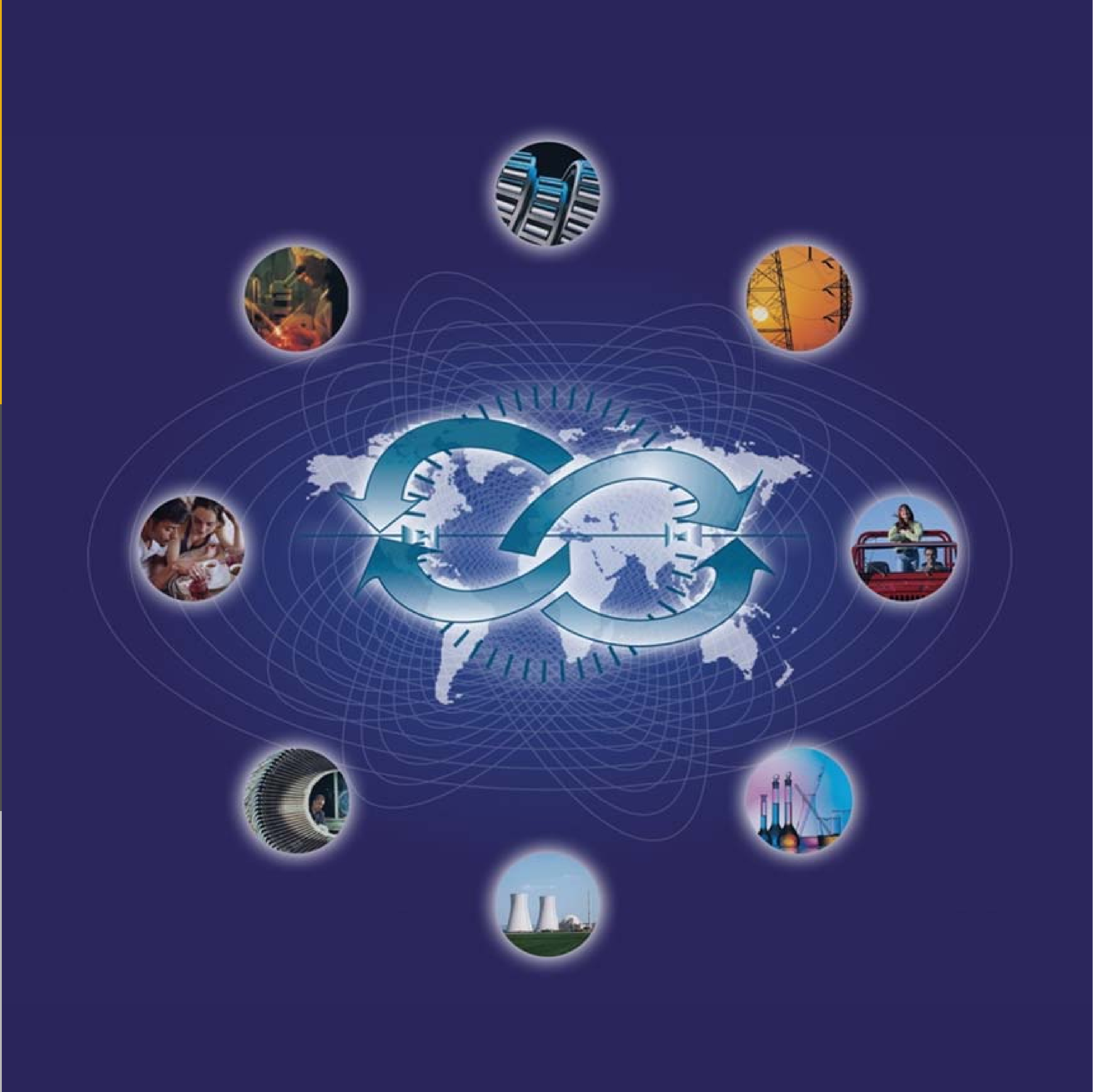

STE Preprint 22/2010

What can post-Keynesian input-output models tell us about social sustainability?

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Executive Summary

Sustainable development (SD) is a multi-dimensional concept incorporating environmental, economic, and social aspects. The empirical literature focuses on environmental and economic issues, while the social dimension has been somewhat marginalised. As social tensions are currently increasing in many countries, model-based studies should pay more attention to social sustainability.

It is argued in this paper that post-Keynesian input-output models are particularly well suited for studying certain aspects of social sustainability, notably unemployment, the distribution of income, and fiscal sustainability (i.e. public debt). In order to illustrate this argument, a post-Keynesian input-output model for the German economy is constructed, incorporating the input-output structure of the German economy and a full representation of the circular flow of income between institutional sectors. In line with post-Keynesian theory, final demand consists of autonomous and induced components. In the household sector, two types of households are distinguished according to their main income source (labour or capital income).

The model is used to explore the effects of two possible policy measures. The first is a shift from material consumption (industrial products) to immaterial consumption (services). The second is a massive investment programme in energy-saving technologies. The model suggests that these policy measures do not generally improve all indicators of sustainability. In the first case, unemployment is reduced, but the income share of capital rises at the expense of labour. While the increase in employment is beneficial, the associated increase in poverty among worker households is problematic for social sustainability. These findings provide further support for adopting a multi-dimensional approach to sustainability and illustrate that post-Keynesian input-output models can make a useful contribution to studying certain aspects of social sustainability, especially those involving structural change in the distribution of consumption expenditure and income.

Keywords

Input-output model, social sustainability, income distribution, green new deal

Contribution to

18th International Input-output Conference, Sydney, Australia, 20-25 June 2010

I Introduction

The term Sustainable Development (SD) was developed in the 1980's to describe a type of social and economic development which can be sustained over (by mankind's standards) very long periods of time. It was interpreted as a desirable alternative to the type of social and economic development which had occurred before that time and was widely considered unsustainable, because economic development had until then coincided with increasing environmental problems and non-decreasing social problems (poverty, unemployment). Thus, SD was from its very beginning firmly focussed on economic, environmental, and social aspects.

Economists have done a lot of research on SD, including theoretical and empirical work. The latter has often concentrated on the relationship between environmental and economic policy goals. Based on the impressive body of literature which has been produced on this matter, many economists would argue that there is a tradeoff between GDP growth and environmental conservation, although in some cases it may be possible to design clever policies that overcome the tradeoff to a certain extent. The proposal of an ecological tax reform, which may achieve a 'double dividend' by reducing pollution and unemployment, is one example of such a clever policy. Nevertheless, since it will not generally lead to a Pareto improvement, it is likely that some interest groups will always oppose it [Kronenberg, 2009c].

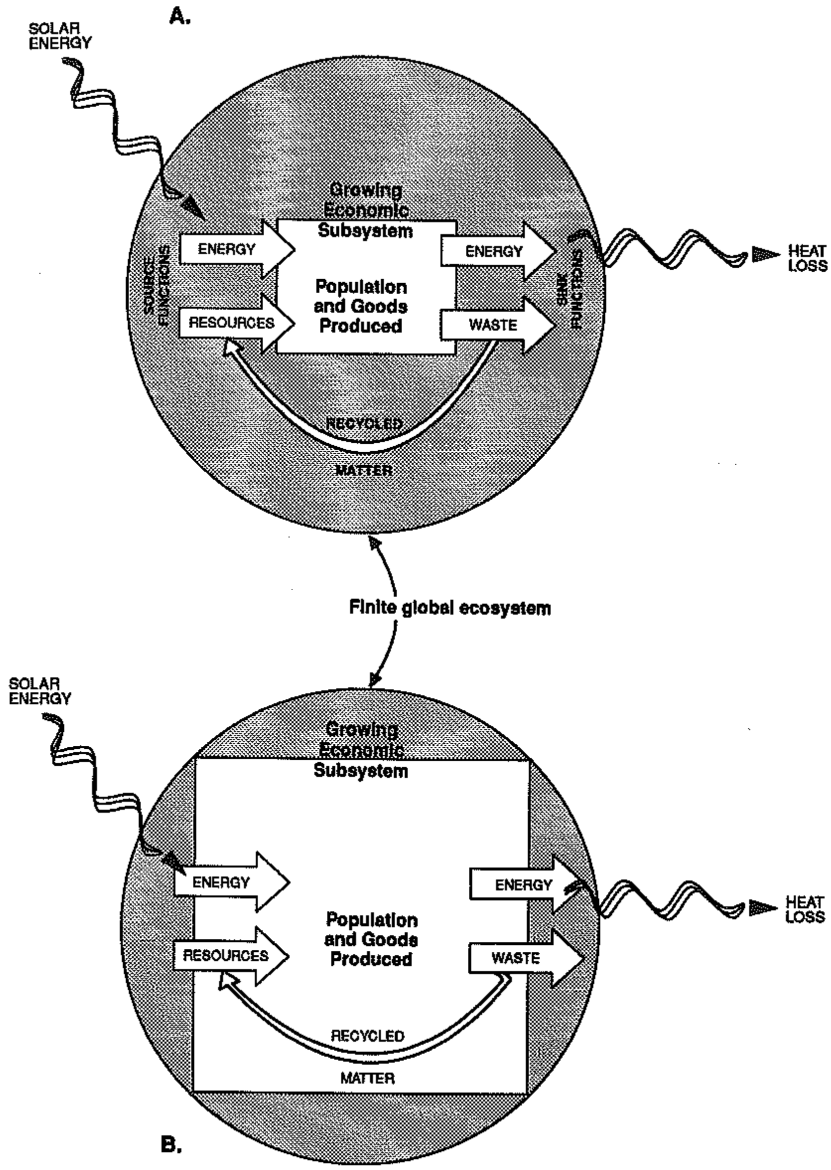
It is argued in this paper that the empirical literature on SD has tended to focus on the environmental and economic aspects of SD, and that the social aspects have been comparatively neglected. Furthermore, it is argued that post-Keynesian input-output models are particularly well suited to fill this gap in the literature because their theoretical foundation allows them to tackle many important features of the social dimension of SD. This claim will be supported by illustrative results from a model for the German economy, which is used to study the effects of two SD-motivated policy measures. The model is still in an early stage of development, so all results should be interpreted as preliminary.

