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Monocausalism versus Systems Approach to Development – The Possibility of Natural Resource-based Development

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Abstract: *Development economics has over the years produced several one-factor explanations that we term as "fundamentalisms". The authors argue that these fundamentalisms are interdependent and complement each other, and hence, the process of economic development must be understood as systemic. The focus is on "production-structure fundamentalism" in the form of the resource curse. By use of empirical examples it is argued that resource-based development is possible by building institutions supporting development of new knowledge and competences. The paper concludes that rather than individual development factors, it is the by institutions sustained interdependency and interaction between different types of development factors that underlie development processes.*

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1. Introduction

There exists a deep mistrust among many scholars, especially economic historians, relating to monocausal explanations of development: *"Economic analysis cherishes the illusion that one good reason should be enough, but the determinants of complex processes are invariably plural and interrelated. Monocausal explanations will not work*" (Landes, 1998:517). That notwithstanding, a strong focus on one single factor, which is believed to be the basic development factor or root cause of development, to some degree, continues to characterise development thinking and development policy. There has been a tendency to focus excessively on one single factor as driver of development before the focus shifts to another factor (Adelman, 2001).

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We may describe such monocausal explanations as “fundamentalisms”. A single or narrow set of factors are regarded as fundamental, i.e. as the main cause of development. Accordingly, we can identify elements of at least “market fundamentalism”, “institutions fundamentalism”, “knowledge fundamentalism” and “structure fundamentalism” in recent development thinking. The tendency to seek monocausal explanations, while often casting light on both the benefits and limitations of specific, “fundamental” development factors, underestimates the complexity and context dependency of economic development and stands in the way of formulating usable development strategies and policies.

Economic development as a discipline is less than half a century old but it has already produced a number of conventional wisdoms, which can be challenged. One of them is that structural change necessarily moves in one specific direction - from the primary sector to the secondary sector towards the tertiary sector, i.e. from agriculture and natural resource-based activities, to industry and towards services. A peculiar version of this way of thinking is that the primary sector is cursed and cannot be the basis of good development. Manufacturing activities are seen as the fundamental driving force in development, which dismisses a proactive role for natural resource-based industries. Consequently, an economic structure which relies heavily on natural resource-based industries is a “bad” structure. The resource-curse argument may be seen as a kind of reversed fundamentalism. It is a one-factor explanation for the absence of development. Resource-based activities are regarded as a developmental blind alley, which distorts the mechanisms of resource allocation and prevents economic growth. By critically scrutinising this form of “structure fundamentalism” the authors illustrate the weaknesses of monocausalism by demonstrating that much of the weakness in fundamentalism thinking stems from its association with an endowment approach which has optimal allocation of scarce resources at its core. If one, on the other hand, takes a process approaches to fundamentalisms, it is apparent that factors of development interact and feed on each other over time in processes of learning and innovation. It is argued that the various monocausal explanations should be integrated in a framework capable of grasping a fuller interactive picture of development, and that natural resource-based development can be a viable development strategy. On this basis, the authors suggest an innovation systems framework as a workable approach for grasping the complexities of economic development. The paper is thus mainly conceptual. The authors’ analysis is of particular relevance for natural resource-based economies but the conclusions are valid for development in general.

In the next section, we discuss the types of fundamentalism mentioned above. In section three, we consider the role of natural resources in structural change on the basis of structure fundamentalism using empirical examples. In section four, we argue that disagreements about the role of natural resources are rooted in different approaches to economics. Section five presents an alternative conceptual formulation of the role of economic structure in development. Section six summarises the differences between these conceptual models by outlining a distinction between an endowment approach and a process approach to economic development. The paper concludes with a short discussion on approaching the study of economic development and overcome fundamentalist tendencies.

2. Types of Fundamentalism

2.1 Market Fundamentalism

During the "Washington Consensus" in the 1980s and 1990s, it was widely believed that policies for macroeconomic balance (which, oddly enough, did not include full employment) should be at the core of an effective strategy for development. Balancing state budgets, using restrictive monetary and fiscal policies to curb inflation and adjusting exchange rates to reduce current account deficits were referred to as "getting policies right". This was combined with institutional recommendations which were supposed to strengthen the market mechanisms; financial liberation, trade liberalisation, openness to foreign direct investment, deregulation, privatisation and secure (private) property rights (Amsden, 1992; Chang, 2002; Wade, 1990). This policy stance – stabilise, privatise, liberalise and let markets do their job – has been referred to as "market fundamentalism" (Rodrik, 2006).

