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Foundational ontologies and multi-paradigm analysis, applied to the socio-technical transition from mixed farming to intensive pig husbandry (1930–1980)

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This article adds a new case study to the expanding literature on socio-technical transitions: the shift from mixed farming to intensive pig husbandry in the Netherlands. With regard to this transition, the article addresses a new direction, namely the role of foundational ontologies in explanation. Five ontologies are distinguished, which are based on different assumptions about causal agents and causal mechanisms: rational choice, functionalism, conflict and power struggle, interpretivism, and structuralism. The article demonstrates how these ontologies provide different explanations of same case. It also empirically investigates the strengths and weaknesses of different ontological explanations, and identifies possible complementarities in this case. The article ends with theoretical reflections on the relationships between ontologies and the role of meta-paradigm analysis.

Keywords: transitions; pig farming; agribusiness; foundational ontologies; multi-disciplinarity; crossovers

1. Introduction

This article makes empirical and theoretical contributions to the transitions literature, which studies shifts in socio-technical systems (Geels 2002; Elzen, Geels, and Green 2004; Smith, Stirling, and Berkhout 2005; Geels and Schot 2007). These socio-technical systems fulfill societal functions (such as transport, agro-food, communication, housing, medical care) through the interplay of elements such as technology, science, markets, user practices, policy, infrastructure and cultural meaning.

Empirically, this article deals with agro-food systems, focusing in particular on the Dutch transition in the production and consumption of pigs. One quantitative indicator of this transition is the increase in the number of pigs from 2 million in 1930 to 14 million in 1990, making the Netherlands the biggest European net exporter of pork (Figure 1).

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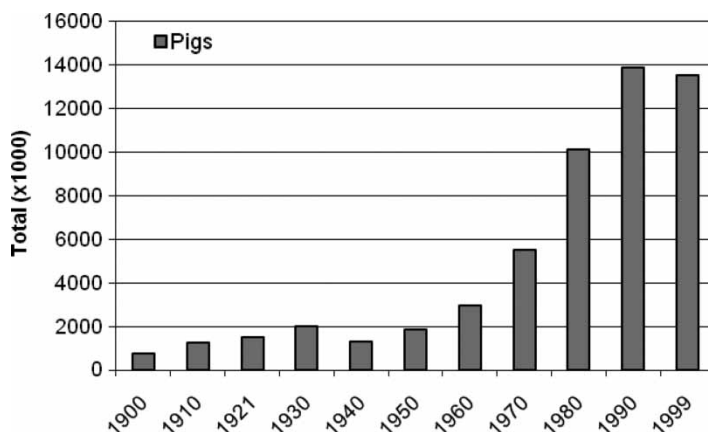


Figure 1. Number of Dutch pigs (data from the Central Bureau of Statistics).

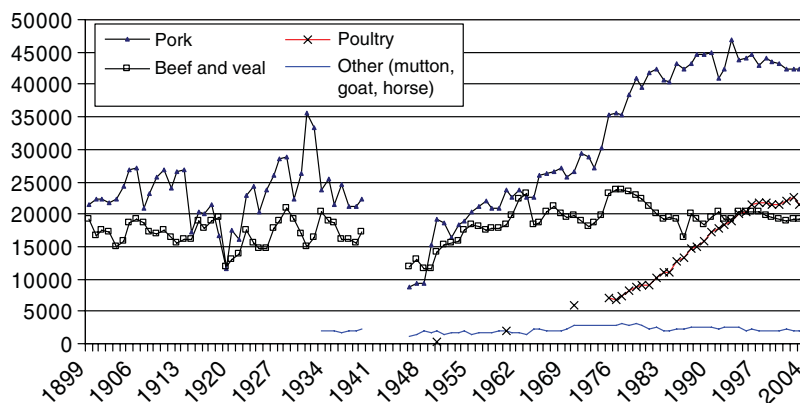


Figure 2. Dutch meat consumption per capita per year (in grams) (data from the Central Bureau of Statistics).

The consumption of pork also increased during the transition, from about 26 kg/year in 1930 to 45 kg/year in 1990 (Figure 2). Pork thus came to constitute the bulk of total meat consumption, which in this period grew from 43 to 84 kg/year.

In qualitative terms, the transition entailed a shift from mixed farming to intensive animal husbandry, which involved many socio-technical changes, further delineated in Section 2. The empirical research question is: how did the pig farming transition come about?

This question is not simply answered with a historical description. Instead, the article uses the case study to address foundational issues regarding the explanation of transitions. One kind of explanation is given by the multi-level perspective (MLP), which explains the overall pattern of transitions through dynamic interactions between technological niches, socio-technical regimes and socio-technical landscape (Geels 2002). The MLP provides a particular kind of explanation, because it is a 'global model' (Geels and Schot 2007):¹

The global (macro, long-run) model depicts the overall course of development of an innovation and its influences, while the local (micro, short-run) model depicts the immediate action processes that

Table 1. Typology of foundational ontologies (adapted from Mahoney 2004, 463).

	Rational choice	Functionalism (systems theory)	Power struggle	Interpretivism (constructivism)	Structuralism
Causal agent	Individual actors	Social system	Collective actors with conflicting interests	Individual actors with varying ideas and interpretations	Cultural ‘deep struc- tures’ (collective belief systems or mindsets)
Causal mechanism	Free choice based on instrumental rationality and utilitarianism	Actors fulfil tasks that contribute to overall system goals	Conflict and power struggle	Sensemaking, learning, debates, construction of shared meaning	Actors are embedded in taken-for-granted ‘deep structures’, which operate ‘behind their backs’

create short-run developmental patterns. ... A global model takes as its unit of analysis the overall trajectories, paths, phases, or stages in the development of an innovation, whereas a local model focuses on the micro ideas, decisions, actions or events of particular developmental episodes. (Poole and Van de Ven 1989a, 643)

While the MLP develops a ‘global model’ of transitions, this article addresses ‘local models’, i.e. explanations from the viewpoint of the actors involved. The problem with such explanations is that social science contains different understandings of agency, which relate to foundational ontologies, i.e. the underlying assumptions scholars make about the nature of the (social) world and its causal relationships. Ontologies postulate a certain causal agent and primary causal mechanism. ‘causal mechanisms are treated as ontologically primitive causes of outcomes and associations; they are original movers or “ultimate causes”’ (Mahoney 2004, 461). Table 1 distinguishes five basic ontologies, with different causal agents and causal mechanisms.

Within social theory there have been many *theoretical* debates about the strengths and weaknesses of different ontologies, and also attempts to develop specific theories that make crossovers between two or more ontologies. There is much less work, however, that addresses these issues empirically.² Against this background, the article addresses the following research questions:

- (1) How do different ontologies explain the transition in pig farming?
- (2) What are strengths and weaknesses in the explanations of this case? How and where do these empirical explanations complement or contradict each other?

With these questions, the article contributes to work on multi-paradigm analysis (Gioia and Pitre 1990; Lewis and Kelemen 2002). Lewis and Grimes (1999) distinguish three types of multi-paradigm analysis: (1) multi-paradigm review, which theoretically juxtaposes insights from different ontologies, recognising divides and bridges in existing theories, (2) multi-paradigm research, which applies divergent ontological lenses empirically, showing how concrete cases can be interpreted differently, (3) meta-paradigm analysis, which investigates linkages and interaction mechanisms between different paradigms. This article practices the second kind of multi-paradigm analysis and provides some reflections on the third kind.

The article is structured as follows. To provide further background, Section 2 describes the basic socio-technical characteristics of the case. Section 3 answers the first question, providing five explanations of the transition, each from a different ontology. Data in these mini-case studies, which remain brief and stylised because of space limitations, come from secondary sources, especially in agricultural history, food history and history of technology. Section 4 addresses the second question, empirically analysing the strengths, weaknesses and complementarities in the five ontological explanations. The article ends with reflections on meta-paradigm analysis in Section 5.

2. Socio-technical delineation of the transition

The pig farming transition was not only about new technologies, but also about changes in social networks and farming practices. Important *technical* changes were breeding research, artificial insemination, population genetics, antibiotics, artificial designer foods, indoor husbandry systems, automatic water supply and feeding systems, electric lights, air conditioning, artificial heaters and manure removal systems.

An important change in *social networks* was consolidation, as the number of farms with pigs decreased from 146,000 in 1960 to 29,000 in 1990, about 80% reduction (Table 2).³ As small

Table 2. General developments in pig farming (Termeer 1993, 56).

	1960	1970	1975	1983	1987	1990
Number of pigs (million)	3	5.5	7.3	10.7	14.3	13.9
Number of pig farms ($\times 1000$)	146	76	55	38	35	29
Average number of pigs per farm	20	73	132	282	406	476

farms went out of business and/or were taken over by larger ones, pig farming experienced a scale increase, with the average number of pigs per farm rising from 20 in 1960 to 476 in 1990.