II Theoretical Background

II.1 The Social Dimension of Sustainable Development

The concept of SD was developed simultaneously with, and greatly influenced by, a relatively new field called 'ecological economics'. Ecological economics initially focussed on the relationship between the economy and the ecosystem. The founding fathers of ecological economics pointed out that the former should be seen as a subsystem of the latter, and that the growth of the subsystem 'economy' cannot go on indefinitely if the size of the overall system 'ecosphere' is limited. This view is often visualised by a geometrically inspired drawing as, for example, Figure 1.

Figure 1: The economy as a subsystem of the global ecosystem



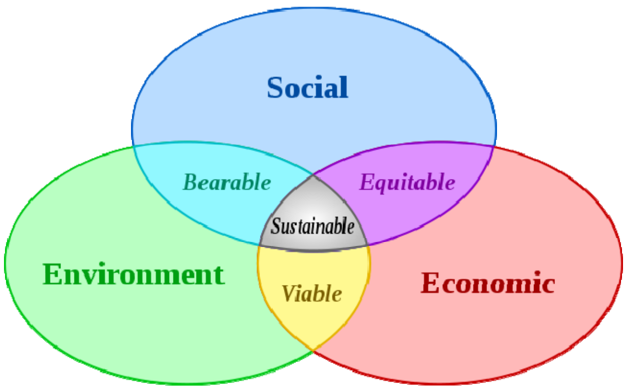
Source: Goodland [Goodland, 1992] IEF-STE 2010

Figure 1 shows the growing economic subsystem (the white rectangle) within the boundaries of the finite global ecosystem (the shaded circle). Panel A represents a situation in which the economic subsystem is relatively small in comparison to the global ecosystem. Panel B, by contrast, represents a situation in which the economic subsystem has grown considerably while the global ecosystem, being limited in size, has not grown. Ecological economists point out that when the latter situation is reached, further growth of the economic subsystem is not possible. They argue that macroeconomic variables such as GDP may continue to grow, but the observed growth of GDP becomes at some point 'uneconomic' in the sense that it does not improve the well-being of the population anymore [Daly, 2007].

The goal of SD was ultimately motivated by the desire for social equity and justice between generations and within each generation. A main concern was that present generations are consuming limited natural resources at the expense of future generations. In practice, however, political discussions often boiled down to simple bipolar confrontations between environmentalists, who proposed policy measures in order to reduce resource consumption and waste, and industrial lobbyists, who argued that such measures are bad for the economy. Thus, the lay public often got the impression that SD was simply about a tradeoff between economy and environment.

Probably as a response to such simplistic misinterpretations of SD, a more elaborate conception of SD was developed, which explicitly acknowledged social issues at the same level of importance as economic and environmental issues. This concept became known as the three-pillar concept. More recently, the three pillars have been converted in to three partly overlapping spheres, as illustrated in Figure 2.

Figure 2: The 'three spheres' model of SD



Source: Wikipedia IEF-STE 2010

By drawing each of the three spheres equally large, Figure 2 graphically illustrates the idea that social issues should receive just as much attention as environmental and economic issues. The areas of overlap between two spheres are labelled 'bearable' (achievement of social and environmental goals), 'equitable' (achievement of social and economic goals), and 'viable' (achievement of economic and environmental goals). SD is achieved in the area of overlap between all three spheres, which is appropriately labelled 'sustainable'.

Empirical economists studying questions of SD should accordingly devote equal attention to all three spheres of SD. However, the literature which has so far been produced seems to be biased toward the environmental and economic spheres. The social sphere, by contrast, has received little attention by empirical economists. As the present paper agues, post-Keynesian input-output models are particularly well suited to fill this gap in the empirical literature on SD.

II.2 Post-Keynesian Economics

Post-Keynesian economics is a school of thought which is characterised by a healthy degree of heterogeneity. This heterogeneity manifests itself in debates on the spelling (‘post-Keynesian’ versus ‘post Keynesian’) as well as the ‘boundaries’ of the term. In the present paper, the term ‘post-Keynesian’ is used in a rather broad sense, encompassing the work of ‘fundamentalists’ like Paul Davidson as well as the ‘Kaleckian’ and ‘Sraffian’ contributions inspired by what Luigi Pasinetti has called the ‘Cambridge school of Keynesian economics’ [Pasinetti, 2005].

Post-Keynesian economics has a variety of features that make it especially well for the analysis of social sustainability: First, it has always put great emphasis on social issues such as income distribution and unemployment. Second, it has always recognised the implications of fundamental uncertainty about the future. Third, it has placed production rather than exchange at the centre of interest. Fourth, it readily accepts the frequent occurrence of market failures. These four features are further discussed in the following.

II.2.1 Emphasis on income distribution and unemployment

Post-Keynesian economics prides itself in having descended directly from the economics of Keynes himself. Since Keynes was highly interested in explaining the existence of unemployment and finding a cure to it, it follows quite logically that the direct heirs to Keynes would be interested in unemployment as well.

Post-Keynesian economists follow Keynes in rejecting Say’s assertion. This allows them to explain why there may be an excess supply of labour even if prices are fully flexible[1]. The level of employment is largely determined by the level of aggregate demand, and even with full wage and price flexibility, the level of aggregate demand may never be high enough to ensure equality between labour demand and labour supply. Thus, unemployment is not a paradoxical puzzle; it is simply a common outcome of the economic process.

Since the level of aggregate demand plays such a crucial role, post-Keynesian economists are naturally interested in the determinants of aggregate demand. They realised from the very beginning that the level of aggregate demand depends on the distribution of income due to variations in the propensity to consume (PTC) between individuals, households, social groups or classes. Generally, if income is redistributed from a social group with a low PTC to another group with a high PTC, aggregate consumption expenditure increases. This constitutes an increase in aggregate demand, which in turn raises the demand for labour, raises employment, raises income,

[1] The widespread belief that the Keynesian explanation of unemployment relies on some sort of wage or price rigidity is a myth.

and raises aggregate demand further. The existence of such multiplier effects is a central feature of Keynesian economics in general and post-Keynesian economics in particular.

There are, of course, alternative theoretical frameworks which deal with unemployment and income distribution at the macroeconomic level. However, post-Keynesian economics is unique in its ability to study the interrelationships between income distribution, unemployment, and the level of output. Rather than developing one model to explain unemployment, one model to explain income distribution and yet another model to explain the level and growth of output, post-Keynesian economics offers the possibility of an integrated assessment of all these variables in one single, plausible, and more or less realistic theoretical framework.

II.2.2 Fundamental uncertainty about the future

Post-Keynesian economists make a sharp distinction between *uncertainty* and *risk*. The latter refers to events whose outcome cannot be known in advance but can be reasonably estimated using statistical methods. An example of such an event is the roll of a die. Although the actual outcome cannot be predicted, it can be reasonably estimated because the distribution of the potential results is precisely known – it as a uniform distribution containing the elements 1, 2, 3, 4, 5, and 6. Hence, we actually know a lot about the outcome of the event. We know that the result will be a full number between 1 and 6, and that each of these numbers is equally likely. This knowledge allows us to compute the odds of a certain outcome and the expected value of bets and wagers. Risk can be assessed, and expected values can be calculated. The law of large numbers then allows us to derive successful strategies for playing a repeated game subject to risk.

