocation of operating surplus between the factors of production is a difficult process because of the high frequency of family labour and owner occupied land used in farming. Family labour is an important factor of production in the agriculture sector and is not part of wages and salaries.

The share of each component used in each agricultural activity is calculated taking into account the NFS 2005 and OIIA 2009. First, the share of labour for each activity in the farm was calculated using the standard man day (SMD) variable (available from the MDFP 2005), which provides detailed information about the number of days needed for each type of activity on the farm. The NFS 2005 provides information on the total labour units employed in each farm. For example, given the fact that we know the number of beef cows per farm and the SMD used in rearing one beef cow we are able to calculate the total number of days used in rearing the total number of beef cows reported in the NFS and similarly for the other farm outputs.

Then knowing the number of paid and unpaid (family) labour units (one labour unit equals 1,800 hours) employed in each farm, the total number of labour units used for each activity on the farm was calculated by multiplying the SMD (represents eight hours of work) with the number of livestock units or output (cultivated hectares) on the farm. Consequently, labour shares for each agricultural sector were calculated. These shares are used to allocate the value of labour between the 12 agriculture sectors in the AgriFood-SAM. The 2005 Input-Output Tables give the value of employed labour in the agriculture sector, which amounts to €448 million, excluding family labour. The NFS 2005 reports the units of family (unpaid) labour used on the farm and the value of family labour which allows us to calculate the share of family labour in total labour for each activity. These shares are used in allocating the paid and unpaid labour to each agricultural activity. The value of family labour is obtained using the average agricultural wage taken from the NFS and then subtracted from the operating surplus. The remaining operating surplus is divided between land and capital.

The CIAS 2008 provides details on the total area farmed for different crops, fruits and vegetables, potatoes, sugar, hay, silage, grazing and pasture. The total area farmed in 2005 was 4,302 million ha. The rental land price per ha in 2005 was calculated using NFS 2005 and is equal to €238.13 giving a value for land services of €1,024 million. Hence, out of total agriculture gross value added of €3,709 million, wages and salaries plus family labour amounts to €1,877 million, land rental value is €1,024 million and the returns to capital is the residual and equal to €807 million.

The quantity of land used in the six tillage sectors is taken directly from CIAS 2008. Hence, €438 million represents the value of land used in the tillage sectors (i.e. potatoes, cereals, fruit and vegetable, etc). This would leave €586 million for the pasture and grazing area used by the different livestock. The allocation of land used between the livestock sectors is calculated using the information provided in the NFS 2005 regarding the share of land used per livestock unit. Hence, 20 percent is allocated to the milk industry, 65 percent to cattle, 14 percent to sheep and 0.6 percent to horses. The use of land in farming poultry and pigs is close to zero and is treated as insignificant. Agricultural land is assumed to be used entirely in the agricultural sectors.

The capital used in the agricultural sector is allocated across the 12 new agricultural sectors as a balancing account, given the fact that it is calculated as a residual after subtracting the land and labour from value added in each sector. Table 5 shows the disaggregation of value added between the 12 agricultural sectors.

As a check on the results from disaggregating the value added we compared our numbers with

Table 5: Factor of Production Allocation

Sectors	Labour	Family Labour	Capital	Land	Total
Milk	236	361	323	123	1,044
Cattle	98	886	334	381	1,700
Sheep	9	61	48	78	197
Pig	0	0	19	0	20
Poultry	0	2	13	0	15
Horses	3	20	2	4	28
Cereals	55	54	39	67	215
Fruit & Veg	3	3	1	2	10
Sugar	19	19	11	8	57
Potatoes	8	8	5	3	23
Other Crops	3	3	0	15	21
Fodder Crops	12	12	12	343	379
Total	448	1429	807	1024	3709
	50.6%		21.8%	27.6%	

Source: Authors' calculation

those from the Henry estimates of the breakdown of agricultural value added in 1990 reported in Matthews (2000). Henry estimates that approximately 50 percent is attributed to the labour input, 30 percent to capital and the remaining 20 percent to land. The higher share accruing to land and the lower share accruing to capital reported in Table 5 is consistent with the dramatic increase in land values in Ireland over this period.

3.1.3 Disaggregation of taxes and subsidies and other CAP instruments

The taxes and subsidies accounts are of great importance for the agricultural sectors. The National Accounts System (CSO,2009b) differentiates between subsidies and taxes on products and other subsidies and taxes on production. Subsidies and taxes on products are included in the calculation of output. Other taxes and subsidies are not included in the calculation of output. Examples of subsidies on production are the Single Payment Scheme (SPS), Area-based Compensatory Allowance Scheme, and Rural Environmental Protection Scheme (REPS).

The 2005 Input-Output Table (CSO,2009e) contains a vector of net-taxes on commodities and activities which is used as an instrument in the transformation of producer prices into basic prices and the reverse. Annual Accounts by Current Account, Institutional Sector, Year and Uses and Resources (CSO,2009a) and Economic Accounts for Agriculture 2005 (EAA 2005) provide further information on those four types of taxes and subsidies and how they are split across institutions, commodities and activities accounts.

Taxes on production and imports (D2 in national accounts system) include taxes on products (D21) and other taxes on production (D29). Other taxes on production include building taxes, stamp duties, vehicle taxes and other taxes of this type. The Economic Accounts for Agriculture 2005 (EAA 2005) and the Compendium of Irish Agricultural Statistics 2008 (CIAS 2008) were used in the allocation of these taxes between the agricultural sectors. The major components of taxes on products are value added tax (D211), tax and duties on imports (D212) and taxes on products except VAT and import duties (D214). The next paragraph gives a brief description of the allocation of the latter three taxes across the SAM accounts.

VAT and import duties are assigned across the commodities according to the 2005 VAT rates and additional information provided in the Statistical Report 2005 published by Revenue Commissioners (2006). The Statistical Report 2005 offers a breakdown on a percentage basis of VAT revenue based on the NACE alphabetical code, A to Q. This in turn is further disaggregated into the 2 digit NACE code used in the SAM using information on the different VAT rates of the specific commodities produced. The domestic VAT is calculated as the gross collection less refunds, but the VAT on imports is not included. The VAT and excise duties apply to imports and locally produced goods at the same rates. The VAT is allocated between the agricultural sectors using the NFS information on the type of enterprises that are registered for VAT and their total amount of sold goods.