The confidence in the Washington Consensus eroded during the 1990s and there is now widespread agreement that it didn't work – even within the Bank (World Bank, 2005). The transition in Eastern Europe was accompanied by a long and deep decline in spite of efforts to privatise and liberalise. Sub-Saharan economies failed to take off in spite of policies inspired by the Washington Consensus. Financial crises in Latin America, East Asia, Russia and Turkey as well as disappointing growth rates in Latin America were a reflection of the failure of the Washington Consensus; developing countries that didn't adopt the Washington Consensus (especially China and India) on the other hand, did very well (Rodrik, 2006).

2.2 Institutions Fundamentalism

As a result of its failure, market fundamentalism developed into a kind of "institutions fundamentalism". The new slogan "get the institutions right" was substituted with the earlier one "get the prices right" (Rodrik, 2006). "Good governance" became the new jargon among one-factor explanations for development. This now very common term typically includes notions such as "the rule of law", "political accountability", "transparency in policy-making" and "quality of bureaucracy" (Kaufmann and Kraay, 2007).

A rather clear empirical correlation between good governance and the level of national income has been demonstrated over broad groups of countries and this is one reason it has become an important target among development aid donors and in the World Bank[1]. Institutions fundamentalism which concentrates on good governance can be placed within the transaction costs school. The policy approach is to support the kind of institutional changes which are thought to reduce transaction costs. Such institutions fundamentalism fits better with static efficiency than with long run growth and development. It is close to weak (in contrast to strong) institutionalism (Coriat and Dosi, 1998) and new (in contrast to old) institutionalism (Hodgson, 1998). There are, however, also examples of more dynamic types of institutions fundamentalism. For example, Douglass North focuses on how institutions shape incentives for change. "Efficient" property rights form incentives which induce people to make growth-inducing decisions. Under efficient property rights, it does pay for people to save and invest in production, education, research and so on. In contrast inefficient property rights can lead to rent-seeking[2] behaviour or even to directly harmful activities like piracy, violent crime and warfare (North, 1990).

The problem with institutions fundamentalism is that it tends to disregard other development factors, especially the interactions between technological and institutional change, and that it focuses on a too-narrow set of institutions, i.e. primarily those related to transaction costs. Furthermore, it tends to underestimate the importance of context dependency for the effects of institutions. Every specific institution works differently in different contexts which makes it difficult to predict the economic outcome of simple institutional recommendations such as "reduce corruption" or "strengthen property rights".

2.3 Knowledge Fundamentalism

In knowledge fundamentalism, knowledge is taken as the root cause of development. It asserts that knowledge transfer from the North to the South and improved exploitation of knowledge constitutes a tremendous but underutilised opportunity in development. The roots of knowledge fundamentalism go deep in economic theory. According to Marx (1859), development of the "forces of production" (an expression for technology or knowledge) is the main source of social and economic change, and Marshall (1890) stated that "…knowledge is the most powerful engine of production; it enables us to subdue nature and satisfy our wants".

But knowledge fundamentalism in development theory and policy is more recent. It can be traced to the exaggerated expectations about the development power of human capital that were common in the 1960s and 1970s, when the previous focus on investment in physical capital gave way to investment in human capital. It was also triggered by the developmental success of some East Asian countries, which prioritised the accumulation of human capital before embarking on intense industrialisation. Early contributions to new growth theory also imply that investments in knowledge and human capital are able to lift developing countries from a low-growth to a high-growth path utilising economies of scale (Adelman, 2001).