Uncertainty, by contrast, is said to exist when the outcome of an event cannot be estimated by statistical means because there is no way of getting any useful information on the distribution of random variables. In cases of true uncertainty, we are not able to specify either the range of possible outcomes or their likelihood. Hence, statistical methods are of little help, and it is impossible to devise winning strategies based on the expected values of uncertain outcomes.

Post-Keynesian economists argue that fundamental uncertainty about the future is the reason why money is different from all other goods in the economy. Money provides liquidity, and people want to hold liquid means of payment as an insurance against events which cannot be reasonably predicted. In this sense, money plays a special role which makes it fundamentally different from all other goods. It is not only a 'medium of exchange' which a barter economy implements to bring transactions costs down; it is a store of value and an insurance against uncertain future events. Thus, fundamental uncertainty is the principle foundation of the post-Keynesian theory of money.

Fundamental uncertainty also plays a crucial role in the SD debate. SD is about the welfare of future generations. Thus, the ‘future’ which we have to consider is decades, centuries, even millennia away. All serious participants in the SD debate admit that the behaviour of complex systems such as the economy or the ecosphere cannot be reasonably predicted over such long time spans. Therefore, a macroeconomic theory which acknowledges the existence of fundamental uncertainty about the future is the proper framework in which to discuss the macroeconomic impacts including social repercussions of environmental and climate policy.

II.2.3 Production at the centre of interest

Post-Keynesian theory places production rather than exchange at the centre of its analysis. This is especially true for its Sraffian stream, as can be seen by the title of Sraffa’s influential *Production of Commodities by Means of Commodities* [Sraffa, 1960]. This book was widely interpreted as a sort of ‘update’ or ‘resurrection’ of the Ricardian theory of production. Inspired by Sraffa’s ideas, many economists have subsequently developed a theory of production which forms, in a way, a bridge between the classical theory of Ricardo and the macroeconomic revolution initiated by Keynes and his followers [Pasinetti, 1977, Schefold, 1989, Kurz & Salvadori, 1995]. This approach has also become known as the classical-Keynesian approach.

The Sraffian approach, having its origins in Ricardo’s writings on production, rejects the theory of marginal productivity. Not all post-Keynesians share this view, pointing out that Keynes himself frequently argued on the basis of marginal productivity. However, they also acknowledge the special role of production in comparison to exchange. In their view production is special because it takes time, so the goods whose production starts today will earn an uncertain amount of revenue in the future. This implies that the equalisation of marginal profit and marginal cost, which theoretically maximises profit, is usually not possible in reality. Because of this, producers often follow rules of thumb (e.g. mark-up pricing).

Thus, there is some disagreement between post-Keynesians on which theory of production is to be used (classical or marginal productivity). However, both sides of the argument come to similar conclusions concerning the implications on pricing and distribution. In both views, the price of a good is generally not equal to the marginal cost of production. This implies that the prices of primary inputs such as capital labour are generally not equal to their marginal productivities. Although environmental issues do not appear very frequently in the post-Keynesian literature, some post-Keynesians have made an effort to study the role of environmental resources as a primary input factor. The implications are quite clear: If market prices do not reflect marginal cost, and primary input prices do not reflect marginal productivities, there is no reason to assume that market forces will ever determine the ‘correct’ price of environmental resources. Consequently, post-Keynesians tend to have little faith in ‘market-based’ environmental policy measures.

The theory of pricing and distribution is highly relevant from a SD point of view because social equity is an important feature of SD. Moreover, in the post-Keynesian view the distribution of income is not only an *outcome* of the economic process; it is a central *determinant* of the level and the composition of aggregate demand. Through its effect on demand, the distribution of income ultimately affects the type and amount of goods which are consumed and produced as well as the accompanying emissions. Therefore, the distribution of income is not only an indicator relating to social aspects of SD; it also has important implications for the environmental sphere of SD. Through its well-developed theory of production, distribution and consumption, post-Keynesian economics can provide a substantial contribution to various issues related to SD [Kronenberg, 2010].

II.2.4 Acceptance of frequent market failures

Achieving SD is made difficult through the existence of a wide variety of market failures. In a world with perfectly functioning markets, the economy reaches a Pareto-optimal state without the intervention of government. That state may not conform to the ideals of SD, because Pareto optimality does not guarantee social equity. However, it is clear that in a world without market failures SD is much easier to achieve than in reality. Failures in the market for exhaustible resources, for example, tend to increase the rate of resource consumption [Kronenberg, 2008].

Post-Keynesian economics acknowledges the fact that market failures occur frequently in reality. Its theory of pricing, for example, is based on the observation that producers usually do not apply marginal cost pricing because a) it is in reality not possible to compute marginal cost and b) many producers possess some kind of market power, at least within a market niche. By incorporating frequent market failures into its theoretical foundation, post-Keynesian economics put itself into a good position to study SD-related problems, which are often caused by the existence of market failures, using relatively realistic models.

II.3 Input-output models

Input-output analysis was developed by Wassily Leontief in the mid 20th century[2]. Since that time, it has come a long way. The current state of the art is described in the 2nd edition of the well-known introductory textbook by Miller and Blair [Miller & Blair, 2009].

In the early days, input-output models were characterised by their treatment of final demand. Models which treated final demand (e.g. consumption by households) as endogenous were called ‘closed’. Conversely, models which treated final demand as

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[2] Antecedents of Leontief’s work have been surveyed by Kurz and Salvadori [Kurz & Salvadori, 2000].

exogenous were called ‘open’. The latter type was frequently applied to identify, for example, the amount of primary inputs ‘embodied’ in goods for final consumption. For this kind of analysis, the open input-output model is the proper framework.

In the wake of the Keynesian revolution, however, economists became interested in the dynamic relationship between autonomous demand (which includes many types of government expenditure, investment, and exports) and induced demand (final consumption expenditure by households, depending on their income level). The solution to this problem was to build semi-open input-output models in which household consumption is modelled, in accordance with Keynesian macroeconomic theory as a function of current household income. If this relationship is assumed to be linear, it can be read directly from an input-output table. Alternatively, it may be specified in a flexible way using econometric techniques. These developments have given rise to the development of extended input-output models or, as they are sometimes called in reference to the technique of estimating functional relationships, econometric input-output models.

Input-output models have been used frequently in the SD literature for obvious reasons. As mentioned above, the simple open input-output model can be used to compute the amount of primary inputs that is required to produce a certain good for final consumption given the technology currently in use. This model is an appropriate tool for calculating embodied energy, CO2 emissions, and the like. It has been used for this purpose by a great number of researchers.

Input-output models have also been used by post-Keynesian economists because their structure fits nicely with the Sraffian theory of production and because they can easily be extended to incorporate some key features of Keynesian macroeconomics, for example the distinction between autonomous and induced demand. When such models are enriched with data from the environmental-economic satellite accounts, they can be used to study a variety of SD-related questions. Dejuán et al., for example, use a model clearly inspired by post-Keynesian theory to forecast the energy demand of the Spanish economy [Dejuán et al., 2008].

III A Multisectoral Model for Germany

Considering the theoretical background mentioned in the previous section, a multisectoral model for Germany (MMG) was constructed with the purpose of analysing certain policy measures and their impact on the social dimension of SD. The model was implemented in GAMS. In the following, the structure of the model is first discussed verbally. Then, the technical aspects of its implementation are explained in detail.

III.1 The input-output core

The model structure follows the basic philosophy of the SAM approach, which highlights the importance of tracing all transactions between people and organisations in an economy. The core of MMG consists of a simple input-output model capturing the production of commodities by means of commodities. This 'core' reflects the interindustry transactions which take place whenever an industry purchases commodities produced by another industry in order to produce its own commodities. However, in order to achieve a complete coverage of all expenditure flows, MMG also captures all the transactions described in a SAM. In the input-output literature, there is no universally accepted terminology. In order to prevent misunderstandings, the semantic conventions of MMG are described in the following.

The IOT of MMG follows the commodity-by-industry concept. That is, each row of the Northwest quadrant refers to a **commodity** while each column refers to an **industry**. The classification of commodities is based on CPA 2002. Each industry is understood as a homogenous branch producing only one type of commodity (joint production is thereby ruled out). Thus, the resulting IOT is of the 'symmetric' variety, with column *j* referring to the production of the commodity to which row *j* refers. This concept is also used in the input-output tables published by the statistical offices of the EU member states and Eurostat. In the current version of MMG, there are only three commodities and three industries: 'goods', 'services', and 'energy'. Future versions of MMG will operate with a larger number of commodities and industries.