Forward and backward integration in the value chain also changed the social network in which pig farmers were embedded. Farmers developed new network ties with supermarkets, slaughterhouses, meat processing companies, technology suppliers, pharmaceutical industry, feed companies, chemical industry and banks. These changes transformed pig farming into 'agri-business', a network activity with multiple interdependent chains. Farmers also developed closer ties with governments, extension agencies, agricultural schools and agricultural research institutes.

In terms of *practices*, the transition from mixed farming to intensive pig husbandry entailed several changes:

- On mixed farms, pig farming co-existed with other activities. Most farmers held some cows and worked small plots of land to produce potatoes, corn, or legumes. Because pigs ate leftovers, they acted as 'garbage cans' that earned additional incomes (Somers 1991). The shift to intensive animal husbandry entailed specialisation. As some farmers decided to focus on one particular product, pigs changed from side-activity to core business. Specialisation also meant that pig farmers came to rely on commercial feed suppliers, who sold specially designed food, tailored to high growth rates. This food supply eliminated the need for pasture and uncoupled pig farming from the land. Farmers only needed a small plot of land to build a shed for pig farming.
- Pig farming used to follow the seasonal cycle, which was related to the availability of crops from the land. Farmers typically bred their hogs in the fall so that piglets would be born in the spring and could be fed on pastures during summer and fall (Finlay 2004). Fresh pork therefore used to be only available during certain parts of the year. The shift to specialised food supply and indoor husbandry systems broke this seasonal dependence, allowing pig farming to develop into a continuous flow pattern that ensured a steady supply of fresh meat throughout the year.
- Pig farming shifted from outdoor pastures to confined animal husbandry systems. In these closed sheds, pig farming occurred on an industrial scale, focusing on productivity and throughput. Fattening pigs were kept in small cells or crates and lived on concrete floors. Gutters and sloped floors guided manure to storage cellars. Breeding sows had somewhat bigger cells to limit the risk of crushing piglets. The pig sheds used new technologies such as automatic water supply and feeding systems, large food storage silos, electric lights, air conditioning, artificial heaters, germicidal lamps (to prevent fungus and infections). To construct the new housing systems, farmers came to rely on specialised technology suppliers (Finlay 2004).
- With the change to crowded indoor living conditions, pigs became more susceptible to disease. Sanitation and disease control thus became more important. The intermittent cleaning of stables with lye and creosote made farmers dependent on the chemical industry. Farmers also used increasing quantities of antibiotics to suppress diseases. An unexpected side-effect of antibiotics use was more uniform growth, improved weight gain and enhanced feed-conversion efficiency with about 5% (Finlay 2004).⁴

The transition also entailed changes in the physical shape and performance of pigs. In the 1930s, when consumers appreciated the high energy content of lard, breeding focused on *fat* pigs. Pigs, which existed in a large variety of shapes and races, would be fattened up to 150 kg before they were slaughtered. In the 1960s, when consumer preferences shifted to lean meat, the animal's physiology was changed through selective breeding, resulting in 'meat-type' hogs with reduced back fat measurements. These pigs were typically sold when they weighed around 100 kg, which prevented the accumulation of fat. Breeding also focused on the production of more uniform and similarly shaped pigs, which better fitted the specifications of slaughtering machines (Finlay 2004). Figure 3 schematically represents the changes in pig shapes.

Pigs were also physically adjusted after birth to fit the new husbandry systems: tails were cut off to prevent 'cannibalism' and tail biting, which resulted from boredom in small confinements; male

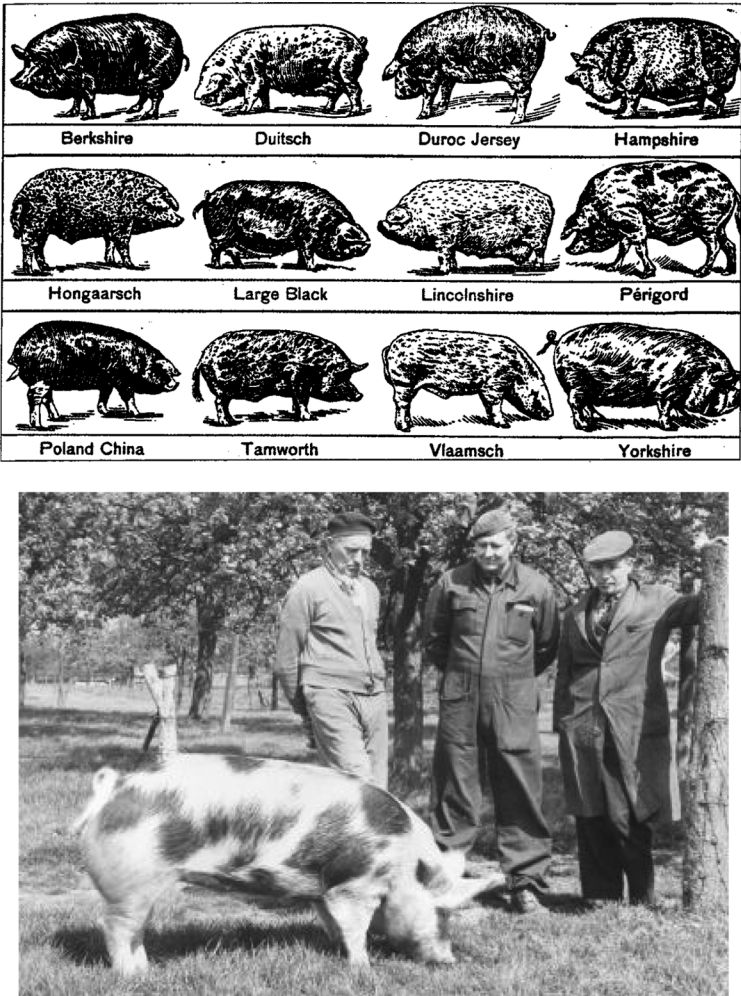


Figure 3. Fat-oriented pigs in the early twentieth century (top) vs lean meat-oriented Piétrain pig in the 1960s (bottom) (Niessen et al. 2003, 103).

Table 3. Technical performance improvements in pig breeding and fattening (Groenestein 2003: 3).

	1965	1970	1980	1990
<i>Breeding</i>				
Number of piglets per birth per sow	8.9	8.7	8.5	9.3
Number of births per sow per year	1.66	1.72	1.85	2.20
Number of piglets per sow per year	14.8	15.0	15.7	20.5
Average deaths of piglets per sow/year (percentage of total births)	3.9 (26%)	3.6 (24%)	2.7 (17%)	2.1 (10%)
<i>Fattening</i>				
Weight growth (g/day)	547	563	610	719
Food uptake (kg/day)	1.99	1.95	2.04	2.07
Food conversion (kg food/kg growth)	3.64	3.47	3.4	2.88

piglets were castrated, because sex hormones were thought to influence meat tastes as they grew older; teeth were commonly clipped to protect the sows' nipples and reduce damage from biting.

Pig 'performance' also improved substantially during the transition (Table 3). The yearly number of piglets a sow produced increased from 15 in 1965 to 22 in 2000. Breeding research played an important role in these improvements. Population genetics, heritability data and mating systems analysis enabled the use of statistical analysis to enhance valuable traits through intensive selection and inbreeding (Boyd 2001). Artificial insemination, which enabled breeding with champions, also improved results. Improvements also came from the introduction of a new practice, namely separating baby pigs from the sow within a few days of birth. With no need for suckling, the sow could be bred again within just nine weeks (Finlay 2004). The young piglets were fortified with antibiotics and vitamins, and kept in artificially heated environments. Yearly piglet deaths per sow were reduced by new stable designs, which made it less likely for sows to crush their offspring.

In pig fattening, food uptake and food conversion rates (kg food needed per kg growth) increased substantially, because of improved breeding techniques and designer foods, with special ratios of fats, proteins, carbohydrates, minerals, vitamins and amino acids (Groenestein 2003). These designer foods were based on research into nutrition, digestion, and pig's physiological needs.

3. Explanations from five ontologies

Having described the outlines of the transition, we now turn towards different explanations. Each subsection first describes the ontology and then provides empirical explanations of the transition in pork production. The descriptions are short and stylised, focusing only on the basic logic (see Geels 2010, for more elaborate discussions of the ontologies).

3.1. Rational choice: adjustment to changing prices and factors costs

General ontology

The rational choice ontology is based on methodological individualism. It assumes that individuals with clearly formulated (material) interests are the basic causal agents. When actors choose between alternative courses of action, they use instrumental rationality and cost-benefit

calculations to make the choice that optimises their self-interest. Neo-classical economics is the prime example, with cost and utility/performance being important dimensions.

Transitions in production technology, such as the shift to intensive pig husbandry systems, depend on capital investment decisions by producers (farmers). Such decisions depend on calculated return on investments and the availability of capital (borrowing from banks, interest rates, etc.). Producers will make the investments if the new technologies lower the costs of input factors (e.g. labour, land, inputs, capital) and enhance output and profitability. A population of producers transforms if profitable firms push 'weaker' firms off the market.