More recently, also the World Bank has emphasised the role of knowledge and knowledge diffusion in development. "*Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. ... This World Development Report proposes that we look at the problems of development in a new way – from the perspective of knowledge (p.1)*" (World Bank, 1999). The oversimplification that characterises one-factor explanations is clear from this quotation, which seems to follow the standard assumption in mainstream economics that it is legitimate to reduce knowledge to information, which floats more or less freely between countries[3]. It should also be acknowledged that scholars who have emphasised knowledge as fundamental in economic development as a rule have realised that it doesn't stand alone. Marx, for example, not only underlined the development of the "forces of production" but also placed it in a dialectical interaction with the "relations of production", which primarily refers to the relations defining and enforcing the property rights to capital.

2.4 Structure Fundamentalism

Structure fundamentalism is premised on the belief that the most important factor for economic development is the country's industrial structure. Most now-industrialised countries have gone through a similar process of structural change during their development process. Applying the tripartite classification of primary, secondary and tertiary sectors, the composition of GDP has moved away from primary production (agriculture) towards, first, secondary production (manufacture) and then tertiary production (services) (Kuznets, 1971). This pattern of structural change has the status of a stylised fact which suggests that it is a necessary part of economic development. Moreover, the direction of structural change indicates that some economic activities are better than others for generating wealth. This implies that changing the economic structure is a fundamental aspect of development. These propositions are also found in resource-curse literature (see e.g. Gylfason, 2001; Sachs and Warner, 1995).

The argument is that natural resources will prevent an economy from embarking on a prosperous path of structural change and development because they are subject to a "pathological disorder" (Gunton, 2010). Following this logic, development policy should aim at changing the economic structure towards a structure dominated by higher shares of manufacturing and services, and consequently away from natural resource-based industry. Hence, 'getting the economic structure right' is the mantra of this fundamentalism. However, the argument does not fit well with the fact that some countries have *moved* away from being natural resource-based economies toward advanced, knowledge-based economies, as e.g. most Scandinavian countries and the United States. According to Smith (2007), it is a misunderstanding that all natural resource-based economies are poor. On the contrary, some of the richest, and/or fastest growing, economies today are resource based. The paradox shows that natural resources are not unambiguously 'bad' and that structure fundamentalism may be misleading.

3. Natural Resources and Development

The resource curse, and thus structure fundamentalism, argues that natural-resource abundance results in poor economic performance (Sachs and Warner, 1995). Though a correlation can be established the suggestions for causality are many. Here we explore two often suggested channels of causality: the Dutch Disease and the absence of linkages.

3.1 The Dutch Disease

Though prominent in the resource-curse literature, the Dutch Disease is really neither a disease nor Dutch. It is, according to Gylfason (2008), rather a recurring phenomenon that involves a reallocation of resources – for example from high-tech, skill-intensive service and manufacturing industries to low-tech, low-skill primary production – with lasting negative effects on economic growth and diversification. The name remains in use because the Netherlands was the first "patient" to be diagnosed. The Dutch Disease describes a situation where an economy suddenly receives windfall earnings from an unexpected discovery of natural resources – it is named after the Dutch discovery of natural gas in the North Sea in the 1960s. A gas export boom led to an appreciation of the Dutch Guilder, and subsequently total exports from the Netherlands decreased. The causality of the argument goes like this: (i) an export boom (of natural resources) leads to appreciation of the exchange rate which cet. par. tends to weaken the balance of payment; (ii) the export boom will draw capital and labour away from manufacturing sectors into the natural resource sector. This reallocation of resources will lead to an increase in cost of labour and materials (because initially the economy was in equilibrium) resulting in an increase in the general price level; (iii) because of the latter, and the currency appreciation, exports of manufacture decrease and the price of non-tradeables rises; (iv) foreign income from natural-resource export will in turn be used to import now cheaper foreign manufactured goods (spending effect).

Thus, as the natural resource-based industry grows, it attracts key labour inputs from the rest of the economy which benefits natural resource-based industry and the non-tradable sector. Since the starting point is that natural resource-based industry cannot lead growth and development, the process will inhibit long-term economic development by negatively affecting the manufacturing sectors. In general, the Dutch Disease has given precedence to a range of so-called crowding-out explanations for the resource curse. Scholars state that some factor x is positive for economic growth, and that "natural-resource abundance" in some way crowds out x. Such arguments have been put forward regarding foreign direct investment, social capital, human capital, saving, investment, financial depth and price stability (Gylfason, 2004). Even if we accept that natural resource-based industry is inferior to manufacture, then there are several degrees of freedom for the government to take counteracting measures.