Table 1: MMG input-output table, Germany, 2005

Input-ouput table Germany, 2005	Homogenous branches				Final uses					Total use
	Production of goods	Production of services	Production of energy	Total	Final consumption expenditure by households	Final consumption expenditure by government	Gross capital formation	Exports	Final use	
Goods	793,795	122,530	8,750	925,075	291,860	14,056	300,559	736,095	1,342,570	2,267,645
Services	321,518	707,120	21,503	1,050,141	818,183	402,685	51,613	137,397	1,409,878	2,460,019
Energy	42,721	29,669	70,670	143,060	56,196	279	4,428	23,558	84,461	227,521
Total intermediate use / final use at basic prices	1,158,034	859,319	100,923	2,118,276	1,166,239	417,020	356,600	897,050	2,836,909	4,955,184
Net taxes on products	13,188	42,792	1,399	57,379	130,001	4,490	26,760	-430	2,836,909	4,955,184
Total intermediate use / final use at purchaser prices	1,171,222	902,111	102,322	2,175,655	1,296,240	421,510	383,360	896,620	2,997,730	5,173,384
Compensation of employees	353,246	760,785	16,969	1,131,000						
Net taxes on production	2,084	18,836	-260	20,660						
Consumption of fixed capital	72,325	253,127	10,128	335,580						
Net operating surplus	94,698	432,829	11,633	539,160						
Value added	522,353	1,465,577	38,470	2,026,400						
Output	1,693,575	2,367,688	140,792	4,202,054						
Imports of similar products	574,070	92,331	86,729	753,130						
Total supply of products	2,267,645	2,460,019	227,521	4,955,184						

Source: Destatis, author's calculations IEF-STE 2010

Table 1 shows the input-output table for the German economy of 2005 according to the MMG layout. There is a row for each of the three commodities and a column for each of the three industries. The Northwest quadrant describes the interindustry transactions, as discussed below.

The Northeast quadrant of Table 1 describes the final use of commodities. MMG distinguishes four **final use categories**: final consumption expenditure by households (including NPISH), final consumption expenditure by government, gross capital formation, and exports. In Table 1, the last two columns also report total final use and total use of commodities.

Normally, all monetary magnitudes are valued at **basic prices** (b.p.). Table 1 also shows the relationship between the valuation at basic prices and **purchaser prices** (p.p.). In the fourth row, total intermediate consumption and total final use are reported in terms of basic prices. The fifth row reports the amount of net taxes on the commodities concerned. Adding rows 4 and 5 yields the respective magnitudes valued at purchaser prices.

The Southwest quadrant describes the generation and distribution of primary income by dividing total value added among four **value added components**: compensation of employees (gross wages plus SSC paid by employers), net taxes on production, consumption of fixed capital, and net operating surplus. In the second-to-last row, imports of similar goods are reported. Note that in the standard ESA 95 tables, imported commodities are reported as 'imports of similar goods' in the column referring to the domestic industry producing the same (or similar) commodities. Furthermore, they are recorded as deliveries from that industry to the industry (or final use category) which was actually responsible for importing the commodities. Thus, imported commodities appear twice in the input-output table[3].

III.2 Social accounting tables

Although the input-output table (Table 1) contains a lot of useful information, it does not contain all the information necessary to provide a full account of the flows of income and expenditure in an economy. Therefore, MMG uses a number of additional accounts to capture those transactions. The information contained in these social accounting tables could, in principle, be used to fill out an entire SAM for the German economy. In the present paper this is not done because a SAM would quickly become too large to be displayed on paper. Furthermore, some of the 'data' used by MMG was obtained using a few 'heroic' assumptions which are certainly not very realistic. Putting such 'data' into a SAM together with the official input-output accounts, which were compiled by Destatis with great care and access to highly detailed survey data, would not do justice to the efforts of Destatis to provide reliable statistical information.

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[3] For a more thorough discussion of the allocation of imports, see also [Kronenberg, 2009a].

The first social accounting table continues basically where the input-output table leaves us – with primary income. It is therefore called the primary income distribution table. It shows how the three types of primary income (compensation of employees, net taxes on production, and net operating surplus) are distributed between **sectors**. MMG distinguishes four sectors: households, firms, government, and the rest of the world (ROW). Firms do not (yet) play a big role in MMG. By assumption, the entire net operating surplus is transferred to households in the form of capital income. The compensation of employees is assumed to be transferred directly to the household sector. In reality, a large chunk of this amount is redistributed through the social security system. At the end of the day, however, social security contributions are finally transferred back to households. Therefore, in order to keep the model structure simple, it is assumed at this stage that the entire compensation of employees is transferred to the household sector in the form of labour income.

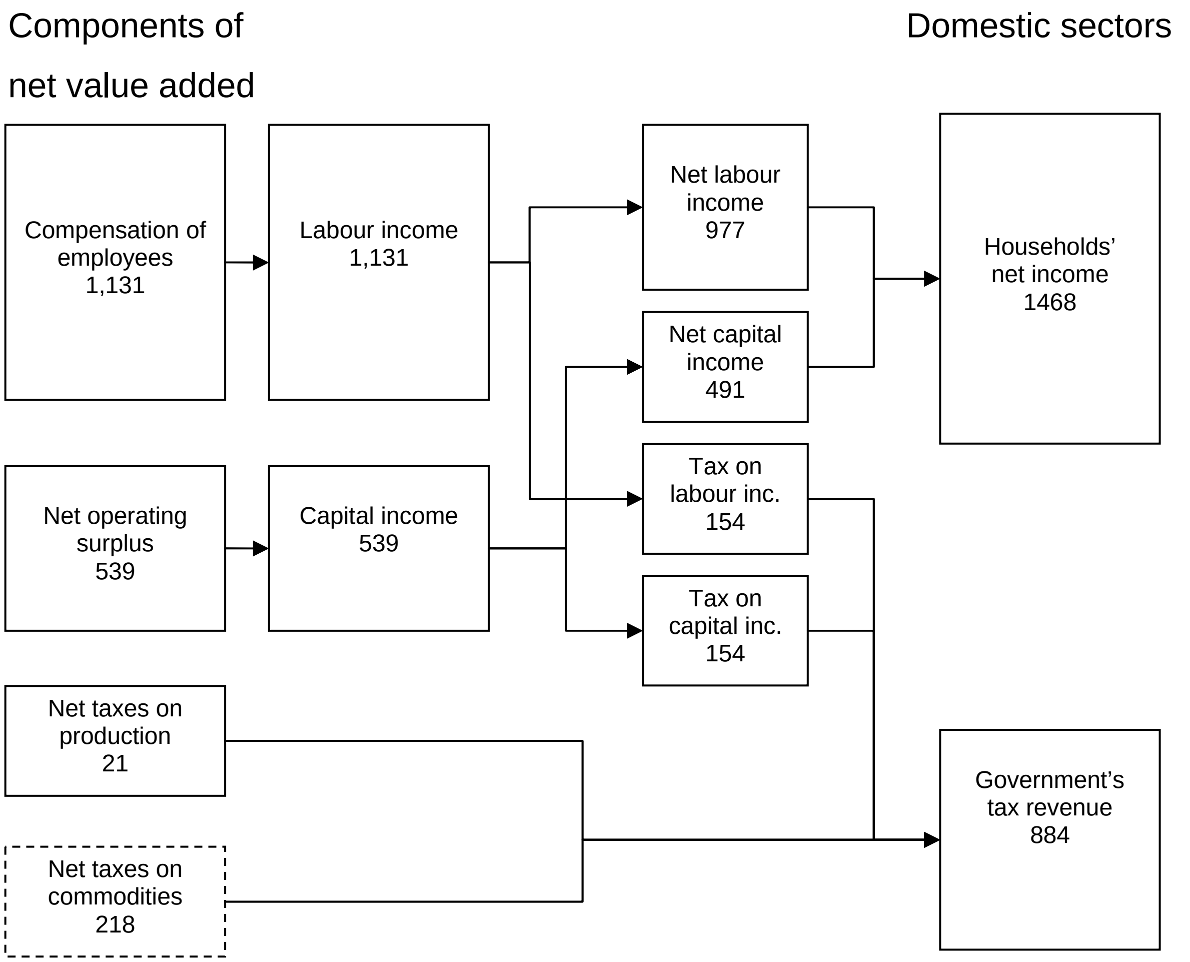
The government generates revenue by raising taxes. Currently, MMG recognises four types of taxes: net taxes on commodities, net taxes on production, taxes on labour income, and taxes on capital income. Net taxes on commodities are reported in a special row of the input-output table (Table 1). Net taxes on production, according to MMG, form one component of value added. The remaining types of taxes are levied on labour income and primary income.

