Import Dependency of Food Production

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Abstract

Self-sufficiency figures based on the relationship between domestic production and consumption fail to take into account the fact that domestic production itself is dependent on imported resources. In this paper, an indicator for measuring the import content of food production industries is introduced. With the aid of Eurostat input–output tables, the total dependency on imports, comprising both direct as well as indirect imports of raw materials and intermediates, is calculated for Finland, Germany and Denmark. The results of agricultural and food manufacturing production are presented, indicating a growing trend in import dependency, including energy, chemicals, feed protein and services.

Keywords: agriculture, food industry, imports, inputs, input-output model

1. Introduction

Food security is increasingly being discussed as a matter of concern, even in developed countries. Two main triggers appear to be at work. In the context of dramatic and rapid changes on the international agricultural product market in the past few years, and of a shift to a more open, and less subsidy-dependent, trading environment, the issue of national food security policy is often raised. Other factors have also emerged that have contributed to a sense of growing unease: geopolitical tensions, international terrorism, environmental issues, the potential for short- term interruptions in the fuel supply, and longer-term concerns over energy security.

Discussions concerning food security can be confusing, however, because food security is a multi-faceted and complex issue. National self-sufficiency figures based on market shares provide a broad indicator of the ability of agriculture to meet consumer demands under normal conditions. However, simply looking at the self-sufficiency figures fails to take into account the fact that domestic production itself is dependent on imported resources such as fertilizers, fuel and machinery. The degree of self-sufficiency thus reflects the general competitiveness of agriculture in the domestic and international markets more than the level of food security.

A definitive assessment of import dependency in food production requires that both direct and indirect raw materials and intermediates are taken into account. Direct imports refer to goods and services that are imported by the industries in which they are to be used. One can also calculate indirect imports, in other words, the sum of all imports that indirectly end up in a sector's production processes from other industries. When tracing indirect imports, all past imports are included in the supply chain from all the industries engaged in the production process. This provides a broader picture of a sector's total dependency on imports.

This paper presents an indicator for measuring the import content of industries in the domestic food chain. The indicator is applied for Finnish, Danish and German data. The only way to add together various dissimilar inputs is in monetary terms. Thus, the content of imports for each industry is calculated by dividing inputs imported (€) by the industry's output (€). However, only intermediates, and not investment goods, are included in this study. To include an industry's indirect imported inputs, input–output analysis (output-to-output model) is utilized in the paper.

This paper is organized as follows. In section 2, the method used and indicator for measuring the rate of imports are introduced. In section 3, the results based on Finnish, Danish and German data are presented, and in section 4 some conclusions are drawn.

2. Method

We calculate input imports of the food sector industries using the output to output model which is an application of Leontief's basic model (equation 1).

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F} , \qquad (1)$$

where **X** is the vector of outputs, **F** is the vector of final demands, **A** is a matrix of fixed input coefficients ($A = Z\hat{X}^{-1}$, and **Z** is a matrix of intermediate uses) and **I** is the identity matrix. The so-called Leontief's inverse matrix $(\mathbf{I-A})^{-1}$ represents a multiplier used to calculate overall relationships in industrial outputs caused by final demands (See more Miller & Blair 2009).

In the output-to-output model, outputs of industries are dependent on outputs. The multiplier matrix of the output (TF) model is derived from Leontief's inverse as solved by Szyrmer (1992). He generated a TF matrix from the inverse of the Leontief matrix in the following way:

$$\mathbf{TF} = (\mathbf{I} - \mathbf{A})^{-1}\hat{\mathbf{D}}^{-1} , \qquad (2)$$

where $\hat{\mathbf{D}}$ refers to a diagonal matrix based on the diagonal of the Leontief inverse matrix and **TF** matrix, in which the multiplier effects of a unit of output are captured [Szyrmer ibid., Knuuttila et al. 2007)]. As an analysis tool, the **TF** matrix is analogous to Leontief's inverse (see Vatanen 2011, 22–23). Column sums of the **TF** matrix, i.e. output multipliers, define how much an output unit of industry in the column requires output totals from all industries in the economy. Thus, the output multipliers indicate the comparative total effects of industrial output units.

The consideration from output to output is explained ex post. The interest is in the effects of industrial outputs in the past time period (Szyrmer 1992). Thus, it is possible to define the absolute gross effects of industries by multiplying a diagonal matrix composed of the outputs of all industries (**X**) by the total flow matrix (**TF**) to obtain an analytical matrix of outputs (Vatanen 2001)

$$\mathbf{R} = (\mathbf{TF})\hat{\mathbf{X}} . \qquad (3)$$

The diagonal cells of matrix R indicate the outputs of different industries, and the off-diagonal column cells indicate the direct and indirect output requirements of the industry represented by the row concerned with respect to the output of the industry denoted by the column. The sum of a column in matrix **R** indicates the total gross outputs associated with that industry in the economy (the industry's own output and the direct and indirect output requirements of other industries, i.e. the total gross effects of the industry concerned). In other words, the total gross effects describe the amount of outputs that would be lost if the industry of the column would suddenly disappear (Vatanen 2001, 32; Cai & Leung 2004, 74, 78-80).