The Dutch Disease is in effect a result of poor management relating to issues of institutions rather than a problem with natural resource-based industry per se. The argument rests on idealisation of manufacturing, acceptance of Malthus' (1798) argument, and a vast number of historical examples of staple traps. The latter is reflected by Matsuyama (1992) where he, in a two-sector model (about agricultural productivity) at the outset, assumes learning by doing in manufacturing and no learning in agriculture. One could argue that when operating under such assumptions, conclusions are given a priori. On the one hand, this negative perception is related to the idealising of manufacturing industries as growth poles. To explain the negative aspects of de-industrialisation, Palma (2008) states that "…manufacturing is an activity considered by many as the most effective engine of growth – either because it is a crucial driver of outward shifts of the production frontier, or due to its capacity to set in motion processes of cumulative causation based on increasing returns".

Hence, if manufacturing is good, then what is not manufacturing is bad. In addition, the Malthusian perception of natural resources as a fixed stock also feeds the negative perception. For example, Gylfason (2008) argues that natural resource wealth is a fixed factor of production that hampers economic growth because it causes increasing shares of labour and capital to go into diminishing returns activities. As an auxiliary explanation, Gylfason (2001) finds that in "natural-resource abundant" countries, investment in education is relatively poor. From this, he infers that workers in natural resource-based industry tend to have a relatively low level of education. Seeing human capital as a source of growth, Gylfason (2001) further infers that:

> "*natural resource-based industry as a rule is less high-skill labour intensive than other industries, and thus confers relatively few external benefits on other industries… primary production and primary exports tend to impede learning by doing, technological advance and economic growth* (p. 856)".

A general objection to this "negative" perception is the obvious omission in Malthus' argument of the role played by technological progress, which has continuously increased agricultural productivity. Ferranti et al. (2002) show that productivity growth in agriculture has outpaced that of manufacturing in both developed and less developed countries during the 20th century. More precisely, they find that in the period 1967 to 1992 total factor productivity growth was significantly higher in agriculture than in manufacture - especially in developed countries. On this basis, the authors conclude that:

> "*natural resource-based activities can have high productivity growth, technical spill overs, and forward and backward linkages as much as modern manufacturing … the view that manufacturing has something special must be called into question*" (pp.4–7).

The latter point indicates that the resource curse tends to confuse historical coincidences with universal laws.

3.2 Linkages and Natural Resources

In economics, it is generally thought that industries in the primary sector have fewer, or no, linkages to other industries compared with industries in the secondary and tertiary sectors. For example Humphreys et al. (2007) argued that:

> *"…unlike other sources of wealth, natural resource wealth does not need to be produced. It simply needs to be extracted. Since it is not a result of a production process, the generation of natural resource wealth can occur quite independently of other economic processes that take place in a country; it is in a number of ways, enclaved … without major linkages to other industrial sectors"* (p. 4).

The quote acknowledges the importance of linkage dynamics, but holds that natural resource-based industries are not relevant in that respect. It echoes the work of Hirschman (1958) on linkages who also excluded primary production from linkage dynamics:

> *"The lack of interdependencies and linkages is of course one of the most typical characteristics of underdeveloped economies... agriculture in general and subsistence agriculture in particular, are of course characterized by the scarcity of linkages effects. By definition, all primary production should exclude any substantial degree of backward linkage... the case for inferiority of agriculture to manufacturing has most frequently been argued on grounds of comparative productivity. While this case has been shown not to be entirely convincing, agriculture certainly stands convicted on the count of its lack of direct stimulus to setting up new activities through linkage effects: the superiority of manufacture in this respect is crushing. This may yet be the most important reason militating against any complete specialisation of underdeveloped countries in primary production"* (Hirschman, 1958: pp. 109-110).