Figure 3 provides a graphical representation of the distribution of primary income. At the left side of the figure, the three components of net value added (compensation of employees, net operating surplus, net taxes on production) are shown. Net taxes on commodities are also shown (with a dashed line) because they form another part of the government's tax revenue.

Figure 3 shows the distribution of income under the simplifying assumptions of MMG. Compensation of employees and net operating surplus are directly converted into primary factor (labour, capital) income. Both types of primary income are then subjected to taxation. After taxes have been paid, net labour income and net capital income are then transferred to households. Thus, the household sector's income is equal to the sum of net labour income and net capital income.

In the current simple version of MMG, the only source of income for the government is taxation. The four types of taxes are shown in Figure 3. Net taxes on production and net taxes on commodities are also displayed in the input-output table. Taxes on labour income and capital income are not recorded in the input-output table; they are only recorded in the distribution of primary income account.

Figure 3: Distribution of primary income in MMG terms



Source: author's illustration IEF-STE 2010

In order to capture distributional effects and socio-demographic changes, MMG breaks down the household sector into **social groups**. At its current stage of development, MMG makes a distinction between two groups called 'workers' and 'rentiers'. By assumption, workers receive the entire net labour income while rentiers receive the entire net capital income. This identification of social groups by their main source of income is, of course, motivated by the post-Keynesian theoretical background discussed above. In the future, the household sector will be further disaggregated into smaller groups.

Table 2: MMG social groups account

	Workers	Rentiers	Total
Net labour income	977,184	0	977,184
Net capital income	0	490,636	490,636
Total net income	**977,184**	**490,636**	**1,467,820**
Consumption of goods	220,022	71,838	291,860
Consumption of services	616,796	201,387	818,183
Consumption of energy	42,364	13,832	56,196
Total consumption expenditure at b.p.	879,182	287,056	1,166,239
Net commodity taxes	98,002	31,999	130,001
Total consumption expenditure at p.p.	**977,184**	**319,056**	**1,296,240**
Saving	**0**	**171,580**	**171,580**

Source: Destatis, author's calculations IEF-STE 2010

Table 2 shows MMG's social groups account, representing the income and spending of the two social groups. It should be noted that most of the numbers in Table 2 have little to do with the official statistics; they are merely based on simple hypotheses that were adopted during the construction of MMG. The only numbers in Table 2 that come from official sources are the total figures for consumption.

The distribution of primary factor income in Table 2 is based on the aforementioned assumption that workers receive the entire net labour income while rentiers receive the entire net capital income. Under this assumption, total net income for each group can easily be computed. The numbers for consumption were derived under two simple assumptions: First, it was assumed that the saving rate of workers is equal to zero. With total net income of workers 'known', total consumption expenditure by workers (at p.p.) is then also 'known'. And since total consumption expenditure by households is known from the official input-output table, the level of consumption expenditure by rentiers can be easily deduced. The amount of saving by rentiers was then calculated by subtracting consumption expenditure from net income.

A second assumption was made in order to derive the composition of each group's consumption expenditure. It was assumed that the structure of consumption expenditure is the same for both groups, and hence equal to the overall structure of consumption expenditure which can be computed from the official input-output table. Thus, Table 2 was completely filled.

It should be noted that the two simplifying assumptions mentioned above were made because they facilitated the construction of a rough work functioning model. They are, however, not entirely realistic and will be replaced with estimations based on household survey data in the near future.

III.3 Mathematical Structure

In the following, the mathematical structure of MMG is described. For easy reference, the appendix contains a list of all variables and parameters used in MMG.

The first block of equations refers to individual industries, indexed by *j*:

```
(1)   Z_ij(i,j) = A(i,j) * TOTSUP_j(j)
(2)   INTCONS_j(j) = SUM(i,Z_ij(i,j)
(3)   NETCOMTAX_j(j) = PI_coef("NETCOMTAX",j) * TOTSUP_j(j)
(4)   INTCONS_PP_j(j) = INTCONS_j(j) + NETCOMTAX_j(j)
(5)   COMPEMP_j(j) = PI_coef("COMPEMP",j) * TOTSUP_j(j)
(6)   NETPRODTAX_j(j) = PI_coef("NETPRODTAX",j) * TOTSUP_j(j)
(7)   CONSFIXCAP_j(j) = PI_coef("CONSFIXCAP",j) * TOTSUP_j(j)
(8)   NETOPSURP_j(j) = PI_coef("NETOPSURP",j) * TOTSUP_j(j)
(9)   GVA_j(j) = COMPEMP_j(j) + NETPRODTAX_j(j) + CONSFIXCAP_j(j) +
      NETOPSURP_j(j)
(10)  OUTPUT_j(j) = INTCONS_PP_j(j) + GVA_j(j)
(11)  IMP_j(j) = IMP_coef(j) * TOTSUP_j(j)
(12)  TOTSUP_j(j) ≥ TOTUSE_i(j)
```

Equation (1) describes the use of input i by industry j as the product of the total supply of commodity j and the corresponding I-O coefficient A(i,j). Note that this equation is always true; it does not require the assumption of a constant A matrix (although this assumption will be made in the following). Equations (2) to (10) simply follow from the ESA 95 guidelines and describe the relationships between certain magnitudes which are true by definition (for example, the definition of value added). Equation (11) describes imports of commodity j as the product of the total supply of commodity j and an import coefficient (which is currently assumed to be constant but this assumption may be relaxed in future versions of MMG). Equation (12) is, strictly speaking, not an equation but a constraint stating that the supply of commodity j must not be smaller than the total use of commodity j.

The second block of equations sums industry-specific magnitudes such as value added over all industries in order to compute aggregate magnitudes:

```
(13)  INTUSE_i(i) = SUM(j,Z_ij(i,j))
(14)  INTUSE = SUM(i,INTUSE_i(i))
(15)  INTCONS = SUM(j,INTCONS_j(j))
(16)  NETCOMTAXINTUSE = SUM(j,NETCOMTAX_j(j))
(17)  INTUSE_PP = INTUSE + NETCOMTAXINTUSE
(18)  COMPEMP = SUM(j,COMPEMP_j(j))
(19)  NETPRODTAX = SUM(j,NETPRODTAX_j(j))
```

```
(20)  CONSFIXCAP = SUM(j,CONSFIXCAP_j(j))
(21)  NETOPSURP = SUM(j,NETOPSURP_j(j))
(22)  GVA = SUM(j,GVA_j(j))
(23)  OUTPUT = SUM(j,OUTPUT_j(j))
(24)  IMP = SUM(j,IMP_j(j))
(25)  TOTSUP = SUM(j,TOTSUP_j(j))
```

Equations (13) to (25) are of a purely definitional nature and therefore do not warrant more attention at this point.

The third block of equations refers to the distribution of primary income to households and government, and describes how the two social groups use that income for consumption purposes.

```
(26)  PUBREV = t_compemp*COMPEMP + t_netopsurp*NETOPSURP + NETCOMTAX
      + NETPRODTAX
(27)  NETLABINC = COMPEMP*(1-t_compemp)
(28)  NETCAPINC = NETOPSURP*(1-t_netopsurp)
(29)  NETINC_gr(gr) = NETLABINC*L_gr(gr)/L + NETCAPINC*K_gr(gr)/K
(30)  NETINC = SUM(gr,NETINC_gr(gr))
(31)  FINCONSHH_PP_GR(gr) = PTC_gr(gr)*NETINC_GR(gr)
(32)  FINCONSHH_GR(gr) = FINCONSHH_PP_GR(gr)*(1-t_conshh)
(33)  FINCONSHH_i(i) = SUM(gr,FINCONSHH_gr(gr)*C_coef(i,gr))
(34)  FINCONSHH = SUM(i,FINCONSHH_i(i))
(35)  NETCOMTAXCONSHH = t_conshh*FINCONSHH_PP
(36)  FINCONSHH_PP = FINCONSHH + NETCOMTAXCONSHH
```

Equation (26) states that public revenue PUBREV is equal to the sum of income taxes, net commodity taxes and net production taxes. The taxation of primary factor income is modelled as a simple linear function with constant factor-specific tax rates. Equations (27) and (28) then describe the share of primary factor income which remains in the form of net factor income. Equation (29) then computes the net income of each social group. The share of net labour income accruing to group gr is assumed to be equal to group gr’s share in total labour provided. Currently, that share is equal to 1 for workers and equal to 0 for rentiers, but future extensions of MMG will incorporate more interesting features with respect to the distribution of factor income. Net capital income is distributed in the same fashion. Finally, aggregate net income of the household sector is computed in equation (30). The distribution of income is thus fully described.