Taxes and duties on imports are available from the Revenue Commissioners (2006) as an aggregated value and are allocated across the SAM accounts according to the main type of imported goods and the specific tariff rate applied to the main country of origin.[3] The tax on products except VAT and import duties is calculated as the difference between the total indirect tax minus VAT and Taxes and duties on imports for each SAM account.

The national accounts system (CSO,2009b) differentiates between subsidies on production and on products as described above. The EAA 2005 provides information on the allocation of the subsidies on products between the 12 agricultural sectors. The subsidies on production have two sources, national and EU. The EU subsidies are provided through the CAP to which the national government contributes as well. Other subsidies and grants provided exclusively by the national government are the disease eradication scheme, the installation aid for young farmers and the forestry premium. The latter is allocated to the forestry and related services account.

Under the 2003 CAP reform, in 2005 Ireland opted for full decoupling, meaning that the single farm payment replaced direct livestock and arable payments. This payment is based on the number of premium claims made in the historical three year reference period from 2000-2002. Today, the subsidies and grants offered through the CAP are the Single Payment Scheme (SPS), Area-based Compensatory Allowance Scheme (DACAS), and Rural Environmental Protection Scheme (REPS).

The allocation of those three main subsidies on production, as found in the national accounts, is

[3] European Commission 2009, Taxation and Customs Union, Chapter 3

done in three stages. First, given that Ireland opted for the historical model, the SPS subsidies are allocated between the agricultural sectors on the basis of historical information on the coupled payments received by each sector in 2000-2002. In the second stage the REPS and DACAS payments are allocated to sectors using the NFS 2005. The value of each subsidy payment to each farm is allocated to individual sectors according to the gross output of the specific farm, and these payments are then aggregated to the national level using the NFS weights and normalized so that the totals agree with the actual payments made under each scheme in 2005.

The AgriFood-SAM is explicitly modified to take account of the operation of the milk quota regime in 2005. Under this regime, individual dairy farmers are constrained to limit the volume of their milk output and butterfat to the amount of quota that they hold. Quota can be transferred between farmers either by sale or lease. The quota was binding in 2005, implying that dairy farmers would have been prepared to supply additional milk at the milk price prevailing in that year. The existence of the binding quota gives rise to a quota rent. This quota rent value is introduced explicitly in the AgriFood-SAM. The quota rent is estimated to be 5.4 cents/litre, with a value for the sale/purchase of quota of 16.4 cents/litre, using NFS 2005.[4] The average price of raw milk is 27.2 cents/litre in 2005. Thus the value of quota rent amounts to almost 20 percent of the price of milk. Hence, €180 million represents the share of quota rent in the total output of milk production. This amount is subtracted from the value of the return to milk capital and explicitly introduced in the social accounting matrix as a new account. On the income side of the matrix, quota rent is distributed to farm households, in particular the dairy farm households, according to the information provided by NFS 2005.

3.1.4 Disaggregation of the final demand accounts

The household consumption of agricultural goods amounts in 2005 to €1,066 million at purchasers' prices. We used the HBS 2005 to calculate shares of household consumption for the main agricultural goods. In order to allocate this expenditure across the sectors the CSO 2009e data are used as a control. Exports and imports data for each agricultural and food processing sector were taken from CIAS 2008, which provides the total value of exports and imports for the main agricultural and food goods and the sources of destination (UK and rest of the EU). The ROW values were calculated as the difference between the total exports/imports and those two newly created accounts.

[4] According to DAFF, Annual Report 2005, the 2005 scheme was the first part of a two-year Restructuring Programme and the price for the sale/purchase of quota was fixed at 17.5 cents/litre (80c/gal) for 2005 which is close to the reported value in the NFS for that year.

3.2 Manufacture of food and beverages breakdown

The manufacture of food and beverages sector is disaggregated using a two step method. First, using the Eurostat NACE Rev. 1.1. 3-digit disaggregation, the Food and Drink (FD) industry is disaggregated into seven industries: meat, fish, fruit-vegetable, dairy, animal feed-grains, other food products, and beverages. Tobacco is distinguished separately at the 2-digit level NACE Rev. 1.1. The meat industry is then further disaggregated into four sub-industries: Beef Meat, Pig Meat, Poultry Meat and Sheep Meat using the domestic supply data taken directly from CIAS 2008. The calculated shares for the four new food sectors are as follows: 56.5 percent represents beef meat production, 23.8 percent of the total meat output is pig meat, 12.7 percent poultry meat, and 7 percent sheep meat. Table 6 summarises the CIAS 2008 and Eurostat information.

Table 6: Sectoral allocation of Input, Output and Value Added for FD industry

	Gross Output Value (pp) (OIIA 2009)	Taxes less Subsidies on products (IO 2005)	Gross Output Value (bp) (IO 2005)	Intermediate Input Expenditure (IO 2005)	Taxes less Subsidies on production (IO 2005)	Value Added (author calculation)
Beef meat	2,028	-10	2,038	1,593	30	415
Pig meat	854	40	814	609	4	202
Poultry meat	456	19	437	343	1	93
Sheep meat	251	37	215	143	4	68
Fish and other fishing products	301	117	184	134	2	48
Fruit and vegetable	160	2	158	117	0	41
Dairy products	2,504	353	2,151	1,634	47	470
Animal feed	929	46	883	485	3	395
Other food products	8,284	494	7,790	2,661	9	5,120
Beverages	1,767	124	1,643	557	4	1,082
Total	17,535	1,221	16,314	8,275	104	7,936

Source: Authors' calculation using OIIA 2009 and 2005 Input-Output Tables.
Gross Output = Gross Value Added + Intermediate Input Expenditure + Taxes less Subsidies on Production

The intermediate consumption matrix was constructed on the basis of information provided by the Census of Industrial Production 2005 (CIP 2005) and the EEA 2005 accounts. The food and drink industry provides intermediate inputs mainly to the hotels and restaurants sector and to the agricultural sectors in the form of animal feed. As an example, in Table 3 it can be seen that animal feed which enters the intermediate consumption of agricultural sectors comes from two sources, inside the agricultural sectors (i.e. produced in the fodder crops sector) and outside it from the Animal Feed and Grain Milling sector of the Food and Drink industry.