Thus, the argument is that backward linkages are thought to be few because natural resource-based industry does not demand inputs. The input needed is nature, and nature is just there to be taken. Hence, backward linkages to science and capital goods are thought to be weak. Consequently, there is no application of sophisticated knowledge and no innovation. However, this is only true for the simplest perception possible of agriculture, as for example, picking an apple from a tree. Still, today much of agriculture and fruit production are knowledge-intensive and innovation plays an important role (Hirsch-Kreinsen *et al*., 2005). Backward linkages to infrastructure and especially transport are equally important (Watkins, 1963).

Forward linkages are thought to be few because end-products go directly to consumers or are used as input to other industries in the form of raw materials. Raw materials per definition do not need processing – they are grown right out of the earth's crust wherefrom they are easily collected. If they were processed, they would not be primary products. But these are simplifying assumptions rather than facts. As pointed out by Fischer (1952), it is not easy to determine the precise stage in the conversion of milk into butter or cheese when this work ceases to be primary and becomes secondary.

Natural resource-based industry products are most often processed even though it may not be to the same degree as secondary products. Regarding demand linkages, Engel's law is not misplaced when we talk of levels of income, but as pointed out by Marin et al. (2009), the last four decades of globalisation have been more about incorporating new consumers rather than sky-rocketing levels. Demand for natural resources is further unlikely to decrease due to (a) new niche natural-resource markets as ecological and sustainable products, and (b) the emerging techno-economic paradigm (bioenergy, biomaterial, nanotechnology and biotechnology) is closely related to the processing technologies in natural resource-based industries with respect to food, raw materials and energy (Pérez, 2010).

The understanding of primary production as exposed by Hirschman (1958) is supportive of the resource-curse literature. Combined, these studies have contributed to transforming context-specific experiences into a general conceptual model for understanding natural resources which is in accordance with the tripartite model of structural change. The latter stereotypic understanding ignores that the nature of economic activities tends to differ across time and place, and tends to underestimate or dismiss learning activities in natural resource-based industries.

3.3 The Nature of Natural Resources - Finiteness and Exogeneity

Underlying the resource-curse thesis is a perception of natural resources as finite and exogenous to the economy upon which the whole argument stands. We will promote an alternative and evolutionary understanding of resources which argues that the knowledge stock in a given country determines to which extent it is capable of identifying and utilising natural resources. For example, oil and minerals have been in the earth's crust as long as homo sapiens have inhabited the planet, but it was only very recently that we identified oil as a valuable source of energy. Thus, natural resources, to some extent, are social constructs.

Zimmermann (1972) points out that a resource is defined by its *function*. Coal is a resource in as much as it serves the function of generating energy for various operations. Without this function, coal would still be coal, but it would not be a resource. These remarks set the stage for a conflict between the viewpoints of natural science and social science:

> "*If nature is thought of as the universe, it may be considered constant… Nature in that sense is the topic of natural science. The social scientist is concerned, not with the totality of the physical universe, but with the meaning of nature for man, with that ever-changing portion of nature that is known to man and affects his existence. That portion is both expanding and contracting. It expands in response to increase in knowledge and improvement of the arts. Nature reveals herself gradually to man, but no faster than he can learn*" (Zimmermann, 1972: p. 80).

It is therefore possible to describe the natural scientists' view of nature as *nature*, and the social scientists' view as natural resources, see Table 1. In the interface between nature and natural resources, there are on-going processes of resource creation, resource obsolescing and resource extension[4].

Table 1: Nature and natural resources

Natural science (nature)	Social science (natural resources)
Constants of natural science	'Relatives' of social science
The world a bundle of hay – zero sum game	Non zero sum game
Natural resources *are*	Natural resources *become*
Abstract or physical perception of natural resources. Nature exists only because it exists, there is no function behind the existence of our planet and its characteristics.	Functional perception. A natural resource is a mean to an end, an end defined by man and society, which makes it functional.
Static perception of natural resources	Dynamic perception of natural resources
Land supply is given and fixed	Land: its function, yield and supply must be interpreted in relation to time, space and knowledge.
Nature = natural resources	Nature is converted to natural resources in a process of learning and knowledge accumulation

Source: Andersen, 2012

Rubber from the Amazon had been known to westerners for centuries but it was not until Charles Goodyear discovered 'vulcanisation' in 1839, that rubber became a resource (creation). It became a resource because his discovery made it possible to satisfy human wants with the use of rubber. Eventually rubber production from the Amazon region was overtaken by producers in South East Asia (obsolescing), and both were later overtaken by production of synthetic rubber (extension) developed during World War 2 (Zimmermann, 1972). Obviously, these processes are characterised by learning and accumulation of knowledge. Rosenberg (1976) argues that successful resource creation and extension have been the foundation of countries' capability to follow the shifts in dominant energy sources and materials that have characterised economic development in the later centuries. "Knowledge explosions" have historically undermined the tendency to diminishing returns to scale in natural resource-based industries.