The following equations then refer to the use of income for consumption purposes. Government expenditure is assumed to be an autonomous component of final demand and will be discussed below. The consumption expenditure of households, by contrast, is modelled endogenously by means of a simple linear consumption function. Equation (31) described the level of final consumption expenditure (valued at p.p.) of group gr as a function of that group's propensity to consume (PTC) and the level of its net income. Currently, the PTC of workers is set equal to 1 by assumption. The PTC for rentiers is smaller than one and can be calculated from Table 2.

Equation (32) computes final consumption at p.p. using the assumption of a constant commodity tax rate applying to all social groups. This assumption is somewhat unrealistic, since in reality different groups consume a different basket of goods and therefore the average commodity tax rate may differ, and will be relaxed in future versions of MMG. Equation (33) then allocates the total consumption expenditure of each group over individual commodities by multiplying the level of expenditure with the corresponding consumption coefficient (which is currently exogenous). Equations (34) to (36), finally, compute the aggregate levels of final consumption expenditure by households valued at b.p. and p.p. as well as net taxes on commodities consumed by households.

The fourth block of equations refers to the components of autonomous demand.

```
(37)  FINCONSGOV_i(i) = AUTDEM(i,"FINCONSGOV")
(38)  FINCONSGOV = SUM(i,FINCONSGOV_i(i))
(39)  NETCOMTAXCONSGOV = t_consgov*FINCONSGOV_PP
(40)  FINCONSGOV_PP = FINCONSGOV + NETCOMTAXCONSGOV
(41)  GCAPFORM_i(i) = AUTDEM(i,"GCAPFORM")
(42)  GCAPFORM = SUM(i,GCAPFORM_i(i))
(43)  NETCOMTAXGCAPFORM = t_gcapform*GCAPFORM_PP
(44)  GCAPFORM_PP = GCAPFORM + NETCOMTAXGCAPFORM
(45)  EXP_i(i) = AUTDEM(i,"EXP")
(46)  EXP = SUM(i,EXP_i(i))
(47)  NETCOMTAXEXP = t_exp*EXP_PP
(48)  EXP_PP = EXP + NETCOMTAXEXP
```

In line with the theoretical background discussed above, autonomous demand consists of three major components: final consumption expenditure by government, gross capital formation, and exports. Equations (37) to (48) therefore do not contain any behavioural elements. Taking the use of each commodity for any of the autonomous demand components as exogenous, they simply compute the amount of net commodity taxes (assuming, for simplicity, constant tax rates and abstracting from structural changes within a component of autonomous demand) and the level of aggregate consumption expenditure by government, gross capital formation, and exports at b.p. and p.p.

The fifth and final block of equations refers to the calculation of some totals and aggregate figures.

```
(49)  FINUSE_i(i) = FINCONSHH_i(i) + FINCONSGOV_i(i) + GCAPFORM_i(i)
      + EXP_i(i)
(50)  FINUSE = FINCONSHH + FINCONSGOV + GCAPFORM + EXP
(51)  NETCOMTAXFINUSE = NETCOMTAXCONSHH + NETCOMTAXCONSGOV +
      NETCOMTAXGCAPFORM + NETCOMTAXEXP
(52)  FINUSE_PP = FINUSE + NETCOMTAXFINUSE
(53)  TOTUSE_i(i) = INTUSE_i(i) + FINUSE_i(i)
(54)  TOTUSE = INTUSE + FINUSE
(55)  NETCOMTAX = NETCOMTAXINTUSE + NETCOMTAXFINUSE
(56)  TOTUSE_PP = TOTUSE + NETCOMTAX
```

These 56 equations fully describe the model at its current stage of development.

III.4 Implementation in GAMS

The current version of MMG is, basically, an extended input-output model with a disaggregated income multiplier. Due to its linear structure, such a model can be solved in the ‘usual’ way by computing a modified Leontief inverse. In fact, this was done with an earlier embryonic version of MMG [Kronenberg, 2009b]. However, since MMG is supposed to be linked to the energy systems model IKARUS-LP, it was decided to use GAMS as a common platform for both models. Therefore, the current version MMG was implemented in GAMS.

The GAMS programme consists of five parts. In the first part, MMG reads the required data (input-output table and social accounts for the base year) from an Excel file, calculates the values of parameters such as tax rates etc. from the data and checks the data for consistency. The second part sets up the actual model by declaring the parameters, variables and equations. In the third part, the parameter values for the base run are entered. In the fourth part, GAMS solves the model and writes the relevant results (in the form of an input-output table and the MMG social accounts) into an Excel file. Since the base run results reproduce the actual observations from the base year, this part of the model serves as a check for programming errors etc. In the fifth part, alternative parameter values are entered, the model is solved again, and the results for the alternative run are exported to an Excel file. Another Excel file is linked to the GAMS output files and makes it possible to compare directly the results of the alternative run with those of the base run.

IV Simulations and Results

In order to illustrate some of the analyses which could contribute to the SD debate, two hypothetical scenarios were run. In the following, each of these is described, and the results are compared to the base run (actual 2005).

IV.1 A change in consumption patterns

In the first scenario, consumers change their lifestyle in order to reduce the environmental impact of consumption. More specifically, they try to 'dematerialise' consumption. In model terms, this is understood as a reduction in the consumption coefficient of goods and an increase in the consumption coefficient of services. The former was equal to 0.25 in 2005, while the latter was equal to 0.70. In the alternative scenario, the consumption coefficient of goods is set equal to 0.15 and the consumption coefficient of services is set equal to 0.80 (in other words, 10 percent of total consumption expenditure by households are reallocated from goods to services).

Table 3: Input-output table for scenario 1 (deviation from base run in %)

	Homogenous branches				Final uses					Total use
	Production of goods	Production of services	Production of energy	Total	Final consumption expenditure by households	Final consumption expenditure by government	Gross capital formation	Exports	Final use	
Goods	-7.0	7.0	0.5	-5.1	-38.2	0.0	0.0	0.0	-8.3	-7.0
Services	-7.0	7.0	0.5	2.6	17.6	0.0	0.0	0.0	10.2	7.0
Energy	-7.0	7.0	0.5	-0.4	3.0	0.0	0.0	0.0	2.0	0.5
Total intermediate use / final use at basic prices	-7.0	7.0	0.5	-1.0	3.0	0.0	0.0	0.0	1.2	0.3
Net taxes on products	-7.0	7.0	0.5	3.6	3.0	0.0	0.0	0.0	1.2	0.3
Total intermediate use / final use at purchaser prices	-7.0	7.0	0.5	-0.8	3.0	0.0	0.0	0.0	1.3	0.4
Compensation of employees	-7.0	7.0	0.5	2.5						
Net taxes on production	-7.0	7.0	0.5	5.6						
Consumption of fixed capital	-7.0	7.0	0.5	3.8						
Net operating surplus	-7.0	7.0	0.5	4.4						
Value added	-7.0	7.0	0.5	3.2						
Output	-7.0	7.0	0.5	1.1						
Imports of similar products	-7.0	7.0	0.5	-4.4						
Total supply of products	-7.0	7.0	0.5	0.3						

Source: author's calculations IEF-STE 2010

Table 3 shows the input-output table which results from scenario 1 (compared to the base run). The starting point of scenario 1 is the reallocation of consumption expenditure by households. As Table 3 shows, households spend 38.2% less on goods and 17.6% more on services (compared to the base run). Interestingly, total consumption expenditure by households increases by 3.0%. This observation is quite interesting – a change in the *composition* of consumption expenditure has a significant effect on the *level* of consumption expenditure. The explanation for this can be found by looking at the Southwest quadrant of Table 3. The second-to-last row shows that imports are reduced by 4.4%. Value added, by contrast, is increased by 3.2%. Thus, the consumption shift leads to higher domestic value added and lower imports. This is quite plausible, because the share of imported goods is higher than the share of imported services (cf. Table 1). The shift in consumption from goods to services therefore constitutes a shift from imported commodities to domestically produced commodities. As a result, value added increases, households receive more income and spend part of the additional income on consumption.

The Southwest quadrant of Table 3 also shows the effects of the consumption shift on the distribution of income. As value added is increased by 3.2%, compensation of employees rises by 2.5% and net operating surplus rises by 4.4%. Thus, the share of net operating surplus in total value added rises at the expense of compensation of employees. Tax revenue also rises more than proportionally: The net revenue from taxes on commodities grows by 3.6% while net taxes on production grow by 5.6%.

