

THE CONCEPT OF SUSTAINABLE FOOD CHAIN (CASE STUDY – THE DAIRY FOOD CHAIN)

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Abstract. The paper proposes definition of food chain in natural and economic approach. In paper is presented classical economics approach to issues of sustainable development. Idea of sustainable food chain and its goals were defined. Also macroeconomics and microeconomics interpretation of sustainable development and econometric model of sustainable dairy food chain were shown. For analysing impact of activities on sustainable development linear programming was suggested. This article shows that life styles are the base and driving force behind sustainable development. Latest technological and economical solutions in dairy sector and their links with sustainable development were described.

Key words: food chain, sustainability, classical economy, goals, macro economy, micro economy, linear programming, life styles, dairy sector

INTRODUCTION

In the last decade the problem of analysing food chain from the sustainability point of view became critical. Relation between sustainability and classical economy should be considered. In the paper the concept of sustainable food chain is presented on the basis of the dairy sector.

Food chain – definition

Food chain is an ambiguous term. Scientists use it referring mainly to energy flows from one organism to another – when eaten – to sustain particular organisms' life. Economists do not ignore the above approach, but obviously they relate it to the human, conscious activity of food production and consumption [Malik 2004]. The food chain

may consist of several links, e.g. food production, assembling (collection), processing, storage, trading and finally purchase of food. Raw agricultural products while moving through the food chain are processed, packed, merchandised and finally consumed.

Classical economy and sustainability

Classical, liberal economists expect that the food chain has to provide maximum return on the capital invested in the chain. In fact, environmental and social issues are considered as limiting factors or constraints. Some environment elements are treated as free goods which do not cost anything – for example air. The dispute over the way to include ecological, environmental and social aspects in economic models, calculations and considerations has always been very important. Linear programming, a very popular mathematical method in the second half of the 20th century, seemed to be the best method for merging ecology and the environment into the economic model to maximize profit. The concept of sustainability may enrich classical economy with environmental and social aspects.

Some people believe that the concept of sustainability is the UE self-defence theory, necessary in WTO negotiations to protect the European Model of Agriculture. They even forecast the theory should collapse under the free market regime. As it was said, economists have discussed environmental issues for a very long time. Maybe the concept of sustainability is the right one economists have been looking for.

Economists, including the author, who had lived under centrally planned economy for years, remember that communists tried to practice a kind of sustainability, hidden behind such key words as equality and harmonious development. Neither equality nor harmonious development have ever been achieved. It is evident that the terms at most may express the human willingness and may only direct the way of development. Strong backward and independent processes have always created a new big inequality and disharmony. The final result of centrally planned economy was disastrous. The author's personal experience indicates that we have to be aware that sustainability may trigger strong backward processes.

Sustainable food chain

As it is widely known, sustainability may be linked to institutions, economy and ecology. The following three elements play a key role here: sustainability, durability and balance. All these above involved in the food chain result in sustained development. Food chain directed toward sustainability or considered as sustainable must achieve environmental, nutritional, economic and social goals.

Goals of the sustainable food chain

The food chain classified as sustainable should lead to the following clusters of objectives:

- A. Environmental objectives:
 - 1) air pollution control,
 - 2) water pollution control,
 - 3) soil pollution control,

- 4) noise pollution control,
 - 5) protection against radiation.
- B. Nutritional objectives:
- 1) providing enough food for mankind,
 - 2) providing nutritious food (macro- and microelements),
 - 3) providing safe food,
 - 4) providing stable food delivery,
 - 5) providing food in time and place required by consumers.
- C. Economic objectives:
- 1) achievement of equality point between supply and demand,
 - 2) ensuring moderate food prices,
 - 3) maintenance of job posts,
 - 4) maximization of added value,
 - 5) maximization of return on investment.
- D. Social objectives:
- 1) ensuring a good standard of life for families of farmers, processors, traders and all involved in the food chain,
 - 2) promotion of good interpersonal relations between people involved in the food chain,
 - 3) promotion of good health of all food consumers,
 - 4) promotion of prolonged lifespan of all food consumers.

The concept of sustainability leads to many other goals, which not necessary concern the food chain. Other activities and undertakings seem to be proper to fulfil them.