2.1. Import effects of the output

The value of import commodities in the production of an industry with respect to the output value of the industry is the direct rate of imports of the industry. The direct rate of imports *mj* is defined in equation 4 for one industry, and the direct rates of imports for all industries **m** in matrix equation 5.

$m_j = M_j / X_j$ (4)

where X_j ja M_j are the output and the direct import of industry j.

$\mathbf{m}' = \mathbf{M}'\hat{\mathbf{X}}^{-1}$

where $\hat{\mathbf{X}}^{-1}$ is the inverse of diagonal matrix of all industries' outputs

and $\mathbf{M}'$ a row vector of all industries' direct imports (5)

The industry's output also contains indirect imports, which are included in domestic intermediates bought by the industry from other industries to be utilized as inputs in its own production. The relationship of the output model and also in real production is as follows: the direct import of industry *i* is dependent on the output of industry *j* to the extent that industry j requires the output of industry i as its input. Thus, the total rate of import inputs in industry *j* (mt_j) is (the direct import + the indirect import)/output of industry j. The method of the calculation is presented in equations 6 and 7.

$mt_j = (M_j + IM_j)/X_j$ (6)

where X_j, M_j ja IM_j are the output, the direct and indirect import of the industry j.

$\mathbf{mt}' = \mathbf{M}'\mathbf{R}\hat{\mathbf{X}}^{-1}$

where $\mathbf{mt}'$ is a row vector which includes rates of total import inputs in all industries (7)

2.2. Imported products of the output

The amount (value) of import products required in the outputs of industries is possible to calculate when the imports of products by different industries are known. Initially, rate of direct import of products in different industries is calculated for this purpose in equation 8.

$\mathbf{mc} = \mathbf{MC}\hat{\mathbf{X}}^{-1}$

where the matrix **MC** includes direct import of different products by industries and

mc displays rates of direct different product imports in industries. (8)

Each industry *j* required for the import of different products can be calculated by the matrix $\mathbf{RMC}^j$. This is the result when matrix **mc** is multiplied by matrix $\hat{\mathbf{R}}_j$, which is a diagonal matrix from column *j* of matrix **R** (equation 9). The column of the matrix indicates how much the output of industry *j* demands outputs from different industries, and how much these outputs require imports of different products, i.e. the cells of the columns in matrix $\mathbf{RMC}^j$. The sums of rows in this matrix reveal the amounts of products of the rows that have to be imported for the output of industry *j* (equation 10). The output of industry *j* demands that the total import of the different products is the sum of all cells in the matrix **RMC**j (equation 11).

$$\mathbf{RMC}^j = \mathbf{mc}\hat{\mathbf{R}}_j \quad (9)$$

$$\mathbf{MC}_i^j = \mathbf{RMC}^j\mathbf{i};\ \mathbf{i} = \text{unit vector (column)} \quad (10)$$

$$MC^j = \mathbf{i}'\mathbf{MC}_i^j;\ \mathbf{i}' = \text{unit vector (row)}$$

$$MC^j = M_j + IM_j. \quad (11)$$

3. Results

Both in agriculture and food manufacturing, the rate of imports was the highest in Denmark, being 26% and 32%, respectively (Figure 1). In food manufacturing, the rate of imports was at the same level in Finland (23%) and Germany (22%), whereas in agriculture, Germany (16%) was more import-dependent than Finland (11%).

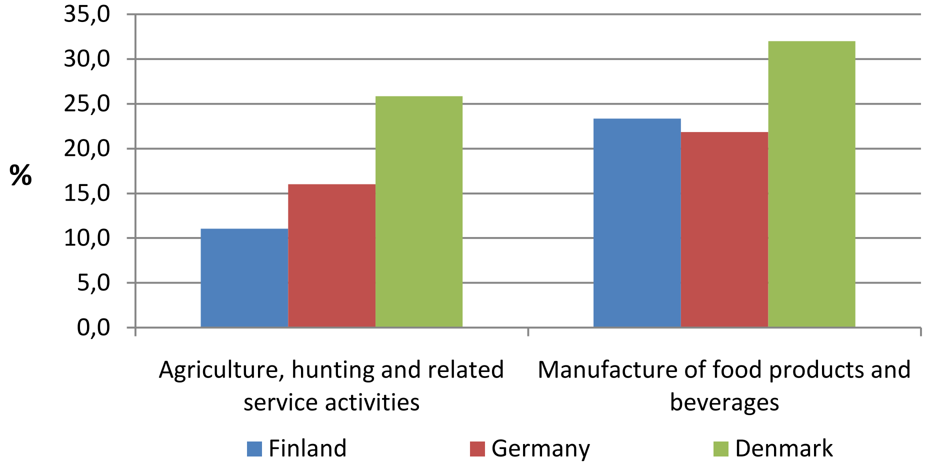

Figure 1. Import rates (%) of agriculture (*SIC01 Crop and animal production, hunting and related service activities)* and food manufacturing (*SIC10_11 Manufacture of food products and beverage)* in Finland, Germany and Denmark in 2007.