Labour and capital are allocated according to the CIP 2005 which provides the number of employees, wages and salaries, total labour costs and capital assets (addition and sales) at the 4-digit NACE Rev.1.1 for each of the food industries mentioned above, excluding beef, sheep, poultry and pig meat industries. The average wage in the meat industries is calculated and used to construct the labour costs for those four meat producing sectors in the absence of specific information on average wage differences between sectors. Capital returns for each of the Food and Drink processing sectors is introduced as a balancing account.

Indirect taxes excluding VAT are reported in the CIP 2005. VAT and import duties are assigned according to the same procedure used in the case of the agricultural sectors. Exports are evaluated at basic prices including export refunds, which in 2005 amounted to €160m. The household consumption of food products is taken from the HBS 2004-2005 using the national figure (CSO, 2009e) as a control tool. Further disaggregation and discussion of household consumption is provided in the next section.

3.3 Disaggregating the Household Sector

To analyse issues of income distribution it is useful to further disaggregate the household sector. This exercise is facilitated by the link between the Household Budget Survey 2004-2005 and the National Farm Survey (2004), which were merged as 620 farm households interviewed in the latter are also part of the former.

The HBS 2004-2005 contains 6,884 households, of which 66 percent are urban households, 25 percent rural non-farm households and 9 percent rural farm households. Both surveys are representative for Ireland and after the merge a total of 6,866 households are used to replace the household account in the AgriFood-SAM.

Reconciling survey data and national accounts data is the next important step. The household survey data is organised in terms of the SAM income and expenditure accounts, using three concordance, CPC Ver. 2, ISIC Rev.4 and NACE Rev. 1.1.[5] Each product in the consumption category in the HBS 2004-2005 was first identified in the CPC Ver. 2 at a five digit level using the United Nations Statistical Division website, which also provides code correspondence with the CPC Ver. 1.1 and ISIC Rev. 4.[6] Then, using a correspondence table[7] between ISIC Rev. 4 and NACE Rev. 1.1 each good/service consumed by the households was translated into its corresponding NACE Rev 1.1, two digit code, used by the Central Statistics Office Ireland in constructing the 2005 Input-Output Table for Ireland (CSO, 2009e). The final step is to bring these values to national level by using the weights provided in the HBS 2004-2005.

On the income side, links were first established between the household income sources in the SAM (remuneration of factors, net transfers from/to government and rest of the world) and the sources of income identified in the HBS 2004-2005. These links were based on a set of assumptions. First,

[5]CPC - Central Product Classification
ISIC - International Standard Industrial Classifications of all economic activities
NACE - Classifications of Economic Activities in EC.

[6]According to the "Statistical work programme of the Commission for 2010", Eurostat is currently working on a single correspondence table from CPC to NACE.

[7]Source: United Nations Statistical Division website.

wage labour income is assumed to include all income (cash and in kind) received by the household members as return to their labour. Second, the return to land value was determined for each farm household according to the rental land price per ha of €238.13 and the size of the respective farm. Third, dividends, property income, etc. are the source for the return to capital. Fourth, the transfers from government and enterprises are those reported in the HBS as government and private transfer income, respectively. The concordances established are available on request.

Table 7 gives an overview of the differences between the household consumption expenditure (using the HBS weights) reported in the survey and the household expenditure figures reported by the 2005 Input-Output Tables (CSO, 2009e). We have deliberately highlighted those sectors where the largest discrepancies arise. The total consumption expenditure reported in the HBS 2004-2005 is under reported by 13 percent compared with the national figure. Total household expenditure on tobacco products tends to be under reported in expenditure surveys given the negative social attitudes to smoking. Household final consumption expenditure for sectors like transport, recreation and culture, health and education cannot be observed at the individual household level mainly because government partially or totally finances household consumption in these sectors. The under reported figures for insurance and financial intermediation services could be explained by the fact that the HBS 2004-2005 registers the household expenditure over a two week period which differs from the household consumption of the specific service. To account for the differences between the survey and the national accounts data, the survey data are scaled up or down as reported in Table 7.

For presentation purposes and sometimes also in modelling it is more convenient to work with representative households rather than all 6,866 individual households. To illustrate the method, nine types of representative households were created, as follows: urban households, rural non-farm households, rural dairy farm households, rural dairy and other farm household, rural cattle rearing farm household, rural cattle and other farm household, rural mainly sheep farm household, rural tillage farm household and rural other farm households. The seven types of rural farm households follow the NFS farm systems structure. The income and expenditure of the last type of farm household, which includes pigs, poultry and other farms not represented in the NFS, are calculated and distributed as a residual. The final step in constructing representative households for Ireland was to calculate the aggregated values for the nine household categories by multiplying individual households' values by their respective HBS 2004-2005 weights and summing over all households in each category. Those representative households replace the household sector in the SAM, providing a new AgriFood-SAM with representative households.

3.4 Balancing the AgriFood-SAM using a cross-entropy approach

The AgriFood-SAM is seen as a matrix of economic flows from one account to another, representing expenditures and receipts of all the economic agents and total expenditure and total receipts

Table 7: Household consumption expenditure differences between HBS 2004-2005 and National accounts

SAM Sectors	AgriFood SAM Sectors	AgriFood SAM (€million)	SAM 2005 I-O (€million)	Difference level	Difference %
Products of agriculture, hunting and related services	A_APOL	78	1172	-86	-7.3
	A_AFRVE	696			
	A_APOT	183			
	A_AFOCR	301			
Food products and beverages	A_MBEF	366	7426	62	0.8
	A_MPIG	491			
	A_MPOL	334			
	A_MSHP	137			
	A_MFSH	129			
	A_MFRVE	568			
	A_MDARY	983			
	A_MANFE	3487			
	A_MBEV	870			
Tobacco products		911	1933	-1022	-52.9
Hotel and restaurant services		5828	8035	-2207	-27.5
Land transport; transport via pipeline services		680	1240	-560	-45.2
Financial intermediation services,except insurance and pension funding services		3313	2133	1180	55.3
Insurance and pension funding services,except compulsory social security services		4556	2599	1957	75.3
Real estate services		5849	11196	-5347	-47.8
Education services		1582	2843	-1261	-44.4
Health and social work services		1613	2505	-893	-35.6
Other SAM sectors		31185	32695	-1510	-4.6
Total		64137	73778	-9641	-13.1

of an agent have to be equal. In the process of balancing the AgriFood-SAM additional equality and inequality constraints are formulated as linear constraints on its elements. First, total GDP was fixed at its original value, as it was considered a reliable data value in the AgriFood-SAM. Second, the sum of overall factor payments is fixed to the aggregate value specified in the macro SAM (Table 1, macro values reported in CSO 2009b. Third, trade flows (total imports and exports) are fixed to their initial level. Finally, final demand categories (household and government consumption and investment) are fixed to their aggregate values. The aim of this approach is to use all available information in order to minimize the cross-entropy between the probabilities that are consistent with the information in the data and the prior information. Consequently the new AgriFood-SAM does not show any changes in these cells and columns compared with the unbalanced AgriFood-SAM.[8]