Explaining the pork production transition

The core drivers in this ontology were changes in labour costs, fodder prices and pig sales prices to which farmers rationally adjusted by shifting towards intensive pig farming. *Labour costs* increased steeply as wages increase almost 300% between 1950 and 1980 (Figure 4).

Rising labour costs formed a general incentive to shift from labour to capital. Seasonal workers, who assisted farmers during busy periods, were fired and replaced by agricultural machinery. For pig farming, however, labour costs were less important than *food costs*, which accounted for 40–60% of total costs. Commercial fodder prices decreased in the 1950s and 1960s (Figure 4), which formed an incentive for farmers to shift from mixed farming (where they produced pig fodder themselves) to specialised pig farming (and reliance on commercial food supply). A third incentive was decreasing income, as relative *prices* of agricultural products went down. The labour value per pig per year gradually decreased (Table 4), which meant that farmers with constant production levels would earn less money. This provided an incentive for scale increase and the shift to intensive pig farming.

In response to the changing economic incentives, innovative farmers made investments in intensive pig husbandry systems. This involved a shift in borrowing money practices and the creation of

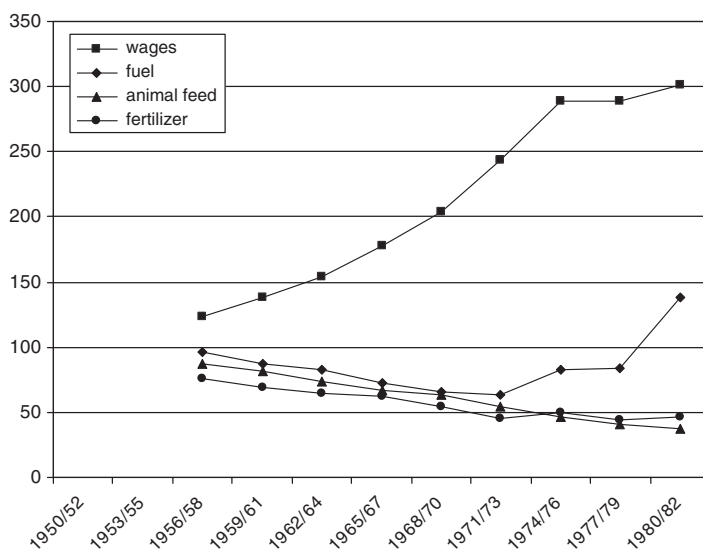


Figure 4. Three-year average, real (inflation-adjusted) price index data for wages and factor costs (1949/50–1952/53 = 100) (Van der Weijden et al. 1984, 18).

Table 4. Economic results in pig farming, five-year averages (not corrected for inflation) (Dröge et al. 1990, 78).

	Sales price (guilders) per kg pig	Food price (guilders/100 kg)	Sales price per pig per year	Costs (excl. labour) per pig per year	Labour value (guilders) per pig per year
1956/57–1960/61	2.13	33.00	415	360	55
1961/62–1965/66	2.37	34.50	477	420	57
1966/67–1970/71	2.84	38.70	557	508	49
1971/72–1975/76	3.33	45.80	705	648	57
1976/77–1980/81	3.63	53.70	799	764	35
1981/82–1985/86	4.15	61.30	971	914	57
1986/87–1989/90	3.30	51.70	827	799	28

new banks. The Rabobank, which emerged in 1972 from a fusion between the Cooperative Central Farm Credit Bank and the Central Raiffeisen Bank, provided about 90% of all agricultural loans. Between 1974 and 1980, at the height of expansion in pig production, agricultural loans (in all sectors) increased from 7 to 20 billion guilders per year (Van der Lans and Vuijsje 1999, 115).⁵

The scale increase was also stimulated by the creation of a bigger and freer European market, created by the Common Agricultural Policy (1958). Dutch pig farming, which had always been oriented towards exports, took advantage of this commercial opportunity and conquered large market shares with a low-cost bulk production strategy (De Groot and Bauwens 1990). Economies of scale provided a self-reinforcing mechanism. Farmers with larger stables had lower production costs per pig, and could conquer larger market shares. This increased their turnover and enabled them to invest in bigger stables. Farmers that refused to modernise were gradually pushed out of the market.

The economic cost–benefit logic also applied to other actors in the pork chain, such as food suppliers, slaughterhouses, meat processing companies and supermarkets. Scale increases and investments in new technologies created a desire for guaranteed markets and predictable supplies, which resulted in forward and backward integration of these actors into pig farming. These developments further stimulated the transition to industrial large-scale pig husbandry.

The business of food supply started in the 1920s and 1930s and exploded in the 1960s, when farmers began to shift to intensive animal farming (Veldman, van Royen, and Veraart 1999). Figure 5 provides an indication of this expansion for *CeBeCo-Handelsraad*, the largest Dutch animal feed company.

Because food supply companies wanted to create stable, predictable and guaranteed markets for their pig feed, they gradually moved into pig farming. In the mid 1960s, *CeBeCo* and food supply company *Hendrix* created their own pig farms and hired existing farmers through ‘contract farming’ (Schönwetter 1999). With the financial muscle of big agribusiness behind them, these farms were very large and set new benchmarks in the process of scale increase.

Slaughterhouses contributed to the standardisation of pig breeding practices to ensure uniform weight and homogeneous quality of pigs (Koolmees 1991). This development was driven new regulations, such as the Meat Inspection Law (1957) and the EU Directive on Fresh Meat (1965), which tightened hygiene regulations and required modernised facilities.⁶ Slaughterhouses therefore invested in new disassembly lines, new machines for heavy cutting, new floors and buildings with better cleaning facilities, and new facilities for deep-freezing (Koolmees 1991). The investments and scale increases led to a wave of mergers. Because the new slaughtering machines were

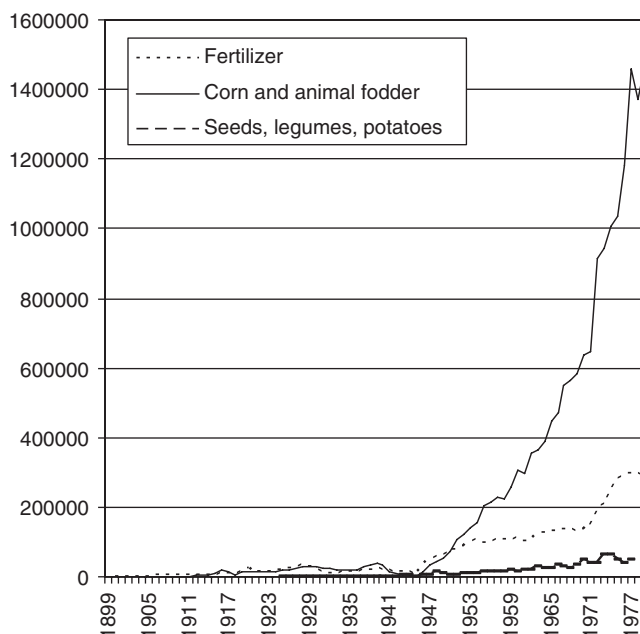


Figure 5. Turnover from CeBeCo-Handelsraad (in thousand guilders) of animal fodder (upper line), fertilizer (dotted middle line) and seeds, legumes and potatoes (bottom line) (Veldman et al. 1999, 94).

designed for particular pig specifications, slaughterhouses also specified new demands, asking suppliers for pigs that remained within narrow margins of particular sizes, shapes and meat/fat ratios. Pig farming practices thus became tailored to slaughterhouse specifications.

Meat processing companies influenced pig farming through a process of backwards integration. The meat processing industry became big business in the 1950s and 1960s as supermarkets offered increasing varieties of processed meat products, e.g. pastries, pies, canned meat, pâté, pre-cooked sausages. To secure a steady meat supply of predictable quality, meat-processing firms moved into slaughtering and pig farming. Some companies (like Homburg in 1963) set up their own pig farms, while others used 'contract farming' to create the predictability and control that were necessary for industrial-scale operations (Schönwetter 1999). This backwards integration also enabled them to avoid the price fluctuations that normally characterised livestock markets.

The rise of supermarkets indirectly influenced pig farming through specified contracts with slaughterhouses and meat processing factories. Supermarkets, which increased from 1 in 1954 to 50 in 1961 to 700 in 1967, used cheap meat as one of the fresh products to attract customers (Montijn 1991). Investments in cooling technologies, supply chains and distribution centres enabled supermarkets to supply fresh meat throughout the year. To ensure steady supplies, supermarkets signed contracts with slaughterhouses and meat processing factories, which, in turn, integrated backwards into pig farming.