Table 4: Public revenue and expenditure in scenario 1

	Base	Alt	Dev abs	Dev %
Net taxes on products	218,200	224,127	5,928	2.7
Net taxes on production	20,660	21,825	1,165	5.6
Taxes in labour income	153,816	157,679	3,863	2.5
Taxes on capital income	48,524	50,647	2,123	4.4
Total tax revenue	441,200	454,279	13,079	3.0
Final consumption expenditure (at p.p.)	421,510	421,510	0	0.0
Net saving	19,690	32,769	13,079	66.4

Source: author’s calculations IEF-STE 2010

Since government consumption remains constant, the increase in tax revenue means that net saving of the government increases. The extent of this effect can be seen in Table 4, which compares public revenue in scenario 1 with the base run. The revenue from taxes rises by 13,079 MEUR. As final consumption expenditure by government remains constant, its net saving rises by the same amount[4].

Table 5: Social groups account in scenario 1

Deviation from base run in %	Workers	Rentiers	Total
Net labour income	2.5	N/A	2.5
Net capital income	N/A	4.4	4.4
Total net income	2.5	4.4	3.1
Consumption of goods	-38.5	-37.3	-38.2
Consumption of services	17.1	19.3	17.6
Consumption of energy	2.5	4.4	3.0
Total consumption expenditure at b.p.	2.5	4.4	3.0
Net commodity taxes	2.5	4.4	3.0

[4] Political discussions in Germany often revolve around the fact that the government has been running a deficit for many years. However, the sector “government” in MMG is not the same as the sector “state” in the national accounts. It excludes the social security system, which is responsible for a large share of the public deficit in Germany. Therefore, net saving in Table 4 is positive.

Total consumption expenditure at p.p.	2.5	4.4	3.0
Saving	N/A	4.4	4.4

Source: author's calculations IEF-STE 2010

Table 5 shows how scenario 1 affects the distribution of income and consumption between the two social groups. The net income of workers and rentiers is increased by 2.5% and 4.4%, respectively, and the net income of the household sector as a whole is increased by 3.1%. Consumption expenditure is shifted from goods (-38.2% for the household sector) to services (+17.6%) while the consumption of energy is increased in line with total consumption expenditure (+3.0%). The saving of workers is not affected because it is by assumption equal to zero, but the saving of rentiers (which is equal to total saving by households) is increase by 4.4%. Since saving grows by a larger percentage than net income, the saving rate of the household sector is increased. The reason for this is the relative redistribution of income from workers to rentiers.

Table 6: Saving and investment in scenario 1

	Base	Alt	Dev abs	Dev %
Gross capital formation	383,360	383,360	0	0.0
Consumption of fixed capital	335,580	348,208	12,628	3.8
Net domestic investment	47,780	35,152	-12,628	-26.4
Net exports	143,490	176,702	33,212	23.1
Net investment	191,270	211,855	20,585	10.8
Saving by households	171,580	179,086	7,506	4.4
Saving by government	19,690	32,769	13,079	66.4
Domestic saving	191,270	211,855	20,585	10.8
Excess saving	0	0	0	N/A

Source: author's calculations IEF-STE 2010

Table 6, finally, shows what happens to aggregate investment and saving. Gross capital formation, being a component of autonomous demand, is the same as in the base run. Consumption of fixed capital increases by 12,628 MEUR, so net domestic investment decreased by the same amount[5]. Net exports, by contrast, are increased by 33,152. The reason for this is that while exports are kept constant (as a part of autonomous demand), imports are reduced. As a result, total net investment is increased by 20,585 MEUR. This has to be met by an equally large increase in net saving.

[5] Consumption of fixed capital increases because it is modelled as a constant share of value added in each industry. The reasoning behind this assumption is that an increase in an industry's output leads to more 'wear and tear' and a faster depreciation of its capital stock.

Table 6 confirms that both macroeconomic reasoning and programming appear to be sound. Net saving indeed rises by the same amount as net investment. The major part (13,079 MEUR) of the additional saving is provided by the government, but households also contribute 7,506 MEUR.

To sum up, scenario 1 describes a shift from consumption of goods, many of which are imported, to services, which are mostly produced domestically. From a macro-economic perspective, this leads to an increase in domestic value added, households receive more income and spend more, and in the end value added is increased by 3.2%. From a national point of view, this seems like a real winning strategy – German households have reduced the environmental impact of their consumption and increased their income. However, if all trading partners do the same the increase in domestic value added and income may turn into a zero-sum game.

IV.2 Large-scale investment in green infrastructure

The second scenario is driven by the idea of a large-scale investment in ‘green’ infrastructure, for example a massive upscaling of renewable electricity generation and distribution. In the case of Germany, such an ambitious energy policy would most likely involve the construction of offshore wind parks in the North Sea and the installation of new landlines to transport the electricity from the shore across the country. This scenario is partly inspired by recent proposals for a ‘green new deal’ which, in reference to Roosevelt’s historical ‘new deal’, is supposed to move the economy out of the slump and reduce unemployment. In addition, it is supposed to contribute to the fight against climate change.

In terms of MMG, such an investment programme constitutes an increase in autonomous demand. More specifically, it can be modelled as an increase in the use of goods for gross capital formation. A more disaggregated model could also capture the special kind of investment goods that would be demanded for the infrastructure projects, but MMG is currently restricted to only three types of commodities. Therefore, the investment programme was simply modelled as in increase in the demand for goods by 100,000 MEUR (at b.p.).

Table 7: Input-output table for scenario 2 (deviation from base run in %)

	Homogenous branches				Final uses					Total use
	Production of goods	Production of services	Production of energy	Total	Final consumption expenditure by households	Final consumption expenditure by government	Gross capital formation	Exports	Final use	
Goods	8.2	4.0	4.8	7.6	5.1	0.0	33.3	0.0	8.6	8.2
Services	8.2	4.0	4.8	5.3	5.1	0.0	0.0	0.0	3.0	4.0
Energy	8.2	4.0	4.8	5.6	5.1	0.0	0.0	0.0	3.4	4.8
Total intermediate use / final use at basic prices	8.2	4.0	4.8	6.3	5.1	0.0	28.0	0.0	5.6	5.9
Net taxes on products	8.2	4.0	4.8	4.9	5.1	0.0	28.0	0.0	5.6	5.9
Total intermediate use / final use at purchaser prices	8.2	4.0	4.8	6.3	5.1	0.0	28.0	0.0	5.8	6.0
Compensation of employees	8.2	4.0	4.8	5.3						
Net taxes on production	8.2	4.0	4.8	4.4						
Consumption of fixed capital	8.2	4.0	4.8	4.9						
Net operating surplus	8.2	4.0	4.8	4.7						
Value added	8.2	4.0	4.8	5.1						
Output	8.2	4.0	4.8	5.7						
Imports of similar products	8.2	4.0	4.8	7.3						
Total supply of products	8.2	4.0	4.8	5.9						

Source: author's calculations IEF-STE 2010

Table 7 shows the input-output table for scenario 2 compared to the base run. The scenario 'trigger' is the increase in gross capital formation. The use of goods for this purpose rises by 33.3%. Total gross capital formation rises by 28.0%.

Interestingly, the increase in output is rather evenly distributed over all industries. The largest increase (+8.2%) is observed in the industry producing goods, but the production of services (+4.0%) and energy (4.8%) is also significantly increased. Thus, an increase in the demand for goods alone leads to an increase of output in all other industries as well.

The widespread increase in output can be mostly explained by the increase in consumption expenditure by households. The income of households is increased by roughly 5%, and their consumption expenditure increases by 5.1%. Since households' consumption expenditure is distributed over all commodities, it is not surprising that the output of the other industries increases by 4% and more.

Table 8: Public revenue in scenario 2

	Base	Alt	Dev abs	Dev %
Net taxes on products	218,200	235,225	17,025	7.8
Net taxes on production	20,660	21,563	903	4.4
Taxes in labour income	153,816	161,941	8,125	5.3
Taxes on capital income	48,524	50,811	2,287	4.7
Total tax revenue	441,200	469,540	28,340	6.4
Final consumption expenditure (at p.p.)	421,510	421,510	0	0.0
Net saving	19,690	48,030	28,340	143.9

Source: author’s calculations IEF-STE 2010

Table 8 shows how the investment programme of scenario 2 affects public revenue. The government collects 28,340 MEUR more from taxation than in the base run. Since its consumption expenditure is not affected, its net saving increases by the same amount.