[8]The pdf version of the 2005 AgriFood-SAM for Ireland is available from the IIIS website; URL: http://www.tcd.ie/iiis/documents/A 2005 AgriFood-SAM for Ireland.pdf

4 Multiplier analysis using the 2005 AgriFood-SAM

In this section, multiplier values derived from the 2005 AgriFood-SAM are presented and a simulation of the economic impact of reducing greenhouse gas (GHG) emissions from the agricultural sector is undertaken.

Several approaches can be undertaken in designing scenarios to reduce GHG emissions in the agricultural sector. Most of the studies on GHG emission in Ireland propose changes in the farm management practices to achieve a reduction in emissions.[9] The FAPRI-Ireland model assumes that the 20 percent reduction in emission is achieved through a reduction in the number of beef cattle. This assumption is supported by a recent study (Donnellan and Hanrahan, 2011) which suggest a reduction in the cattle heard as an effect of reducing GHG emissions form Irish agriculture. In this paper, the 20 percent reduction in GHG emissions is assumed to be undertaken through a reduction in the numbers of livestock in the cattle sector.

4.1 Multiplier values from the AgriFood-SAM

In order to assess the impacts of a change in the value of a final demand account using a social accounting matrix analysis the government account, the rest of the world account, the capital account and the tax accounts are treated as exogenous accounts (Pyatt and Round, 1985). The remaining accounts are viewed as endogenous and include the production (activities, commodities), factors of production (value added) and institutions (households) accounts. For simplicity the exogenous accounts are aggregated into a single account which records the injections into the system and the leakages from it. The leakages include transfer income sent to the rest of the world, institutional savings, indirect taxes and imports. The injections include transfers from the rest of the world, government transfers to institutions (households and enterprises), government consumption and export demand. The exogenous account can be seen as an independent variable while the endogenous account is the dependent variable.

Table 8 presents the multiplier matrix, M, derived from an aggregated 2005 Irish AgriFood-SAM.[10] These multipliers take into account not only the direct impact on the output of an individual sector of a change in its final demand, but also the indirect effects due to interdependencies with other production sectors and induced effects caused by the respending of the institutional accounts. Consider, for example, the first column of Table 8 for the milk industry. If we assume an increase of €100 million in the exogenous demand for raw milk, we can see that this induces a further increase of €7.3 million in milk industry output as well as increases in the output of the

[9] See O'Mara et. al (2007) for detailed review of this approach.

[10] For presentation reasons, we aggregate AgriFood-SAM manufacturing sectors and service sectors in two SAM accounts, thus giving an AgriFood-SAM with 22 sectors. Also, the calves sector is aggregated into the milk and cattle sectors.

Table 8: The Multiplier Matrix, M

Sectors	A_AMIK	A_ACATL	A_ASHP	A_APIG	A_APOL	A_ACER	A_AFRVE	A_APOT	A_AOTCR	A_AFOCR	A_FORE	A_FISH
A_AMIK	1.073	0.006	0.007	0.005	0.005	0.007	0.003	0.003	0.004	0.003	0.004	0.005
A_ACATL	0.005	1.117	0.008	0.005	0.005	0.009	0.004	0.004	0.005	0.004	0.006	0.009
A_ASHP	0.000	0.001	1.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
A_APIG	0.001	0.001	0.001	1.000	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.001
A_APOL	0.001	0.001	0.001	0.000	1.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001
A_ACER	0.007	0.014	0.008	0.033	0.030	1.001	0.057	0.095	0.036	0.068	0.000	0.000
A_AFRVE	0.002	0.003	0.003	0.003	0.002	0.002	1.001	0.001	0.001	0.011	0.001	0.001
A_APOT	0.000	0.001	0.001	0.000	0.000	0.001	0.000	1.000	0.000	0.000	0.000	0.000
A_AOTCR	0.004	0.013	0.004	0.000	0.000	0.001	0.000	0.000	1.000	0.000	0.000	0.000
A_AFOCR	0.047	0.149	0.086	0.220	0.115	0.003	0.002	0.002	0.002	1.002	0.002	0.002
A_FORE	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	1.494	0.001
A_FISH	0.002	0.002	0.003	0.002	0.002	0.003	0.001	0.001	0.002	0.001	0.001	1.062
A_MBEF	0.004	0.006	0.007	0.004	0.004	0.008	0.004	0.003	0.004	0.004	0.005	0.010
A_MPIG	0.003	0.004	0.005	0.002	0.002	0.006	0.002	0.002	0.003	0.003	0.003	0.004
A_MPOL	0.002	0.002	0.002	0.001	0.001	0.003	0.001	0.001	0.002	0.001	0.002	0.002
A_MSHP	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001
A_MFSH	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
A_MFRVE	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.000
A_MDARY	0.007	0.010	0.011	0.008	0.009	0.011	0.005	0.005	0.006	0.005	0.007	0.008
A_MANFE	0.042	0.057	0.067	0.133	0.162	0.004	0.002	0.002	0.002	0.002	0.003	0.003
A_MOTFO	0.019	0.027	0.031	0.010	0.009	0.039	0.013	0.015	0.020	0.016	0.020	0.032
A_MANUF	0.272	0.447	0.424	0.266	0.243	0.643	0.572	0.320	0.324	0.306	0.493	0.272
A_SERV	0.433	0.627	0.657	0.309	0.291	0.793	0.447	0.390	0.440	0.345	0.637	0.391
Output	**1.928**	**2.494**	**2.333**	**2.003**	**1.881**	**2.545**	**2.118**	**1.849**	**1.856**	**1.775**	**2.684**	**1.807**
LAB	0.557	0.721	0.669	0.168	0.166	1.008	0.288	0.424	0.530	0.215	0.551	0.152
LND	0.100	0.229	0.495	0.102	0.059	0.430	0.039	0.080	0.200	0.422	0.022	0.003
CAP	0.392	0.430	0.562	0.222	0.218	0.596	0.254	0.257	0.280	0.186	0.273	0.691
GDP	**1.049**	**1.380**	**1.727**	**0.492**	**0.443**	**2.035**	**0.581**	**0.761**	**1.011**	**0.823**	**0.846**	**0.846**
UHHO	0.451	0.572	0.556	0.151	0.149	0.800	0.240	0.337	0.416	0.180	0.429	0.206
RNFHHO	0.150	0.190	0.186	0.051	0.050	0.265	0.080	0.112	0.138	0.060	0.142	0.073
RDFHHO	0.033	0.065	0.124	0.026	0.017	0.116	0.015	0.026	0.055	0.099	0.015	0.005
RDOFHHO	0.021	0.042	0.082	0.017	0.011	0.076	0.009	0.016	0.036	0.067	0.009	0.003
RCFHHO	0.033	0.067	0.131	0.028	0.017	0.120	0.014	0.026	0.056	0.106	0.013	0.005
RCOFHHO	0.022	0.044	0.086	0.018	0.011	0.079	0.010	0.017	0.037	0.069	0.010	0.004
RSFHHO	0.020	0.040	0.079	0.017	0.010	0.072	0.009	0.016	0.034	0.064	0.008	0.003
RTFHHO	0.009	0.018	0.036	0.008	0.005	0.033	0.004	0.007	0.015	0.030	0.003	0.001
ROFHHO	0.002	0.005	0.009	0.002	0.001	0.008	0.001	0.002	0.004	0.007	0.001	0.000
ENT	0.135	0.160	0.207	0.071	0.068	0.229	0.082	0.092	0.110	0.083	0.099	0.185
Income	**0.875**	**1.204**	**1.495**	**0.389**	**0.339**	**1.798**	**0.462**	**0.651**	**0.902**	**0.764**	**0.730**	**0.484**