Macroeconomic and microeconomic approach to sustainable food chain

Theory of economy allows us to analyse, control and prepare strategies for a sustainable food chain in the macroeconomic and microeconomic dimension. Global, regional or national food chains may be considered. The macroeconomic approach leads to the aggregate matrix of ratios related to a state or a region. Outcomes of the simulation on such a matrix may be useful both for policy-makers and academics. Economists, food technologists, biotechnologists and others may be the right specialists to contribute to the construction of models and interpretation of outcomes.

In fact, the food chain consists of several branch food chains. A particular branch food chain may consist of several sub-branch chains. The general Polish food chain may be split into at least 8 major branch food chains e.g. dairy, meat, grain, sugar, potatoes, oil, vegetable, fruit, which may be further split into smaller detailed chains. Each of the branch food chains consists of several sub-branch food chains. Hence, in fact there exist dozens of individual food sub-chains; for example for pasteurized milk, UHT milk, cheese, cottage cheese, yoghurt, and so on. The microeconomic model of a given food chain has to fit and supplement the macroeconomic model.

Econometric models for developing sustainability in the food chain

At least two methods may be useful in the consideration of the sustainable food chain [Wskaźniki... 2005]. The expertise method seems to be crucial. The linear programming method may be very useful as well. In the expert method all variables,

Table 1. Econometric model leading to sustainable dairy food chain
 Tabela 1. Ekonometryczny model prowadzący do zrównoważonego łańcucha żywnościowego przetworów mlecznych

Relations of balance and links Związki równowagi i ogniwa	Food chain variables – Zmienne łańcucha żywnościowego							
	production subscript p produkcja indeks dolny p	assembling subscript a gromadzenie indeks dolny a	processing subscript pr przetwarzanie indeks dolny pr	packaging and storage subscript pa pakowanie i przechowywanie indeks dolny pa	selling subscript se sprzedaż indeks dolny se	consumption subscript c konsumpcja indeks dolny c	lifestyle subscript l styl życia indeks dolny l	constrains nominats stimulates destimulates przeszkody nominanty stymulanty destymulanty
	$X_{p1} \dots X_{pn}$	$X_{a1} \dots X_{an}$	$X_{pr1} \dots X_{prn}$	$X_{pa1} \dots X_{pan}$	$X_{se1} \dots X_{sen}$	$X_{c1} \dots X_{cn}$	$X_{l1} \dots X_{ln}$	
Environmental subscript e Środowiskowe indeks dolny e	$a_{ep1} \dots a_{epn}$	$a_{ea1} \dots a_{ean}$	$a_{ep1} \dots a_{epn}$	$a_{es1} \dots a_{esn}$	$a_{ese1} \dots a_{esen}$	$a_{ec1} \dots a_{ecn}$	$a_{el1} \dots a_{eln}$	E_1 . .
Social subscript s Społeczne indeks dolny s	$a_{sp1} \dots a_{spn}$	$a_{sa1} \dots a_{san}$	$a_{spr1} \dots a_{sprn}$	$a_{spa1} \dots a_{span}$	$a_{sse1} \dots a_{ssen}$	$a_{sc1} \dots a_{scn}$	$a_{sl1} \dots a_{sln}$	S_1 . .
Macroeconomic subscript ma Makroekonomiczne indeks dolny ma	$a_{map1} \dots a_{mapn}$	$a_{maa1} \dots a_{maan}$	$a_{mapr1} \dots a_{maprn}$	$a_{mapa1} \dots a_{mapan}$	$a_{mase1} \dots a_{masen}$	$a_{mac1} \dots a_{macn}$	$a_{mal1} \dots a_{maln}$	Ma_1 . .
Microeconomic subscript mi Mikroekonomiczne indeks dolny mi	$a_{mip1} \dots a_{mipn}$	$a_{mia1} \dots a_{mian}$	$a_{mipr1} \dots a_{miprn}$	$a_{mipa1} \dots a_{mipan}$	$a_{mise1} \dots a_{misen}$	$a_{mic1} \dots a_{micn}$	$a_{mil1} \dots a_{miln}$	Mi_1 . .
Technical ratios subscript t Techniczne stosunki ilościowe indeks dolny t	$a_{tp1} \dots a_{tpn}$	$a_{ta1} \dots a_{tan}$	$a_{tpr1} \dots a_{tprn}$	$a_{tpa1} \dots a_{tpan}$	$a_{tse1} \dots a_{tse n}$	$a_{tc1} \dots a_{tcn}$	$a_{tl1} \dots a_{tln}$	T_1 . .
Sustained goals for dairy food chain subscript g Zrównoważone cele dla łańcucha żywnościowego przetworów mlecznych indeks dolny g	$a_{gp1} \dots a_{gpn}$	$a_{ga1} \dots a_{gan}$	$a_{gpr1} \dots a_{gprn}$	$a_{gpa1} \dots a_{gpna}$	$a_{gse1} \dots a_{gsen}$	$a_{gc1} \dots a_{gcn}$	$a_{gl1} \dots a_{gln}$	G_1 . .
	$a_{gpk} \dots a_{gpnk}$	$a_{gak} \dots a_{gank}$	$a_{gprk} \dots a_{gprnk}$	$a_{gpka} \dots a_{gpka}$	$a_{gsek} \dots a_{gsenk}$	$a_{gck} \dots a_{gcnk}$	$a_{gkl} \dots a_{glnk}$	G_k