The pork transition thus led to increased economic integration in the entire pork chain. This produced a relative shift in the commercial importance, with the balance changing from primary farming in favour of agribusiness firms. In 1950, primary pig farming earned about 60% of total income in the pork chain. In 1980, farmers earned only 19%, while commercial food manufacturers

earned 18%, meat processors 29%, trade, transport and services 27%, and other non-agricultural companies 7% (Douw 1990).

3.2. *Functionalism: new goals, normative consensus and implementation*

General ontology

The functionalist ontology analyzes the functioning of social systems. Parson's (1951) structural-functionalism, for instance, distinguished four generic functions in social systems (AGIL): (1) *adaptation*: capacity to interact with and adjust to external contexts; modern societies fulfill this function through economic subsystems, science and technology, (2) *goal-attainment*: capability to set goals and implement appropriate decisions; modern societies fulfill this function through political subsystems, (3) *integration*: creation of harmony and convergence through shared values and norms; religion and civil society are important to fulfill this function, (4) *latency*: pattern maintenance over time through socialisation of new members into existing norms and values; schools and family are important to fulfill this function. Social systems thus develop a division of labour to fulfil these functions, with different groups or subsystems fulfilling different tasks or roles. Collectively, however, these subsystems and actors are impelled to contribute to the overall goal: stable long-term functioning of the social system. Functionalism is thus characterised by a focus on stability, consensus and shared goals (teleology). To explain transitions and discontinuities, functionalism therefore relies on external causes. Changes in the external environment create tensions that disrupt the equilibrium state. Changes in the sub-systems responsible for 'goal-attainment' and 'adaptation' functions then lead to adjustment and a new system equilibrium. This often means that political leaders, managers and experts develop new goals and subsequently use science, technology and policy instruments to adjust the economic sub-system. The new goals subsequently spill over to the internally oriented functions (integration, latency) and become anchored in new behavioural norms and values.

Explaining the pork transition

The Second World War was an external shock that disrupted agriculture. In response, policy makers and National Farmer's Associations (NFA) developed new goals in the post-war period: (1) food security: reliable and sufficient food supply ('no more hunger'), (2) cheap food supply: low food prices would allow low wages, which would stimulate industrialisation, (3) reasonable incomes for farmers (guaranteed livelihood), (4) increased export, so that agriculture would improve the national balance of payments (Louwes 1980). These goals, which were relatively widely shared, were subsequently transformed into a new vision of agricultural modernisation and implemented with policy instruments that stimulated economic investments and the dissemination of science and technology.

During the first six-year plan (1947–1952), rationalisation was seen as the best way to increase production (Van den Brink 1990). Rationalisation included land redistribution, intensification of the farm plan (doing multiple tasks with the same land) and dissemination of techno-scientific research. The latter involved expansion of the ERE-triptych (Education, Research, Extension services). Research was boosted through the creation of government-funded research institutes: the Agricultural Economics Research Institute (1947), which performed economic research and acted as agricultural planning bureau; the Institute for Agricultural Technology and Rationalization (1949); the Institute for Animal Husbandry Research (1951); the Institute for Agricultural Buildings and Constructions (1957), the Institute for Soil Fertility Research (1957). To disseminate

research findings, the Agricultural Extension Service was expanded from 500 employees in 1946 to 1420 in 1950 to 1580 in 1956 (Zuurbier 1984). Extension specialists gave presentations for farmers, visited study clubs, distributed reports, and organised excursions to model farms. Also the number of agricultural schools and students expanded rapidly, especially between 1940 and 1960 (Table 5).

The ERE-triptych developed and disseminated ‘rational’ and ‘modern’ knowledge to farmers, with the aim of influencing their attitudes and practices in the direction of modernisation, rationalisation and increased production. To allay farmer’s fears that increased production would lead to lower prices, the government set minimum prices. The level of these minimum prices were based on calculations by the Agricultural Economics Research Institute (AERI) of average production costs, increased with a profit margin and negotiated between the Ministry and NFA’s (Van den Brink 1990). By the mid 1950s, agriculture began to produce surpluses, but at increasing costs to the government. The Common Agricultural Policy (1958), which stipulated financial solidarity in the payment for CAP, helped reduce these costs for agricultural export countries such as the Netherlands.

By the late 1950s, agricultural incomes lagged behind other sectors, where industrialisation led to higher wages. To improve the labour productivity of existing farms, the governments increasingly saw mechanisation and labour reduction as the way forward. To facilitate this, the government developed a new vision of ‘structural adjustment’, which aimed at changing the economic structure: small farms should disappear and make way for large-scale farms with modern production methods (Van den Brink 1990). The NFA’s did not immediately accept this new vision (see also Section 2.4). By the early 1960s, however, the ‘green front’ achieved consensus and developed new policy instruments to implement this new vision.

One instrument was to tailor minimum prices to the economic viability of large modern firms. AERI’s calculations of average production costs were therefore increasingly modelled on *desired* large-scale farms with new production technologies (Van der Ploeg 2001). Price instruments thus became increasingly selective and tailored to the survival of large farms.

Another structural adjustment instrument were regional improvement projects, which targeted not individual farms but entire villages and regions. After two pilot projects (1953–1956), the number of projects increased rapidly (Figure 6). Initial projects subsidised 50% of the costs of new technologies (Karel 2005, 97); later projects received lower subsidies. The extension service organised trips to these projects to convince farmers of the success of modern practices and new

Table 5. Number of agricultural schools operated by the North-Brabant Christian Farmers Organisation, one of the NFA’s (Duffhues 1996, 404).

	Number of NCB schools	Number of students
1922	2	127
1930	7	487
1940	10	1052
1950	39	3475
1960	48	3049
1970	23	1734
1980	11	3019
1990	8	2212
1994	6	2049

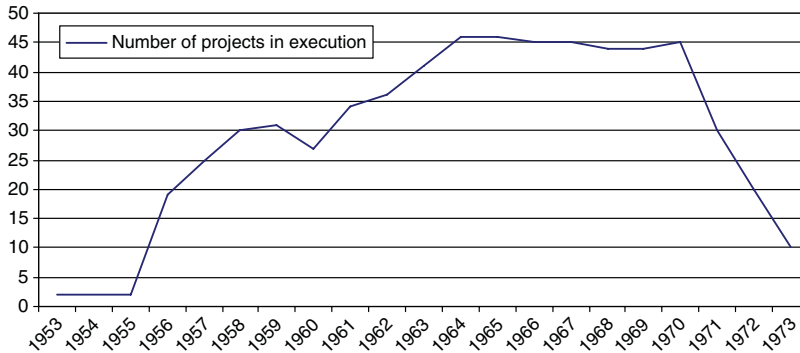


Figure 6. Number of regional improvement projects (data from Karel 2005, 124).

technologies. Around 71,000 farmers, about 35% of the farmer's population, thus came in contact with one of the 132 regional improvement projects between 1956 and 1973 (Karel 2005, 330).

The regional improvement projects increasingly used farm size as selection criterion for participation, thus contributing to the reduction of small farms (Karel 2005). The decline of small farms was further stimulated by another instrument: the Development and Buy Out Fund, created in 1963 (Van den Brink 1990). This Fund provided subsidies to farmers who wanted to invest and expand and provided compensation to farmers who wanted to discontinue operation.

In 1970, the government spent about 5% of the gross national product on different agricultural structural adjustment policies (Van den Brink 1990, 11).⁷ The transition towards 'modern' agriculture thus arose from new goals and policy instruments that increasingly worked towards a new vision organised around modernisation, mechanisation, rationalisation and scale increase.

3.3. Conflict and power struggle: contestants vs the 'green front'

General ontology

Collective actors are key causal agents in the conflict and power struggle ontology. These actors are assumed to have conflicting goals and interests. Hence, the main causal mechanism is conflict and power struggle. Early Marxist theories focused on classes (labour vs capital), while later political economy theories shifted the analysis to branch organisations, industry associations, government agencies, special-interest groups and other collective macro-actors. Stability arises from powerful groups or elites, who protect their vested interests against challengers. Change and transitions often result from shifts in the balance of power, i.e. the weakening of elites or the strengthening of challengers, but it is also possible that a powerful coalition of incumbents pushes through a reform agenda that fits its interests.

Explaining the pork transition

The transition towards large-scale industrial agriculture was not uncontested. Protests initially came from farmers who disliked the increasing government interference and from those who saw their survival threatened. Because 80% of pig farmers went out of business between 1960 and 1990 (Table 2), there were not only 'winners' in the transition, but also 'losers'. In the mid 1950s, a 'Free farmers movement' was created by farmers who opposed the increasing government interference and the worsening conditions for small farmers (Nooij 1969). They created a political party, the

Farmers' Party, which acquired three seats in Parliamentary elections in 1963 and seven seats in 1967. Despite public support, the Farmers' Party was sidelined in Parliament and could not alter agricultural policies.