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Table 8: The Multiplier Matrix, M - Continued

Sectors	A_MBEF	A_MPIG	A_MPOL	A_MSHP	A_MFSH	A_MFRVE	A_MDARY	A_MANFE	A_MOTFO	A_MANUF	A_SERV
A_AMIK	0.057	0.005	0.006	0.005	0.004	0.004	0.492	0.023	0.020	0.004	0.007
A_ACATL	0.797	0.006	0.007	0.009	0.005	0.005	0.005	0.020	0.022	0.005	0.009
A_ASHP	0.001	0.000	0.001	0.351	0.000	0.000	0.001	0.001	0.006	0.000	0.000
A_APIG	0.001	0.208	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001
A_APOL	0.001	0.001	0.179	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
A_ACER	0.011	0.007	0.006	0.003	0.000	0.034	0.004	0.032	0.002	0.001	0.001
A_AFRVE	0.003	0.001	0.001	0.001	0.001	0.006	0.001	0.002	0.001	0.001	0.001
A_APOT	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
A_AOTCR	0.010	0.000	0.001	0.002	0.000	0.000	0.003	0.001	0.009	0.000	0.000
A_AFOCR	0.109	0.047	0.023	0.032	0.002	0.495	0.023	0.136	0.007	0.002	0.003
A_FORE	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001
A_FISH	0.010	0.008	0.009	0.009	0.009	0.008	0.009	0.008	0.008	0.001	0.002
A_MBEF	1.007	0.005	0.006	0.006	0.004	0.005	0.005	0.014	0.018	0.004	0.007
A_MPIG	0.005	1.003	0.004	0.004	0.002	0.003	0.003	0.004	0.015	0.002	0.004
A_MPOL	0.003	0.001	1.002	0.002	0.001	0.002	0.002	0.002	0.007	0.001	0.002
A_MSHP	0.001	0.001	0.001	1.001	0.000	0.001	0.001	0.002	0.003	0.001	0.001
A_MFSH	0.001	0.001	0.001	0.001	1.209	0.001	0.001	0.001	0.008	0.001	0.001
A_MFRVE	0.001	0.001	0.001	0.001	0.001	1.001	0.001	0.001	0.001	0.001	0.001
A_MDARY	0.011	0.007	0.008	0.008	0.005	0.006	1.007	0.043	0.020	0.006	0.010
A_MANFE	0.044	0.030	0.031	0.025	0.002	0.002	0.021	1.004	0.005	0.004	0.004
A_MOTFO	0.071	0.029	0.137	0.044	0.014	0.019	0.054	0.017	1.016	0.015	0.019
A_MANUF	0.466	0.253	0.241	0.305	0.217	0.316	0.264	0.247	0.214	1.436	0.232
A_SERV	0.758	0.757	0.688	0.652	0.610	0.563	0.509	0.583	0.642	0.588	1.665
Output	**3.369**	**2.373**	**2.358**	**2.463**	**2.089**	**2.474**	**2.405**	**2.143**	**2.032**	**2.077**	**1.970**
LAB	0.747	0.357	0.322	0.481	0.417	0.456	0.485	0.344	0.318	0.360	0.478
LND	0.169	0.023	0.014	0.176	0.002	0.210	0.047	0.072	0.013	0.002	0.004
CAP	0.486	0.341	0.350	0.447	0.240	0.236	0.343	0.391	0.509	0.435	0.488
GDP	**1.403**	**0.722**	**0.685**	**1.103**	**0.658**	**0.901**	**0.875**	**0.807**	**0.840**	**0.798**	**0.969**
UHHO	0.599	0.302	0.278	0.405	0.329	0.357	0.392	0.300	0.298	0.317	0.408
RNFHHO	0.199	0.101	0.093	0.135	0.109	0.118	0.130	0.101	0.101	0.107	0.137
RDFHHO	0.052	0.012	0.010	0.049	0.008	0.056	0.020	0.023	0.010	0.008	0.011
RDOFHHO	0.033	0.007	0.005	0.032	0.004	0.036	0.012	0.015	0.006	0.004	0.006
RCFHHO	0.052	0.011	0.009	0.050	0.007	0.058	0.019	0.023	0.009	0.006	0.008
RCOFHHO	0.035	0.008	0.006	0.033	0.005	0.038	0.013	0.016	0.006	0.005	0.007
RSFHHO	0.032	0.007	0.005	0.030	0.004	0.035	0.012	0.014	0.005	0.004	0.005
RTFHHO	0.014	0.003	0.002	0.014	0.001	0.016	0.005	0.006	0.002	0.001	0.002
ROFHHO	0.004	0.001	0.001	0.004	0.001	0.004	0.002	0.002	0.001	0.001	0.001
ENT	0.172	0.107	0.107	0.149	0.083	0.096	0.115	0.122	0.147	0.130	0.150
Income	**1.193**	**0.559**	**0.516**	**0.901**	**0.552**	**0.813**	**0.720**	**0.621**	**0.585**	**0.584**	**0.733**