Source: the author's study.
 Źródło: opracowanie autora.

as their importance varies, might be ranked and classified to group of stimulants, nominates and destimulants. Upper and lower limits of each variable allowing the food chain to operate under sustainable conditions must be set. Table 1 stands for an idea of such a model. It contains ratios for all possible relations between elements of the food chain and the natural environment, social issues, macro- and microeconomic environment, goals, ratios and technical coefficients. The simplex method may be used to find the optimal sustainable solution for the food chain. Modelling must be link to expert knowledge (expert method) as it contains numerous ratios which must be proved by

high quality specialists. Developing the model and interpretation of the outcomes of the model will be a very important task for researchers.

Lifestyle as the keystone combining all available paths of sub-branch food chains

For ages what mankind consumed was the result of outcomes of the food chain. In fact, the food chain for a major part of human history was very simple. It had a few links only, e.g. food production in one's own farm, preparing food from the raw materials and at home consumption. The second half of the 20th century gave us huge development in the food chain. The food chain became more complicated. Several new links were formed in the chain. Home food processing slowly disappears.

New lifestyles impose on farmers and processors a new direction of development. The new lifestyles do not necessary initiate sustaining response of the food sector. Lifestyles at the moment become the keystone combining all available paths of sub-branches of the food chains and the main driving force for the chain development. Hence, a big task is to promote new lifestyles promoting sustainable development of the food chain [Wizja... 2004].

THE POLISH NATIONAL DAIRY FOOD CHAIN

The Polish national dairy sector started its activity at the turn of the 19th and 20th century. In principle the cooperative movement originated the sector. After the Second World War the dairy sector become semi-state property. During the communist time the Polish national dairy sector was characterized by:

- 1) huge milk production – over 16 billions tons,
- 2) huge numbers of dairy farmers – over 1.8 million,
- 3) a big number of milking cows – 6 million,
- 4) low milk quality,
- 5) low herd size farms,
- 6) underdevelopment of processing plants,
- 7) a poor assortment of dairy products available on the market,
- 8) cooperatives' dependency on communist party officials,
- 9) unsustainable economy of dairy firms (huge subvention to dairy products),
- 10) unsustainable impact on the environment.

The official communist doctrine has a slogan: "To battle with nature". Unfortunately, it brought huge pollution for the environment. Air, rivers and soils were badly polluted.

The transition of the economy from centrally planned to market one has turned out, in principle, to the sustainable model for the national dairy sector. Poland has achieved astonishing results in the dairy sector after the collapse of the communist system. However, new challenges for sustainability have appeared [Piontek 2002]. Table 2 presents present-day challenges for the Polish dairy sector in terms of its growing sustainability and the tasks for scientists and economists to support that process.