The scale of farmers' protest against agricultural modernisation was relatively small if compared to its effects, i.e. the decimation of rural populations. Although the government's Long-Range Plan for Land Consolidation (1958) explicitly mentioned the goal of a 50% reduction in the number of farms, this did not lead to major rural protests (Van der Ploeg 2001). One explanation is that farmers, who went out of business, were financially compensated by the Development and Buy Out Fund. Another explanation is that Dutch farmers at the time were relatively docile towards authorities (Duffhues 1996). Also the support of the National Farmer's Associations, which many local farmers respected, created legitimacy for the government's plans.

When the transition was well under way, new kinds of contestation came from special-interest groups, which represented new societal values such as animal welfare and the environment. In the early 1970s, the action group 'Nice Animals' ('Lekker Dier') and the Foundation for Nature and Environment began to criticise the intensive animal husbandry for poor living conditions of pigs, water and soil pollution from manure surpluses, and stench problems (Crijns 1998). These criticisms were neglected or sidelined by the pig farming industry, because they came from agricultural outsiders. But internal criticisms about these issues were also silenced. In 1972, for instance, the Agriculture Ministry prevented the publication of a research report from the Institute for Animal Husbandry Research (1972), which noted that pigs were biting each other's tails and ears, because of boredom and stress that came from confinement in small spaces (Crijns 1998). With regard to manure problems, the Agriculture Ministry engaged in a 12-year 'trench warfare' conflict (1972–1984) with the Ministry of Environmental Affairs to keep the issue off the agenda and delay strict regulations.⁸

By 1984, however, stench and water pollution problems were smellable and visible, leading to much societal and political pressure. That year, the Agricultural Ministry issued the Interim Manure Law, which set limitations on the expansion of pig and poultry farming. Ironically, the law triggered a wave of expansion, because farmers exploited loopholes in the Interim Law. The number of pigs increased with 28% between 1984 and 1987, when the Manure Law was finally introduced (Frouws 1994).

Until the 1980s, the protests were unable to stop the transition, because they were struggling against a powerful 'green front', a corporatist coalition between National Farmer's Associations (NFA), political parties in Parliament, and the Ministry of Agricultural and Fisheries (Louwes 1980).⁹ The social ties between NFAs, political parties and the Ministry were so strong that they were often referred to as the 'iron triangle'. Because of these closed ranks, protesters had few means to advance their cause.

3.4. *Interpretive: learning processes and changing interpretations*

General ontology

The interpretive ontology is rooted in microsociology (ethnomethodology, symbolic interactionism, social constructivism). Actors are perceived as continuously interpretive and engaged in sensemaking (Weick 1979). Interpretation *precedes* (rational) decisions and interactions, since actors need to give meaning to data and situations. This is especially complicated in situations of flux, when there is much uncertainty, and for (system) innovation, which by definition entails uncertainties. Causal mechanisms are socio-cognitive, consisting of social interactions and

negotiations of shared meanings. For technological change, the main exemplar of this ontology is social construction of technology (Bijker 1995).

With regard to transitions, interpretive scholars see changing interpretations of problems and solutions as the main driver. They therefore highlight learning processes, interactions and negotiations through which actors change their interpretations (which subsequently influence policies, investments etc.).

Explaining the pork transition

This ontology highlights two kinds of interpretive explanations. The first concerns changes in the perception of the government and National Farmer's Associations (NFA's) of the 'small farms problem'. This new problem perception, which emerged in the early 1950s, formed the background of the new goals and visions that were discussed in Section 2.2 (scale increase, modernisation, structural adjustment). The second explanation concerns changes in the practices and perceptions of farmers, e.g. perceptions of technical problems, borrowing money and acquisition of entrepreneurial attitudes. Both interpretive explanations are fleshed out below.

Small farms traditionally formed the bulk of Dutch agriculture and were seen as invaluable to a healthy society (see Section 2.5).¹⁰ When the economic depression of the 1930s threatened farmers, the government stepped in to help, laying the foundations for the 'green front' (Louwes 1980). Financial support was substantial. Between 1933 and 1936, total expenditures of the newly created Agriculture Crisis Fund were 200 million guilders per year, almost 40% of total agricultural income (Bieleman 1992, 238–9). The government also established minimum prizes that helped farmers cover their production costs, set production restrictions to combat overproduction and decreasing prices, and established import levies to protect the domestic markets. There were also deliberate efforts to help small farms. The Agency for Small Farms (ASF), which was established in 1936, provided direct support in the form of fertiliser, animal fodder, certified seeds and seed-potatoes (Somers 1991). It also provided information about rational farming practices that would reduce costs and increase yields. The government and NFAs thus perceived small farms as important agricultural actors that were entitled to help.

This perception changed after the war, when economic and sociological researchers began to articulate new views of Dutch agriculture. Articles in the *Monthly Journal for the Extension Service* suggested that the economic problems had not just been related to the economic depression, but also to the presence of too many small farms (Karel 2005). A new problem definition thus appeared, the 'small farms problem': because agricultural incomes were spread over too many small farms, the average per capita income was low. Dutch agriculture was thus defined as having a *structural* problem: too many small farms that relied on inefficient manual labour.

Between 1949 and 1958, three high-profile commissions helped disseminate this new problem definition to policy makers and NFA's. While small farms were previously seen as in need of help, they were increasingly defined as the core problem (Van der Ploeg 2001). This also changed the perception of solutions. Instead of improving *existing* (small) farms, the new view was to decrease the number of (small) farms to alter the economic structure (Van den Brink 1990). The perception of small farms changed from 'problem to be solved' to 'problem to be removed'. By 1955, the government concluded that small farms should either enlarge or disappear. The government's Long-Range Plan for Land Consolidation (1958) explicitly articulated the goal of a 50% reduction in the farm population in 20 years time.

These new perceptions were initially opposed by the NFA's, who saw themselves as representing the *entire* agricultural population and argued that small mixed farms should not be abandoned

(Van den Brink 1990). The NFA's defended small farms arguing, for instance, that AERI should use *real* costs for different farms in its calculation of guaranteed minimum prices, instead of using data from *best-practice* farms (Duffhues 1996). The 1950s thus saw tensions within the green front and debates about problems and policy instruments.

The NFA's attachment to small farms was eroded by a stream of economic and sociological reports. Rural sociologists, who usually identified with modernisation ideals, concluded that some farmers had a 'modern dynamic cultural pattern' while others were more 'traditional'. These findings (and rhetorical terms) legitimated the government's view that some farmers (often on small farms) were inherently less innovative than others. Since they were holding back modernisation, they should either disappear or abandon their 'traditional' agrarian ethic and adopt entrepreneurial attitudes. Extension services should therefore not only engage in knowledge transfer, but also try to influence traditions and attitudes (Karel 2005).

By 1960, the NFA's began to accept the new interpretations, leading to closure in the corporatist coalition and support for the Development and Buy Out Fund (1963), which explicitly stimulated the termination of small farms (Van den Brink 1990).

Interpretive changes and learning processes also occurred at the farm level. There was initial resistance against specialisation and scale increase, because the shared perception was that mixed farming was a rational strategy of spreading risks (Termeer 1993). The 1930s depression had shown that specialisation and reliance on one product created vulnerabilities to price fluctuations.

These perceptions changed gradually through 'learning by doing', experiences, debates and reform programmes. In the 1950s, some farmers increased the number of pigs by constructing low-cost sheds as add-ons to main building (Crijns 1998). But the resulting fragmentation of many small operations was inefficient as extension services and NFA's pointed out to farmers (Duffhues 1996). Hence, mixed farms abandoned some tasks (e.g. poultry farming) and merged multiple small sheds into larger single stables. This moderate scale increases created new bottlenecks, e.g. time-consuming manure removal in pig stables, which still occurred by hand. Hence, farmers gradually adopted mechanical slides, operated by winch and motor power, to shove manure out of the stables (Crijns 1998). Technology suppliers also offered new stable designs that tailored to either the breeding of piglets or the fattening of pigs. The early 1960s therefore saw a process of differentiation, with some farmers specialising in pig breeding and others in pig fattening.

These farm-level developments were stimulated by extension services. Before 1950, they advised mainly about technical *components*. During the 1950s, they gave more attention to *interactions* between components and efficient operation at the entire *farm-level* (Crijns 1998). Extension services also addressed financial and economic attitudes. Advisers visited farmers at home or gave evening courses to teach bookkeeping skills and cost-benefit calculations, providing them with the mental tools to become rational agents (Karel 2005). Extension services increasingly took sociological research as their guiding principle and set out to change 'traditional' attitudes and routines (Zuurbier 1984). This mission included attempts to convince farmers that specialisation and scale increase were rational and economically profitable. This was not easy, because of the view that mixed farming was a rational strategy (Crijns 1998). The transition thus entailed a shift in (perceptions of) rationality and economic attitudes.