Sector listing and labelling can be found in appendix A 1 cattle industry of €0.5 million and fodder crops industry of €4.7 million. The food processing industries register an overall increase in output of €7.9 million, with increases in animal feed industry output of €4.2 million, dairy industry output of €0.7 million and other foods of €2 million. There are larger indirect and induced effects in the manufacturing and services sectors which register output increases of €27.2 million and €43.3 million, respectively. Overall, the €100 million in demand for milk generates a total increase in aggregate output of €193 million.

Income multipliers and GDP multipliers are also calculated and reported in Table 8. Assuming a similar €100 million increase in final demand in the milk sector would lead to an increase in GDP at factor cost of €104.9 million. Labour and capital contribute with €55.7 million and €39.2 million respectively to the GDP increase, while land share is only €10 million. Household income increases by €87.5 million in response to this exogenous shock.

Table 9: Output, GDP and Income multipliers

AgriFood-SAM Sector	Output Multiplier	GDP Multiplier	Household Income Multiplier
Milk	1.928	1.049	0.875
Cattle	2.494	1.380	1.204
Sheep	2.333	1.727	1.495
Pig	2.003	0.492	0.389
Poultry	1.881	0.443	0.339
Cereals	2.545	2.035	1.798
Fruit & Veg	2.118	0.581	0.462
Potatoes	1.849	0.761	0.651
Other Crops	1.856	1.011	0.902
Fodder Crops	1.775	0.823	0.764
Forestry	2.684	0.846	0.730
Fish	1.807	0.846	0.484
Beef Proc.	3.369	1.403	1.193
Pig Proc.	2.373	0.722	0.559
poultry Proc.	2.358	0.685	0.516
Sheep Proc.	2.463	1.103	0.901
Fish Proc.	2.089	0.658	0.552
Fruit & Veg Proc.	2.474	0.901	0.813
Milk Proc.	2.405	0.875	0.720
Animal Feed	2.143	0.807	0.621
Other Food	2.032	0.840	0.585
Manufacture	2.077	0.798	0.584
Services	1.970	0.969	0.733

Table 9 summarizes the multiplier effects for each AgriFood-SAM sector. The sectors with the higher output multipliers among the agri-food sectors are the beef processing sector, cereals, fruit and vegetable, cattle and sheep, ranging from 3.3 to 2.3. Usually sectors which have fewer leakages will have a higher multiplier. Those sectors are more embedded into the national economy. For example the output multiplier for the cattle sector is 2.494; for each euro of output produced by the cattle sector, 1.494 euro of indirect and induced output is generated in other sectors in the economy.

4.2 Impact of reducing GHG emissions from the agricultural sector

To illustrate the use of the AgriFood-SAM the effect of a reduction of 20 percent in GHG emissions from agriculture is simulated. According to the Donnellan and Hanrahan, (2011) estimates using the FAPRI-Irealnd model, this would require a reduction of 12.6 percent in the output of cattle in 2020, or a reduction of €183 million in the value of cattle output in that year.

Considering the structure of the social accounting matrix multiplier analysis and the Teagasc FAPRI-Ireland model results discussed above, we have a change in output and not a final demand exogenous shock. Consequently, the first step is to calculate the final demand change associated with a reduction in cattle output of 12.6 percent. The SAM multiplier matrix, M, is given by the following equation:

$$Y_i = (I - \mathbf{A_i})^{-1} X = \mathbf{M} X \tag{1}$$

The classic case assumes that the exogenous final demand, X, is given and calculates the change in output, Y, for each endogenous account. In this instant the reduction in output, yi, for the cattle primary agriculture sector is known and the question is to calculate the final demand, xi, associated with this change. By re-writing the last equation in a system of equations:

$$\begin{aligned}
y_1 &= m_{11}x_1 + m_{12}x_2 + \ldots.. + m_{1n}x_n \\
y_2 &= m_{21}x_1 + m_{22}x_2 + \ldots.. + m_{2n}x_n \\
&. \\
&. \\
&. \\
y_n &= m_{n1}x_1 + m_{n2}x_2 + \ldots.. + m_{nn}x_n
\end{aligned} \tag{2}$$

This system of equations is used to calculate a reduction in the final demand of €326 million in the beef processing sector (arising say from a reduction in beef exports), which results in the desired reduction in cattle output of €183 million.[11] From a multiplier analysis point a view a reduction in the output of cattle can be seen through a reduction in the final demand. More then half of the cattle output is used in the beef processing sector. The remaining is used in the other food processing sectors and only 6 percent is exported as live cattle. Two assumptions are made: First, the reduction in cattle output is mainly due to a reduction in the final demand of beef products; second, there is no change in the final demand of the other 75 sectors in the economy, meaning,

[11] According to CSO, Output,Input and Income in Agriculture, 2011, cattle output increased by 27 percent since 2005.

the system of equations resumes to one equation with one unknown, the final demand for beef products.

The final demand for beef products is calculated using the equation:

$$x_j = y_i * m \tag{3}$$

where y_i is the reduction in the cattle output of €183 million and $m = (m_{j1}, m_{j2}...m_{jn})^T$ is the column vector of coefficients used in the production of beef products given by the following equation:

$$y_j = m_{j1}y_1 + m_{j2}y_2 + ... + m_{jn}y_n \tag{4}$$

where m_{ji} represents the input of good i needed to produce one unit of good j. So, the production of one units of good j requires $m_{j1}y_1$ units of good 1, $m_{j2}y_2$ units of good 2 and so on. Hence the production of beef products depends on the cattle output.