Indirect imports dominate (63%) the total imports in Finnish agriculture, but they are also high in Germany (45%) and Denmark (41%) (Table 1). Energy goods such as oil, natural gas and coal explain a major part of the indirect imports. Ready-made pesticides are an example of the direct imports of agriculture. Agricultural products such as soya for the feed industry are the main direct imports of food manufacturing.

Table 1. Direct and indirect import effects of agriculture and food manufacturing in Finland, Germany and Denmark in 2007 (%).

	Agriculture, hunting and related service activities			Manufacture of food products and beverages		
	Direct	Indirect	Total	Direct	Indirect	Total
Finland	37	63	100	59	41	100
Germany	55	45	100	68	32	100
Denmark	59	41	100	66	34	100

The rate of imports in food manufacturing (as well as in agriculture) indicates a growing trend in import dependency, especially towards the end of last decade (Figure 2). The growth is due either to an increase in the volume of imports or a rise in input prices. The rise in input prices at least partially explains the growth in the import dependency rate experienced in recent years.

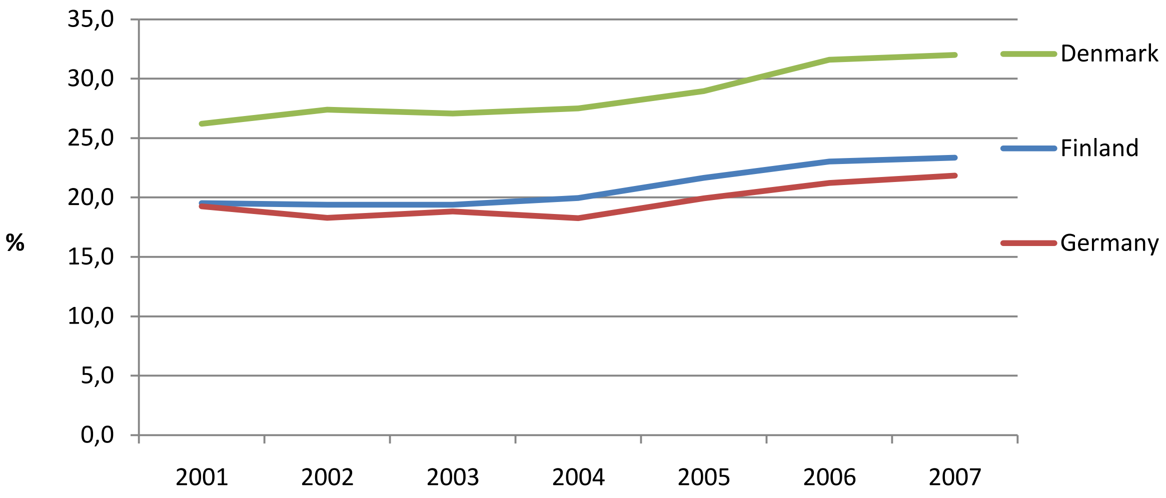

Figure 2. Import rates (%) of agriculture (*SIC01 Crop and animal production, hunting and related service activities)* and food manufacturing (*SIC10_11 Manufacture of food products and beverage)* in Finland, Germany and Denmark in 2001 - 2007.

4. Conclusions

It is concluded that the input–output-based method is ideal in ex-post analysis of economic structures, and is also applicable in studying the import structures of industries. Domestic food production is never entirely domestic when imported inputs are taken into account. Besides imports of agricultural and food products, the import of services is playing an increasing role, highlighting the deepening global distribution of processes. Heavy fragmentation of the food production chain, however, raises concerns. One of these is national food security. The intense use of resources (e.g. energy, soil) requires ecological and social costs to also be fully taken into account for the development to be sustainable.

References

Cai, J. and Leung, P. (2004). Linkage Measures: a Revisit and Suggested Alternative. *Economic Systems Research*, 16, 65–85.

Knuuttila, M., Vatanen, E. and Jansik, C. (2007). Finnish food industry in 1989-2002: an output-oriented input-output analysis. *Acta Agriculturae Scandinavica, Section C: Food Economics* 4(4): 217–228.

Miller, R. E. and Blair, P. D. (2009). *Input-Output Analysis. Foundations and Extensions*. Second Edition. Cambridge University Press.

Szyrmer, J. (1992). Input-output coefficients and multipliers from a total-flow perspective, *Environment and Planning A*, 1992, 921–937.

Vatanen, E. (2001). Puunkorjuun ja puunkuljetuksen paikallistaloudelliset vaikutukset Juvan, Keuruun ja Pielisen Karjalan seutukunnissa. *Metsäntutkimuslaitoksen tiedonantoja* 825, 2001. Joensuun tutkimuskeskus.