To convince farmers, extension services organised trips to experimental model farms, which materialised the new vision of specialisation, rationalisation and mechanisation (Karel 2005). The Ministry also subsidised regional improvement projects, which stimulated collective and experiential learning (Figure 6). Local communities were required to develop a four-year plan, administer the allocation of resources and monitor progress (Duffhues 1996). Projects thus stimulated the build-up of local networks between farmers, local NFA's, the mayor, the priest, the agricultural

schoolteacher, which enhanced the legitimacy of agricultural reform. The projects also stimulated learning processes, the acquisition of new skills (bookkeeping, investment calculations) and attitude changes (Karel 2005).

In the early 1960s, young farmers were the first to make the shift towards specialised pig farming (Crijns 1998). One reason was that the agricultural schools had taught them the required new skills and attitudes, such as bookkeeping and agricultural entrepreneurship (Duffhues 1996). Another reason was the limited availability of land for mixed farming, especially on the sandy soils of Noord-Brabant and Gelderland. Intensive animal husbandry, which required little land, thus provided farmer's sons an opportunity to start a new business (Crijns 1998).

Other farmers initially labelled these specialised pig farmers as 'gamblers' and 'daredevils' (Termeer 1993). This perception was related to the hesitation of most farmers towards borrowing money. In the 1930s, they had experienced that financial dependence might threaten farm survival if economic conditions worsened. Farmers therefore usually financed investments from their savings (Crijns 1998). But young farmers, who had learned book-keeping and entrepreneurship skills, were less hesitant about investing with borrowed money. When these specialised pig farmers achieved good economic results, mainstream attitudes and perceptions began to change by the late 1960s. In the context of positive external conditions, such as governmental support measures, cheap food imports, and the Common Agricultural Policy, many more farmers therefore changed to specialised pig farming in the 1970s. To reduce the financial risks, many of them adopted a new organisational form: 'contract-farming'. This meant that farmers worked for feed companies or meat processing industries that moved into the pig farming business (see Section 2.1). This provided more certainty, but implied that farmers lost their independence and became salaried employees (Crijns 1998). While farming used to be steeped in tradition, it was thus increasingly seen as a normal salaried job.

From this ontology, the enactment of the transition thus involved new attitudes and perceptions, but also hesitations, doubts, debates and new roles for different actors.

3.5. *Structuralism: cultural traditions, ideology and discourse*

General ontology

Structuralism perceives actors as embedded in cognitive-cultural deep structures (*mentalité*, ideology, belief systems) that create a 'deep grammar' of society. Exemplars are structural anthropology (Lévi-Strauss) and traditional philosophy of technology (Heidegger, Ellul, Horkheimer). This monolithic and 'massive' view of culture, which operates 'behind the backs' of actors, leaves little room for agency and change. Since the late 1980s cultural sociology therefore focuses more on dynamics interactions between actors and culture. In their struggles over legitimacy, actors use cultural symbols and repertoires in more strategic ways (Swidler 1986). Structuralist scholars explain transitions by looking at changing traditions, cultural framing and ideology.

Explaining the pork transition

Structuralism highlights several longer-term cultural contexts that legitimated general policies and influenced meat consumption patterns.

(a) *Food culture*. The Dutch choice for a low-cost bulk strategy in the pork transition was partly influenced by an instrumental food culture, which values low prices more than high quality (Table 6).

The alternative modernisation route of flexible specialisation (high quality/high cost strategy) was therefore less likely in the Netherlands than the low-cost mass production route.

Table 6. Different (European) food cultures (Jobse-Van Putten 1995, 529).

Instrumental: eat to live	Quality: live to eat	Joy: Mediterranean kitchen
North-West Europe (Britain, Netherlands, Ireland, North-Belgium)	Central Europe (France, Germany, Denmark, South-Belgium, Luxembourg)	Southern Europe (Portugal, Spain, Italy, Greece)
Price-sensitive	Quality-sensitive	Pleasure motive
Quality less important	Price less important	Fresh products
Food is necessary, not pleasure	Food is social event	Food is social event
Many processed foods	Both processed and unprocessed foodstuffs	Mainly unprocessed foodstuffs
Fast and convenient	Traditional	Very traditional

The instrumental food culture has been taught and reproduced by domestic science schools, which were especially popular between 1930 and 1970 in preparing girls for a housewife career (Montijn 1991). Domestic science schools embodied values such as sobriety, hygiene, thriftiness and convenience, and taught girls how to cook tasty, nutritious meals with little money. In the middle-class ideology, which experienced its heyday between 1920 and 1970, women could achieve status and appreciation as ‘kitchen princess’. As food and meals became expressions of care and nurturing, the interest in cookbooks, magazine recipes and culinary advertisements grew (Montijn 1991). This was accompanied by a shift in the composition of meals. In the early twentieth century, most families ate one-pan dishes (e.g. stews, hotchpotch), where other ingredients could hide the often poor quality of meat (Jobse-Van Putten 1995).¹¹ In the pre-Second World War decades a gradual transition occurred towards the ‘standard Dutch meal’, consisting of two bread meals and one hot meal in the evening (Scholliers 1993). This hot meal usually consisted of three separate dishes: potatoes, vegetables and meat. As meat became the most important part of the meal, women paid more attention to its preparation. This is visible both in cookbook recipes, which paid special attention to meat (Segers 2005), and in the increasing relative expenditures on meat as part of the meal (Figure 7). Meat thus acquired high cultural significance before most families could buy it on a daily basis (Scholliers 1993).

(b) *Socio-political culture*. The 1950s and 1960s were characterised by technocracy, the belief that science and technology formed the rational basis for the improvement of society. This belief gave engineers, economists, sociologists and planners much influence in socio-political decisions. The Agricultural Economics Research Institute (AERI), for instance, functioned as an agricultural planning bureau, using models and calculations to influence and support agricultural policy (Van der Ploeg 2001). The experts had positive views on mechanisation as the best way to modernise agriculture (and society at large). The USA was seen as the guiding nation, because of its advanced position in agricultural modernisation, mechanisation and large-scale production. People who opposed modernisation were labelled as ‘backwards’, ‘traditional’ and ‘non-rational’, requiring them to be ‘educated’ through a dynamic ‘cultural offensive’ that aimed at changing their mentality (Karel 2005). This ideology also explains the strong reliance on extension, education and information activities, and legitimated their organisation in terms of a one-way linear model (from science to farmers).¹²

The discourse of rational planning and modernisation was accompanied by a rapid expansion of the state apparatus (policy makers, extension services, research institutes). There was a widespread

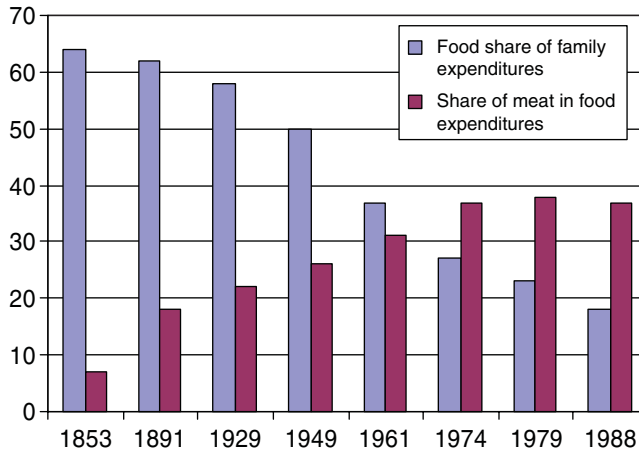


Figure 7. Relative share (%) of food within family expenditures, and share of meat (%) within food expenditures (Scholliers 1993, 135).

belief that the state should play an important role in the post-war reconstruction of society. This belief also provided public authorities with a societal mandate to restructure agriculture. This, in turn, provided legitimacy to the reform plans of the ‘green front’, supported by technical and scientific experts. It also explains why protests against the implementation of agricultural modernisation policies were relatively mild.

(c) *Beliefs about the societal significance of farmers.* Before the war, farmers were perceived as the moral backbone of society. They were presumed to have special virtues such as attachment to the land, solidarity, indifference to the whims of urban culture, common sense, hard work and thrift (De Haan 1993). This ideology explains why small farms were supported when they faced difficulties in the 1930s.

These cultural beliefs changed after the Second World War, when industry (steel, petrochemicals, electro-technical) gained in relative importance. Agriculture came to be seen as a normal economic sector that should contribute to the economy at large (De Haan 1993). As agriculture lost its special status, the willingness to protect farmers diminished. Assistance increasingly focused on growth and expansion, not on survival and continuation of tradition. Farmers were only helped if their business was economically viable. Otherwise, they should disappear (Nooij 1993). The ideology about the moral importance of farmers was replaced with new ideals centred around rational, entrepreneurial farmers ‘motivated by profit maximisation and an industrial lifestyle’ (De Haan 1993, 155). The new ideology provided legitimisation to the policy measures that stimulated the agricultural transition.