This is then the shock afflicted to get the economy wide effect of the required reduction in the output of cattle to meet the GHG target using a AgriFood-SAM based on the 2005 economy database and the multiplier analysis.

Stone's (1955) multiplier decomposition can be used to decompose the economy wide output changes into three effects: the direct (N_1), indirect (N_2) and closed-loop (N_3) effect.

$$\mathbf{M} = \mathbf{I} + \mathbf{N_1} + \mathbf{N_2} + \mathbf{N_3} \tag{5}$$

with

$$\begin{aligned} \mathbf{N_1} &= \mathbf{M_1} - \mathbf{I} \\ \mathbf{N_2} &= (\mathbf{M_2} - \mathbf{I})\mathbf{M_1} = \mathbf{M_2}\mathbf{M_1} - \mathbf{M_1} \\ \mathbf{N_3} &= (\mathbf{M_3} - \mathbf{I})\mathbf{M_2}\mathbf{M_1} = \mathbf{M_3}\mathbf{M_2}\mathbf{M_1} - \mathbf{M_2}\mathbf{M_1} \end{aligned} \tag{6}$$

where $M_1, M_2 and M_3$ represents the three multiplicative matrices described by Pyatt and Round (1979), the direct effect multiplier matrix, the indirect multiplier matrix and the closed-loop or full circular flow matrix, respectively.

The results are presented in Table 10. In addition we consider GDP and household income multiplier effects. A €326 million reduction in beef exports leads to an additional of €946 million reduction in the total gross output in the economy (Table 10). Most of this is accounted for by the direct effect, only a small amount is attributed to the other two effects. The biggest sectoral effects are on beef processing, cattle sector and services. The last column in Table 10 describes the net SAM-linkages effects that arise from the: (i) direct effect, linkages within one account; (ii) indirect effect, linkages between accounts; and (iii) induced effect, linkages arising within-account, the effects of a shock after passing from an account through a set of accounts and back to the same account. Of the €183 million induced indirect reduction in cattle output arising from the decrease in demand for beef products, only 0.6 percent can be attributed to net SAM-linkage effects. The small net SAM-linkages effect in the cattle sector shows that the effects of an exogenous shock on the cattle sector can be explained by input-output linkages only. There is almost no "circular-multiplier" effect or leakages of the cattle sector into the wider economy that an input-output model will fail to capture. In contrast, the high net SAM-linkages of 64,2 percent in beef processing sector show the leakages of the beef processing sector on the wider economy that an input-output model fail to capture and so an input-output model would underestimate the importance of the beef processing and cattle sectors on the economy.

Because there is double-counting when the output changes in individual sectors are summed, looking at the changes in GDP gives a better indication of the effect on national welfare, although this is still imperfect given that GDP does not account for net foreign payments. Here there is a reduction of €457.4 million in factor income almost evenly distributed between labour and capital.

This change in factor income has different consequences for households depending on the composition of their income. The main effect in absolute terms will be felt by urban households followed by rural non-farm households simply because they are the largest household group in terms of numbers. Given the widespread cattle ownership among Irish farmers, most farm household types are also adversely affected. Overall, a reduction of €183 million in the value of cattle output would lead to a total decrease in household income of €332.8 million and of €56.2 million in enterprise income assuming households do not switch in producing another type of output. In Ireland urban households represent 70 percent of the total number of households, while farm household income represents almost 5 percent. On average each urban household incurs a loss in income of about 2 percent, while for a farm household the loss varies between 10 percent and 18 percent depending on the farm enterprise type of the household. The largest share of 18 percent is in the dairy and other enterprise household while the cattle enterprise household registers a loss of 11 percent. Overall, a 20 percent reduction in GHG emissions from agriculture sectors which is equivalent to a reduction of €183 million in the cattle output will cost each cattle enterprise farm household €927 on average. Each urban and rural non-farm households cost will be worse off by approximately €194 and €178 per annum, respectively. The highest reduction will be felt in the dairy and other enterprise farm household with €1,448 per annum, per household.

Table 10: Multiplier effects derived from the 2005 Irish AgriFood-SAM

	Beef processing industry					
	I	M	N_1	N_2	N_3	Net SAM linkages(%)
Milk		-21.54	-20.07	0.00	-1.47	7.14
Cattle		**-183.00**	-181.88	0.00	-1.12	0.61
Sheep		-0.31	-0.14	0.00	-0.17	54.14
Pigs		-0.42	-0.11	0.00	-0.31	71.89
Poultry		-0.38	-0.06	0.00	-0.32	82.77
Cereals		-13.27	-12.70	0.00	-0.57	4.29
Fruit & Veg.		-2.85	-1.17	0.00	-1.68	59.01
Potatoes		-0.54	-0.05	0.00	-0.49	90.38
Other Crops		-10.71	-10.40	0.00	-0.31	3.04
Fodder Crops		-36.02	-35.41	0.00	-0.61	1.81
Forestry		-0.53	-0.20	0.00	-0.33	61.67
Fish		-3.77	-3.01	0.00	-0.76	20.05
Beef Proc.	**-326.08**	-2.44	-0.80	0.00	-1.64	64.26
Pig Proc.		-2.24	-0.49	0.00	-1.75	75.50
Poultry Proc.		-1.33	-0.25	0.00	-1.08	77.59
Sheep Proc.		-0.64	-0.15	0.00	-0.49	73.37
Fish Proc.		-0.94	-0.30	0.00	-0.63	65.85
Fruit &Veg. Proc.		-1.75	-0.12	0.00	-1.63	89.14
Milk Proc.		-6.88	-2.63	0.00	-4.24	60.28
Animal Feed		-46.76	-45.01	0.00	-1.75	4.38
Other Food		-31.89	-21.45	0.00	-10.44	33.88
Manufacture		-234.08	-128.10	0.00	-105.98	45.69
Services		-343.57	-154.00	0.00	-189.57	55.15
Labour		-243.65	0.00	-195.58	-48.07	
Land		-55.17	0.00	-54.42	-0.74	
Capital		-158.63	0.00	-106.43	-52.21	
Enterprises		-56.24	0.00	-26.05	-30.19	
Households						
Urban		-195.25	0.00	-150.78	-44.47	
Rural Non-Farm		-64.87	0.00	-49.97	-14.90	
Rural Dairy Farm		-17.08	0.00	-15.85	-1.23	
Rural Dairy and Other Farm		-10.82	0.00	-10.13	-0.69	
Rural Cattle Rearing Farm		-17.08	0.00	-16.08	-1.00	
Rural Cattle and Other Farm		-11.52	0.00	-10.76	-0.76	
Rural Mainly Sheep Farm		-10.41	0.00	-9.78	-0.63	
Rural Tillage Farm		-4.55	0.00	-4.32	-0.23	
Rural Other Farm		-1.25	0.00	-1.15	-0.10	
Total Multipliers						
Output		-945.83	-618.49	0.00	-327.34	
GDP		-457.45	0.00	-356.43	-101.02	
Income		-389.07	0.00	-294.88	-94.19	