Table 2. Main economic developments (evolutions) in the last decade in the food chain and their impact on development toward sustainability of the chain based on the dairy sector in Poland

Tabela 2. Główne ekonomiczne wydarzenia (ewolucje) w ostatniej dekadzie w łańcuchu żywnościowym i ich wpływ na rozwój w kierunku zrównoważonego rozwoju tego łańcucha w oparciu o sektor mleczarski w Polsce

Link of the food chain Ogniwo łańcucha żywnościowego	Name of the development Nazwa wydarzenia	Example for dairy sector Przykład dla sektora mleczarskiego	Towards sustainability W kierunku zrównoważonego rozwoju	Backwards sustainability Przeciwno zrównoważonemu rozwojowi
1	2	3	4	5
Production on farm Produkcja w gospodarstwie	Yields, productivity maximization Wydajność, maksymalizacja produktywności	Milk yield Wydajność mleka	Moderate milk yield 4 500-5 000 kg Umiarkowana wydajność mleka 4 500-5 000 kg Maximum extension of grazing period on grasslands. Minimization of feeding on supplements. Supplement here means all kinds of feeds obtained from arable lands Maksymalne przedłużenie okresu wypasu na pastwiskach. Minimalizacja żywienia uzupełniającego. Uzupełnianie oznacza tutaj wszystkie rodzaje pasz uzyskane z gruntów ornych	Maximization of very high milk yield over 10 000 kg Maksymalizacja bardzo wysokiej wydajności mleka ponad 10 000 kg Maximization of the share of concentrates and other supplements in daily feed ration Maksymalizacja udziału pasz treściwych i innych uzupełnień w dziennej dawce pokarmowej
	Quality increase Wzrost jakości	Milk quality Jakość mleka	EU milk quality standards Normy jakości mleka UE Animal welfare improvements Poprawa dobrostanu zwierząt	Milk yield increase by BSE injections Wzrost wydajności mleka przez zastrzyki BSE GMO manipulations Manipulowanie organizmami genetycznie zmodyfikowanymi
	Optimization of the scale of production Optymalizacja skali produkcji	Heard size maximization Maksymalizacja wielkości stad	Moderate number of cows on a farm – up to 50-60 cows which will ensure good standard of life for dairy farmer Umiarkowana liczba krów w gospodarstwie – do 50-60 krów, co zapewni dobrą jakość życia rolnikowi specjalizującemu się w produkcji mleka	Huge scale heard over 1 000 cows. Reduced number of work stands Ogromne stada ponad 1 000 krów. Zmniejszona liczba stanowisk pracy
	Administrative regulation for farms Administracyjne regulacje dla gospodarstw	Cattle density Obsada bydła	Up to 2 head per ha. Quality of environment still under farmers' control Do 2 zwierząt na 1 ha. Jakość środowiska nadal pod kontrolą rolników	Over 2 heads per cow. Creates big environmental problems Ponad 2 sztuki na 1 ha, co stwarza ogromne problemy środowiskowe
		Milk quota Kwoty mleczne	Elimination of competition between farmers Eliminacja konkurencji pomiędzy rolnikami	Maximization of milk yield and reduction of the number of cows Maksymalizacja wydajności mleka i redukcja liczby krów

Table 2 – cont.