4. Strengths, weaknesses, and complementarities between the ontological explanations

Because the ontologies assume different causal agents and causal mechanisms, it is obvious that they provide different internally consistent explanations of the empirical case. But single-ontology explanations are also reductionistic, because they emphasise one causal mechanism at the expense of others. The juxtaposition of five different explanations has the advantage of providing a more encompassing understanding. Using this broader understanding, this section

makes an *empirical* assessment of the strengths and weaknesses of different ontological explanation. It also identifies precisely where these explanations complement or contradict each other in this case.

4.1. Rational choice

The strength of the rational choice explanation is the identification of micro-motivations for farmers. The analysis of factor costs, prices, investments and incomes helps to understand the economic benefits and self-reinforcing mechanisms that front-runners in the transition experienced. The rational choice analysis is also strong in explaining the economic drivers for the increasing influence of large agribusiness firms, and the declining independence of pig farmers, who became increasingly entangled in supply, processing and retail networks. The analysis of these economic networks usefully widens the scope beyond the farm gate, and incorporates dynamics along the pork chain.

One weakness is the assumption that farmers are rational entrepreneurs who always make cost-benefit calculations. As the interpretive explanation (Section 2.4) showed, this rationality did not automatically exist, but was actively created. Extension agencies, farmer associations and agricultural schools educated farmers to become rational agents, teaching them new methods and tools such as bookkeeping and accounting. Also attitudes about entrepreneurship, borrowing money, etc., were influenced through projects and home visits. The interpretive ontology thus complements rational choice, making rationality into an empirical topic rather than an assumption.

As farmers developed in the direction of rational agents, the influence of macro-actors (such as NFA's and Ministry of Agriculture) weakened. In the 1950s and 1960s this influence was strong because farmers respected and trusted these macro-actors (Sections 2.2 and 2.5). But during the transition farmers became less compliant and more self-interested. One example is the opportunistic response from farmers to the loopholes in Interim Manure Law (1984). This eroding influence from collective actors thus indicates a negative complementarity between rational choice and functionalist explanations.

Another weakness is that rational choice explanations assume that actors simply adopt the best available technology. This ignores the learning processes, development of new farming practices and acquisition of new skills that usually accompany the adoption of (radically) new technologies (Section 2.4). The focus on adoption of the best available technology also does not explain where new technologies come from. Technical change remains an exogenous variable or is assumed to arise from science (linear model of innovation).

Another weakness of rational choice is that it assumes that rationality is a clear-cut dimension. This assumption ignores changes in the definition of rationality (Section 2.4). The transition was not a shift from irrational to rational, but a shift from one rational strategy (mixed farming as hedge against risks of price fluctuation) to another (profit maximisation through specialisation).

4.2. Functionalism

The strength of functionalist explanation is the focus on new goals and visions that were relatively widely shared in the agricultural sector. The relative consensus about these goals and visions provided legitimacy for the policy instruments and structural adjustment programs, which were developed and implemented by the government and NFAs.

One weakness is that functionalism assumes a 'cockpit view' with political leaders, experts and NFAs developing new goals in the interest of the collective good. This kind of analysis not only has a managerial bias (technocracy, social engineering), but also downplays the local agency of farmers, who are either assumed to willingly implement the new goals or are seen as obedient and responsive to directives and plans from above. The interpretive ontology (Section 2.4) provides a rival explanation that delves deeper into farmer's practices and agency (interpretations, learning processes, negotiations). On the other hand, the societal deep structure (technocracy, ideology of strong state influence, modernisation discourse) provided a context in which Dutch farmers *were* relatively docile in the 1950s and 1960s, trusting and following collective macro-actors (Section 2.5). So, there is analytical complementarity between the functionalist and structuralist ontologies.

A second weakness is that the functionalist analysis says little about the specific *content* of the transition. It analyzes the broad goals and implementation of agricultural modernisation, but not the specific dynamics of pig farming. It shares this neglect with the rational choice ontology. Both ontologies explain the *speed* of change, but say little about the precise *content* and *form*. This is related to the conceptualisation of technological change, which in both cases is close to the linear model (from science to extension agencies to farmers). This one-way flow model ignores the local learning and negotiation processes (Section 2.4) and the bidirectional user–producer interactions.

Third, the functionalist analysis does not really explain the *origins* of the new goals and visions. It is implicitly assumed that the new goals are *logical* responses to the shocks of the Second World War (hunger, insufficient agricultural production). The interpretive ontology, however, provides a deeper complementary analysis that shows how the new vision emerged from changes in discourses and problem framing (Section 2.4).

Fourth, functionalism downplays conflict and power, because of its focus on consensus and shared goals. It neglects the contestation from farmers who went out of business (the 'losers' in the transition) and groups with other values (environment, animal welfare). The functionalist analysis thus hides the fact that the transition advanced some interests (agri-business) at the expense of others.

4.3. Power struggle

The power struggle analysis usefully highlights the conflicts between winners and losers during the transition. It shows that a powerful coalition was able to push through its agenda, thereby advancing certain interests over others. Protests were ignored, sidelined, smoothened with payments or silenced through force. There is no assumption that policy makers act for the collective good (as assumed in functionalism). Instead, political goals and instruments are seen as deeply influenced by particular (corporatist) interests and policy networks.

One weakness in the power struggle analysis is the exclusive focus on *political* decision-making and *overt* coercion. Lukes (1974), for instance, distinguishes two additional 'faces of power': (1) covert power to place issues on or keep them off the agenda (this was partly visible in the Agricultural Ministry's delay tactics regarding manure pollution), (2) power embedded in ideology and discourses; this kind of power influences societal preferences and the legitimacy of particular reform programs; the structuralist explanations (2.5) provide useful complements here.

Secondly, while the power explanation usefully draws attention to interests in transitions, the precise definition of these interests remains unexplained. In an interpretive ontology, interests are not fixed and given, but arise from interpretation and definition. This also means that interests can change over time, something that the power ontology downplays.

4.4. *Interpretivism*

The strength of the interpretive analysis is an emphasis on the enactment of transitions, which occurs as stepwise process with debates, hesitations, doubts, learning processes, and changing perceptions. The interpretive analysis thus contests the suggestions of intrinsic logic in transitions that can be found in some of the other explanations, especially rational choice and functionalism. The interpretivist analysis also contests the view that the transition was a one-way, top-down implementation of new goals and visions (section 2.2). Instead, it highlights the local agency of farmers, who enact bottom-up learning trajectories and create community-based innovation networks. These learning processes were not only about the adoption of new technologies, but also about changes in perceptions, attitudes towards borrowing and entrepreneurship, and accounting skills. While broad visions may provide general directions for transitions, local learning processes are important to work out specific trajectories and develop appropriate routines and skills.

The interpretive analysis further complements the functionalist ontology by explaining the origins of the new vision, which relates to changes in the problem definition of small farms (between 1945 and 1960). In that sense it situates the roots of the transition earlier than the preceding three ontologies. The analysis further conflicts with the functionalist view, in showing dissensus about goals and visions within the green front (with national farmer's associations initially contesting the government's modernisation vision). Closure and consensus in the corporatist coalition did not exist automatically, as functionalism assumes, but was actively constructed. Alternative modernisation visions (flexible specialisation and high-quality, high price strategies) were possible (and actually proposed by some actors), but not chosen. Hence, the mass production pathway had no intrinsic logic (Van der Ploeg 2001).

A weakness is that the interpretive ontology gives little attention to broader institutional structures and economic processes. The analysis assumes much freedom of local agency, suggesting that 'things could have been different'. Other ontologies provide useful antidotes here. The rational choice analysis showed that declining prices and incomes *did* provide incentives for changes in certain directions (section 2.1). While flexible specialisation was, in principle, an alternative to mass production, the latter was more likely because it linked up with societal deep structures, e.g. Dutch food culture that emphasised low costs instead of high quality (section 2.5). Rational choice and structuralist ontologies thus provide useful antidotes against assumptions of too much 'free' agency in interpretivist explanations.

4.5. *Structuralism (cultural discourse)*

One strength is that structuralism analyses the macro-view, which situates the agricultural transition in broader contexts. It does not provide integral explanations, however, but complements explanations in other ontologies. It complements the functionalist explanation (section 2.2) by analysing the broader political culture which enhanced the social status of authorities in the 1950s and 1960s. It also complements the interpretive explanation by providing a broader analysis of Dutch food cultures that help explain the choice for a low-cost, mass production path.

Another strength is the attention for the consumption side and the embeddedness of user preferences in long-term processes (e.g. changing discourses about middle class ideology, changing roles of the meal in family life, growing importance of meat as separate dish).

A weakness is that structuralist explanations, which operate 'behind the backs' of actors, pay little attention to agency and tend towards cultural determinism. This problem can be alleviated

by complementing structuralist views with other types of explanations. Cultural deep structures then form a context on which actors can draw, e.g. to provide legitimacy for political programmes.

5. Concluding remarks on meta-paradigm analysis

While Section 3 provides a juxtaposition of different ontological explanations, Section 4 demonstrates that specific complementarities exist (in the particular case), which points to richer explanations. This concluding section therefore develops some further thoughts about the issue of meta-paradigm analysis, mentioned in the introduction.