This results are based on a SAM-multiplier fixed price analysis that makes use of the results derived from the FAPRI-Ireland partial equilibrium model. For the purpose of this analysis it is assumed, in the partial equilibrium model, a 20 percent GHG reduction target through the cattle sector exclusive of emissions by agricultural fuel consumption. The results show the effect of a potential reduction in the domestic production of cattle output, but does not account for any price change and the supply does not elastically respond to any changes in demand. The negative effect ot household level might be overcome by increase imports or agricultural factors redistribution to other agricultural activities (i.e. dairy) previously used in the cattle sector.

5 Conclusions

This paper describes the construction of an AgriFood-SAM for the year 2005. The specific features of this SAM are the disaggregation of the agriculture and food industry sectors into 12 agricultural sectors and 10 food industry sectors, explicit disaggregation of the value added account and external accounts, careful treatment of the taxes and subsidies account for agriculture, introduction of milk quota rent and explicit disaggregation of the household account. A wide range of data is used for this exercise, from national accounts to national farm and household survey data. The discrepancies and gaps encountered during the "building" process were fixed through the use of the cross-entropy method, designed to balance the flows of income and expenditure at sectoral level. This social accounting matrix can be used in a number of different ways as a descriptive representation of the economy, in multiplier analysis of which an example is given in the paper, and as a database for a CGE model.

This paper also presents the economic impact of reducing GHG emissions from the agricultural sectors by 20 percent, using a SAM multiplier analysis. The linear SAM model is based on the Leontief model, but as it incorporates income generation and distribution as well as the production side, it captures the complete circular flow of the economy. The results suggest that a 20 percent reduction in GHG emissions by 2020, through a reduction in the output for cattle, will have a contractionary effect in the whole economy. This policy will reduce the total gross output in the economy by more than half a billion euro and have an indirect effect on the household by reducing its total income by more than €300 million.

In interpreting the results from a multiplier analysis we should be careful as the model assumes fixed proportion production functions, fixed prices and free availability of resources. In other words, if cattle output reduces by 12.6 percent in 2020 then the level of inputs used in this sector is assumed to be reduced by same percentage. Similarly, employment and income are assumed to be reduced in the same proportions. Also, multipliers are based on the state of technology within a sector at a point in time. Hence, multipliers may change in different sectors over time as technology changes.

Multiplier analysis is useful in considering the significance of growth (or contraction) in a particular economic sector. However, the approach has its limitations, and a sensible discussion of multiplier effects should always acknowledge these limitations.

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Appendix

Table A 1: AgriFood-SAM Sector listing and labelling

NACE CODE	AgriFood-SAM Sectors	LABEL Activities	Commodities
1	Milk	A_AMIK	C_AMIK
	Cattle	A_ACATL	C_ACATL
	Dairy Calve	A_ADCAV	C_ADCAV
	Sheep	A_ASHP	C_ASHP
	Pig	A_APIG	C_APIG
	Poultry	A_APOL	C_APOL
	Horses	A_AHOR	C_AHOR
	Cereals	A_ACER	C_ACER
	Fruit and Vegetable	A_AFRVE	C_AFRVE
	Sugar	A_ASUG	C_ASUG
	Potatoes	A_APOT	C_APOT
	Other Crops	A_AOTCR	C_AOTCR
	Fodder Crops	A_AFOCR	C_AFOCR
2	Products of forestry, logging and related services	A_FORE	C_FORE
5	Fish and other fishing products; services incidental of fishing	A_FISH	C_FISH
15	Beef meat	A_MBEF	C_MBEF
	Pig meat	A_MPIG	C_MPIG
	Poultry meat	A_MPOL	C_MPOL
	Sheep meat	A_MSHP	C_MSHP
	Fish and other fishing products	A_MFSH	C_MFSH
	Fruit and vegetable	A_MFRVE	C_MFRVE
	Dairy products	A_MDARY	C_MDARY
	Animal feed	A_MANFE	C_MANFE
	Other food products	A_MOTFO	C_MOTFO
	Beverages	A_MBEV	C_MBEV
10to14, 16to45	Manufacturing	A_MANUF	C_MANUF
50to71	Services	A_SERV	C_SERV
	Labour	LAB	
	Capital	CAP	
	Land	LND	
	Urban Households	UHHO	
	Rural Non-Farm Households	RNFHHO	
	Rural Dairy Farm Household	RDFHHO	
	Rural Dairy and Other Farm Household	RDOFHHO	
	Rural Cattle Rearing Farm Household	RCFHHO	
	Rural Cattle and Other Farm Household	RCOFHHO	
	Rural Mainly Sheep Farm Household	RSFHHO	
	Rural Tillage Farm Household	RTFHHO	
	Rural Other Farm Households	ROFHHO	
	Government	GOV	
	Enterprises	ENT	

Continued on Next Page…

Table A 1 – Continued

NACE CODE	AgriFood-SAM Sectors	**LABEL** Activities	Commodities
	Direct Taxes	TINCO	
	Taxes on production	TPTON	
	Subsidies on production	SPTON	
	VAT	TVAT	
	Taxes and duties on imports	TIMP	
	Taxes on products excluding VAT and import duties	TPTS	
	Subsidies on products	SPTS	
	Export refunds	EXREF	
	Trade and Transport Margins	TRDTR	
	External Account-UK	UK	
	External Account-Rest of the EU	REU	
	External Account-Rest of the World	ROW	
	Savings/Investments	SAV	

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