1	2	3	4	5
Assembling (collection) Gromadzenie	Minimization of assembling costs Minimalizacja kosztów gromadzenia Diminishing number of delivers Zmniejszająca się liczba dostawców	Minimization of cost of milk collection Minimalizacja kosztów gromadzenia mleka Number of dairy farm has been drastically reduced Liczba gospodarstw mlecznych została drastycznie zredukowana	Elimination of farms in remote areas Eliminacja gospodarstw w odległych rejonach Better standard of life of farmers remaining in business Lepszy standard życia rolników pozostałych w branży	More people seeking for new job opportunities. In case of Poland from 1.8 million to 0.3 million. Further reduction to 0.1 million is expected Więcej ludzi szuka nowych możliwości zawodowych
Processing Przetwarzanie	Changing in types of ownership Zmiana typu własności Enlargement of processing scale Zwiększenie skali przetwarzania Product diversification Dywersyfikacja produktów Efficient of productivity Wydajność produkcji Packaging Pakowanie Advertisements Reklamy	Transformation from cooperatives to limited liability companies Transformacja od spółdzielni do spółek z o.o. Increase of daily throughput of processing plants Wzrost dziennej wydajności zakładów przetwórczych New generation products Produkty nowej generacji Lower costs of production Niższe koszty produkcji Plastic Plastikowe Milk consumption promotion Promocja konsumpcji mleka	Better opportunity for farmers to find a new opportunity by selling their shares Większe szanse dla rolników znalezienia nowych możliwości poprzez sprzedaż swoich udziałów Cheaper waste utilization Tańsza utylizacja odpadów Better response to consumer demands Lepsza reakcja na wymagania konsumenta Product safety increases Zwiększa się bezpieczeństwo produktu Milk consumption is too low. Increase of consumption promotes human health and life Konsumpcja mleka jest zbyt niska. Wzrost konsumpcji promuje ludzkie zdrowie i życie	Non producers may benefit from milk production Nie-producenti mogą czerpać korzyści z produkcji mleka Increase of waste Zwiększenie odpadów Over consumption Nadmierna konsumpcja Environmental problems Problemy ekologiczne Too high consumption leads to health problems Zbyt wysoka konsumpcja prowadzi o problemów zdrowotnych
Retailing Sprzedaż detaliczna	Extending product shelf life Przedłużenie trwałości produktów Entrance barriers Barriere wstępu	UHT Tax taken by supermarkets to introduce new products or to allow products in Podatek pobierany przez supermarkety za rezerwację miejsca na półce	For some countries a solution may be considered the sustainable model (in tropics) Dla niektórych krajów rozwiązaniem może być rozważany zrównoważony model (w tropikach)	For well-developed countries solution – unsustainable Dla wysoko rozwiniętych krajów rozwiązanie – niezrównoważony rozwój Absolutely unsustainable. It limits consumer choice to that available on shelf products Absolutnie niezrównoważony rozwój, ponieważ ogranicza to konsumentowi wybór produktów dostępnych na półkach sklepowych

Table 2 – cont.

1	2	3	4	5
Consumption Konsumpcja	Changing patterns of consumption Zmieniające się wzorce konsumpcji Increase in health concerns Zwiększenie troski o zdrowie	Reduction of liquid milk consumption Zmniejszenie konsumpcji płynnego mleka Increase of cheese consumption Zwiększenie konsumpcji sera Probiotics Probiotyki	Too much fat Zbyt dużo tłuszczu	Osteoporosis Osteoporoza
Lifestyles Style życia	New fashions Nowe mody New lifestyles Nowe style życia	Dairy products are not considered fashionable anymore Mleczne produkty nie są już uważane za modne Lifestyles promoting sustainable development Style życia promujące zrównoważony rozwój	Sustainable lifestyles Zrównoważone w charakterze style życia	Unsustainable fashion Nie zrównoważona w charakterze moda Unsustainable lifestyles Nie zrównoważone w charakterze style życia

Source: the author's study.
Źródło: opracowanie autora.

CONCLUSIONS

The paper shows that the concept of sustainability of food chain might be easily incorporated in both macro and micro economy theory.

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Streszczenie. W artykule przedstawiono definicję łańcucha żywnościowego w ujęciu przyrodniczym i ekonomicznym. Przedstawiono podejście ekonomii klasycznej do problematyki zrównoważonego rozwoju. Zdefiniowano pojęcie zrównoważonego łańcucha żywnościowego oraz określono jego cele. Wyróżniono makroekonomiczne i mikroekonomiczne podejście do zrównoważonego rozwoju oraz przedstawiono ekonometryczny model zrównoważonego rozwoju dla łańcucha żywnościowego. Zaproponowano w tym celu wykorzystanie programowania liniowego. Wskazano, że style życia są podstawą i motorem napędowym zrównoważonego rozwoju. Dokonano analizy ostatnich rozwiązań technologicznych i ekonomicznych w mleczarstwie i ich związku ze zrównoważonym rozwojem.

Słowa kluczowe: łańcuch żywnościowy, zrównoważony charakter, klasyczna gospodarka, cele, makroekonomia, mikroekonomia, programowanie liniowe, styl życia, sektor mleczarski

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