With regard to general combination, I distinguish four positions that scholars have taken with regard to different ontologies: (1) *Full integration* into an overarching synthesising theory, (2) *Incommensurability*: combination is not possible, because ontologies cannot be ‘measured’ in the same units (have different focus and assumptions), (3) *Eclecticism*: bits and pieces of different ontologies can be combined without much concern for differences in theoretical foundations, (4) *Crossovers and meta-paradigm analysis*: combinations are possible, but constrained by ontological assumptions.

The first position is problematic, because the ontologies have different theoretical logics and different epistemologies. They have different theoretical logics, because they make different assumptions with regard to two sociological problems. The first is the problem of order, i.e. how is order created. One extreme assumes that order is externally created by collective phenomena. Another extreme assumes that order arises from individual micro-interactions. The second is the nature of reality and the motivations of action. One extreme assumes that reality is objective, with actors having fixed preferences. Action is seen as instrumental and motivated by material interests. The other extreme assumes that reality is subjective, with actors having fluid preferences and identities. Action is seen as motivated by ideas, meanings and norms. The combination of these two dimensions leads to a 2×2 -matrix which articulates the theoretical logic of different ontological positions (Figure 8).

Because of these foundational oppositions it is difficult integrate the ontologies in a synthetic meta-theory. Attempts in this direction (e.g. Giddens, Bourdieu, Alexander) have been criticised for abstract theorising about philosophical principles rather than sociological mechanisms, for coining new words that restate foundational tensions without solving them and for a general dissociation from the empirical research (Burger 1986; Van den Berg 1998).

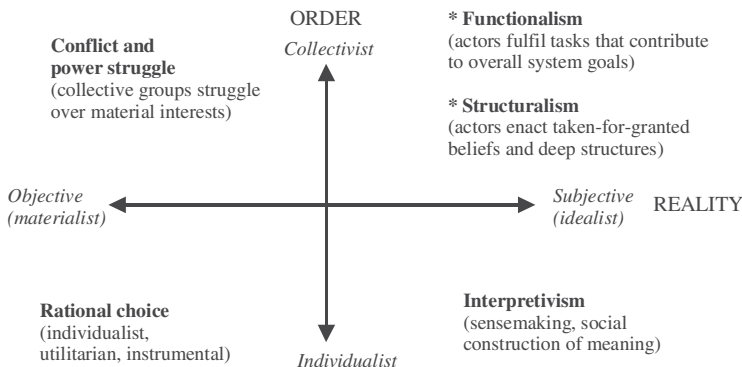


Figure 8. Theoretical logic of different ontologies (adapted from Ritzer 1992, 545).

Synthetic integration is also difficult because ontologies are associated with different epistemological styles and views on theory. DiMaggio (1995) distinguishes three styles: (1) 'theory as covering laws', which provides explanations by drawing on general laws; the emphasis is on objective and measurable factors that together produce outcomes (variance theory, positivism), (2) 'theory as narrative', which explains social processes as sequences of events that are enacted by social groups in situated contexts; because actors may change their identity, perceptions and interests during the process, explanation requires an understanding of the changing motivations of actors (process theory; hermeneutics, *Verstehen*), (3) 'theory as enlightenment', which aims to clear away conventional notions and uncover hidden structures or interests (critical theory, deconstruction). In terms of this distinction, rational choice and functionalism are associated with the first style, the first drawing on economic laws and the second on social logics. Interpretivism is associated with the second style, and structuralism with the third. Work in the power ontology can be associated with all three styles, e.g. Marxism looking for general laws, business strategy and international relations studying the dynamic moves and countermoves in strategic games, and the Frankfurt school criticising foundational structures of Western societies. These epistemological differences further complicate full integration of different ontologies.

The second position, incommensurability, assumes that interaction between ontologies is impossible. It thus privileges 'normal science' that stays within existing paradigms and hinders theoretical innovations through 'new combinations' between ontologies. It also leads to reductionism, which is problematic for heterogeneous topics such as socio-technical transitions. It is also at odds with the analysis in Section 4, which did find crossovers and complementarities.

The third position, eclecticism, can produce workable frameworks for particular purposes (like good engineers can combine technical elements without caring too much about the underlying scientific foundations). The risk, however, is that *ad-hoc* combinations leads to inconsistencies and frameworks that remain unclear about dynamic relationships between conflicting concepts.

The fourth position, crossovers and meta-paradigm analysis, focuses on interactions and relations between ontologies, not integration into a synthetic theory. Different ontological positions are respected, not conflated and merged. This position does not perceive the ontologies as pieces in a jigsaw puzzle, but also does not accept that they are fully incommensurable. Instead, it is interested in dynamic crossover mechanisms through which different ontologies can interact (Hedström and Swedberg 1998). While this position preserves opposition between ontologies, it searches for 'paradigm interplay', which 'accentuates interconnections and differences among paradigm representations, fostering an appreciation of how paradigm insights and limitations are most apparent from an opposing view' (Lewis and Kelemen 2002, 265). In order to deal constructively with foundational oppositions, scholars become increasingly interested in pluralism, ambivalence, paradox, and dynamic tensions (Poole and Van de Ven 1989b; Eisenhardt 2000; Lewis and Kelemen 2002). This has resulted in crossover approaches that capture dynamic relations between agency and structure, change and stability, rational strategy and embeddedness, for instance under headings such as actor-centred institutionalism, economic sociology, institutional entrepreneurship, cultural sociology. In terms of epistemological styles, most of this work belongs to the tradition of process-theory and narrative explanation. While this work sacrifices some parsimony (as in single ontology-work) and generality (as in full synthesis), it gains accuracy and realism.

The above assessments suggest that the fourth position is the most tenable and promising one. With regard to socio-technical transitions, this position is backed up by the analysis in Section 4, which empirically demonstrates that crossovers and complementarities between ontologies are

possible and lead to richer insights, at least in this particular case. Research that acknowledges the existence and relevance of multiple ontologies is important for socio-technical transitions, because these are multi-dimensional phenomena whose co-evolutionary characteristics cannot be fully understood from single ontology-work that remains within the boundaries of existing disciplines. It is hoped that this article contributes to more explicit and more reflexive work on multi-paradigm approaches of transitions (see for instance Geels (2010), on theoretical work in this direction).

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Notes

1. The notion of 'global model' does not refer to geography but to a particular kind of theoretical explanation.
2. A well-known exception is Allison (1971), who analysed the Cuban missile crisis from three ontological models (rational choice, power struggle and functional division of labour).
3. Agricultural statistics before 1960 provide no information about specialised pig farmers, because this category did not yet exist.
4. The use of antibiotics later became controversial, because of another side-effect: some viruses and diseases developed resistance to antibiotics, which created new public health risks (Boyd 2001).
5. 1 guilder = €0.45.
6. The Meat Inspection Law also withdrew exemptions for home slaughtering. Subsequently, the number of pigs slaughtered at private homes rapidly declined from 250,760 in 1955 to 37,793 in 1970 (Agricultural Economics Research Institute 1972).
7. Most of the money went to land consolidation projects, which had less impact on pig farming. Land consolidation entailed land redistribution to create larger patches of land, but also infrastructural projects such as the smoothening of land surfaces, improving canals and drainage ditches, constructing regional roads, piped water and electricity infrastructures.
8. Initially the Ministry of Agriculture ignored the problems (Frouws 1994). The White Paper on *Intensive Animal Husbandry* (1974), for instance, trivialised manure problems, emphasising instead the economic successes and technical performance improvements in the sector. In the mid 1970s, the Ministry blocked all regulations proposed by the Environmental Ministry, arguing that agriculture was their domain of responsibility (Frouws 1994). The Agricultural Ministry also frustrated attempts by the independent Central Bureau of Statistics (CBS) to collect and analyse quantitative data about the number of pigs, the minerals in their diets, and manure production. Between 1974 and 1982, the Ministry prevented the publication of CBS manure-reports by challenging technical calculations, demanding extreme standards of accuracy, and pointing to uncertainties in calculations (Termeer 1993). The lack of quantitative CBS-data hindered effective policy making. The CBS-report was finally published in 1984 (Frouws 1994).
9. The corporatist networks were institutionalised in the Foundation for Agriculture (1946) and the Agricultural Board (1954), where the NFA's consulted with the Ministry about agricultural policy.
10. Between 1890 and 1910, the number of small farms (<5 ha) grew from 76,910 to 109,620 and then remained more or less constant until 1950 (Somers 1991).

11. In the absence of refrigerators and year-round fresh meat, families usually preserved meat through curing, salting, or vacuum preservation in glass bottles. During winter and early spring, many people therefore relied on preserved meat, the quality of which gradually deteriorated with time.
12. Despite the ideology, the knowledge system was more complex in reality, with multi-directional flows between farmers, experimental stations and universities.

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