Table 9: Social groups account in scenario 2

Deviation from base run in %	Workers	Rentiers	Total
Net labour income	5.3	N/A	5.3
Net capital income	N/A	4.7	4.7
Total net income	5.3	4.7	5.1
Consumption of goods	5.3	4.7	5.1
Consumption of services	5.3	4.7	5.1
Consumption of energy	5.3	4.7	5.1
Total consumption expenditure at b.p.	5.3	4.7	5.1
Net commodity taxes	5.3	4.7	5.1
Total consumption expenditure at p.p.	5.3	4.7	5.1
Saving	N/A	4.7	4.7

Source: author’s calculations IEF-STE 2010

Table 9 shows the social groups accounts in scenario 2 compared to the base run. The net income of workers is increased by 5.3%, that of rentiers by 4.7%. Thus, the share of workers in total net income (which grows by 5.1%) is marginally increased. Since the consumption coefficients are not changed in scenario 2, the consumption of each commodity rises by the same percentage as net income. The overall saving of the household sector is increased by 4.7%.

Table 10: Saving and investment in scenario 2

	Base	Alt	Dev abs	Dev %
Gross capital formation	383,360	490,864	107,504	28.0
Consumption of fixed capital	335,580	351,983	16,403	4.9
Net domestic investment	47,780	138,881	91,101	190.7
Net exports	143,490	88,815	-54,675	-38.1
Net investment	191,270	227,696	36,426	19.0
Saving by households	171,580	179,666	8,086	4.7
Saving by government	19,690	48,030	28,340	143.9
Domestic saving	191,270	227,696	36,426	19.0
Excess saving	0	0	0	N/A

Source: author's calculations IEF-STE 2010

Finally, Table 10 shows how the installation of the green infrastructure is financed. Gross capital formation is increased by 107,504 MEUR (the additional 7,504 MEUR appear because in Table 10 all magnitudes are valued at p.p.). At the same time, the consumption of fixed capital is increased by 16,403 MEUR. Thus, net domestic investment is increase by 91,101 MEUR. This amount has to financed by the government, households, and the ROW (firms are, as mentioned above, not yet really incorporated in MMG).

According to Table 10, the ROW finances more than half of the net domestic investment required to install the new infrastructure, as net exports are reduced by 54,675 MEUR. This effect might be problematic if it resulted in a large trade deficit. The German economy, however, was running a large trade surplus in the base year (it still is by the time of writing). In scenario 2, the trade balance is reduced from 143,490 MEUR to 88,815 MEUR, but it still remains in surplus.

In order to finance the increase in net domestic investment, another 36,426 MEUR are required. This amount is mostly provided by the government, which increase its net saving by 28,340 MEUR. Households provide another 8,086 MEUR of net saving, so the balance of aggregate saving and investment is once again fulfilled.

V Conclusion

It was argued above that although Sustainable Development (SD) is a multi-dimensional concept involving environmental, economic, and social aspects, most empirical studies have tended to focus on environmental and economic issues while neglecting the social dimension. As social tensions are currently increasing in many countries, model-based studies should pay more attention to questions of social sustainability.

Post-Keynesian input-output models are particularly well suited for studying certain aspects of social sustainability, notably unemployment, the distribution of income, and fiscal sustainability (i.e. public debt). From a theoretical viewpoint, this conclusion is not surprising, because the main goal of the early post-Keynesians was to understand the complex relationships between unemployment, income distribution and GDP growth. Since Keynes had highlighted the special role of government expenditure in aggregate demand, there was also a close link with fiscal policy. Moreover, post-Keynesian theory (or at least its 'Sraffian' stream) has always acknowledged the importance of structural change, leading to a preference for multisectoral input-output models over highly aggregated 'macro' models. Therefore, an empirical input-output model based on post-Keynesian theory can be a useful tool for understanding certain aspects of sustainability.

In order to illustrate this argument, this paper has outlined a simple post-Keynesian input-output model for the German economy and used it to analyse policy measures from an SD perspective. The model incorporates the input-output structure of the German economy and a full representation of the circular flow of income between households, the state and the foreign sector (firms not yet being properly represented in the current version of the model). In line with post-Keynesian theory, final demand consists of autonomous and induced components. In the household sector, two types of households are distinguished according to their main income source (labour or capital income).

The model was then used to explore the effects of two policy measures that are frequently suggested in the SD debate. The first was a shift from material consumption (industrial products) to immaterial consumption (services). The second was a massive investment programme in renewable electricity generation. The model suggests that these policy measures do not generally improve all indicators of sustainability. In the first case, unemployment is reduced, but the income share of capital rises at the expense of labour. While the increase in employment is beneficial, the associated increase in poverty among worker households is problematic for social sustainability. Such findings provide further support for adopting a multi-dimensional approach to sustainability. Post-Keynesian input-output models can make a useful contribution to studying certain aspects of social sustainability, especially those involving structural change in the distribution of consumption expenditure and income.

Appendix

Table A1: MMG Variables

Variable	Description
COMPEMP	Compensation of employees
COMPEMP_j(j)	Compensation of employees in industry j
CONSFIXCAP	Consumption of fixed capital
CONSFIXCAP_j(j)	Consumption of fixed capital by industry j
EXP	Exports (valued at b.p.)
EXP_i(i)	Exports of commodity i
EXP_PP	Exports (valued at p.p.)

Variable	Description
FINCONSGOV	Final consumption expenditure by government (valued at b.p.)
FINCONSGOV_i(i)	Final consumption expenditure by government on commodity i
FINCONSGOV_PP	Final consumption expenditure by government (valued at p.p.)
FINCONSHH	Final consumption expenditure by households (valued at b.p.)
FINCONSHH_GR(gr)	Final consumption expenditure by group gr
FINCONSHH_i(i)	Final consumption expenditure by households on commodity i
FINCONSHH_PP	Final consumption expenditure by households (valued at p.p.)
FINCONSHH_PP_GR(gr)	Final consumption expenditure by group gr (valued at p.p.)
FINUSE	Final use of commodities (valued at b.p
FINUSE_i(i)	Final use of commodity i
FINUSE_PP	Final use of commodities (valued at p.p.)
GCAPFORM	Gross capital formation (valued at b.p.)
GCAPFORM_i(i)	Gross capital formation
GCAPFORM_PP	Gross capital formation (valued at p.p.)
GVA	Gross value added
GVA_j(j)	Gross value added by industry j
IMP	Imports
IMP_j(j)	Imports of commodity j
INTCONS	Intermediate consumption of commodities
INTCONS_j(j)	Intermediate consumption by industry j (valued at basic prices)
INTCONS_PP_j(j)	Intermediate consumption by industry j (valued at purchasers' prices)
INTUSE	Intermediate use of commodities
INTUSE_i(i)	Intermediate use of commodity i
INTUSE_PP	Intermediate use of commodities (valued at purchasers' prices)
NETCAPINC	Net capital income (after taxes)
NETCOMTAX	Net taxes on commodities
NETCOMTAX_j(j)	Net taxes on commodities used by industry j
NETCOMTAXCONSGOV	Net taxes on commodities consumed by government
NETCOMTAXCONSHH	Net taxes on commodities consumed by households
NETCOMTAXEXP	Net taxes on exported commodities
NETCOMTAXFINUSE	Net taxes on commodities for final use
NETCOMTAXGCAPFORM	Net taxes on commodities used for gross capital formation
NETCOMTAXINTUSE	Net taxes on commodities for intermediate use
NETINC	Net income of households
NETINC_GR(gr)	Net income of group gr
NETLABINC	Net labour income (after taxes)
NETOPSURP	Net operating surplus
NETOPSURP_j(j)	Net operating surplus in industry j
NETPRODTAX	Net taxes on production
NETPRODTAX_j(j)	Net taxes on production paid by industry j
OUTPUT	Output
OUTPUT_j(j)	Output by industry j
PUBREV	Public revenue
TOTSUP	Total supply of commodities
TOTSUP_j(j)	Total supply of commodity j
TOTUSE	Total use of commodities (valued at b.p.)
TOTUSE_i(i)	Total use of commodity i
TOTUSE_PP	Total use of commodities (valued at p.p.)
Z_ij	Consumption of commodity i by industry j

Source: author's imagination IEF-STE 2010

Table A2: MMG Parameters

Parameter	Description
A(i,j)	Matrix of intermediary input-output coefficients
AUTDEM(i,ad)	Matrix of autonomous demand by commodity and AD component
C_coef(i,gr)	Matrix of consumption coefficients by commodity and social group
IMP_coef(i)	Vector of commodity-specific import coefficients
K	Total capital stock
L	Total labour services provided
K(gr)	Capital owned by group gr
L(gr)	Labour services provided by group gr
PI_coef(PI,j)	Matrix of primary input-output coefficients
PTC_GR(gr)	Propensity to consume of group gr
t_compemp	Average tax rate on labour income
t_consgov	Average tax rate on commodities consumed by government
t_conshh	Average tax rate on commodities consumed by households
t_exp	Average tax rate on exported commodities
t_gcapform	Average tax rate on commodities used for capital formation
t_netopsurp	Average rate on capital income

Source: author’s imagination IEF-STE 2010

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