The idea that natural resource-based production has few or no linkages – seeing them as exogenous to the economic system - contributes to a negative perception of natural resource-based industry for two reasons. (1) Linkages are about spread effects – how one thing leads to another. Without linkages, a sector can never generate structural change and development – it may finance it through exports, but it cannot "create" it. (2) Absence of linkages implies that innovation is absent with respect to inputs (freely available) and outputs (no further processing). It implies that growth of natural resource-based industries will not lead to diversification, but instead to poverty. As argued above, natural resources have, in principle, linkages of all kinds. Natural resources must be produced, and are not freely available in nature. Instead, they are extended and created through processes of knowledge development. In sum, linkages are essential for development, but as illustrated below, natural-resource based activities are not necessarily poorly linked to the rest of the economy.

3.3.1 Natural resources in Norway

Norway has historically been specialised in natural resource-based industries. During the 19th century, Norway responded to demands from the leading economy of the time, England, by increasing export of salted/dried fish and timber. The increasing transport of natural resources from Norway to England stimulated the development of shipping and shipbuilding industries as a backward linkage – by the 1880s, Norway had against all likelihood the world's third largest shipping fleet. As a response to the growing natural resource-based industries, several linkages to what we can call manufacturing appeared. Shipbuilding technology improved significantly, and production of intermediate products related to ship transport took off. Also, saw mills improved their equipment and implemented stream-driven saws in the 1870s. Norway actually started to export pulp and paper machinery in the 1890s. With respect to the fishing industry, whaling and canning took hold. In the 20th century, new natural resource-based industries appeared based on access to cheap energy. Development of capabilities in chemical and electronic engineering enabled Norway to exploit its waterfalls for production of hydroelectricity which attracted foreign investments in energy-intensive products as zinc, artificial fertilisers and aluminium (Cappelen and Mjøset, 2009).

Foreign capital played an important role during the 19th century, and foreigners had a strong presence in many areas. After independence from Sweden in 1905, Norway nationalised many sectors of the economy that were dominated by foreigners. Politicians implemented 'concession laws' that gave Norwegian authorities control over the relevant water resources. Still, the changes in law allowed for joint ventures between national and foreign enterprises, which according to Cappelen and Mjøset (2009) was aimed at developing a Norwegian knowledge base for the relevant engineering supply industries. Subsequently, manufacturing of turbines and machinery for power production became significant backward linkages from hydropower. Additionally, after World War 2, production of components for automobile developed as a forward linkage from the production of aluminium.

After World War 2, another natural resource-based industry was added to Norway's portfolio – oil and gas. When Norway discovered oil and gas, it did not possess the capabilities necessary to develop an oil industry, which stimulated a process of foreign capital inflow and suggested a dominant role for multinational enterprises. In the spirit of the earlier concession laws, Norway created a national oil company, Statoil, in 1972 which controlled oil extraction and distribution. The state in Norway had from the start embarked on a strategy of knowledge acquisition from foreign firms, and one of Statoil's main tasks was to organise learning and technology transfers. Also, universities invested in research and education in areas relevant for the oil industry. According to Cappelen and Mjøset (2009), policy was targeted at developing linkages between the oil industry and suppliers. For example, Statoil would exercise public procurement by placing orders with several old and new Norwegian firms, which resulted in old shipyards being converted into producers of oil-related technology. Mainly due to the rough Norwegian waters, a new design for oil platforms was developed. Norway developed several product innovations that would later be internationally competitive. Also, specialised engineering, ICT and other business services have benefitted from the development of the oil industry in Norway. It is remarkable to note that England, Denmark and the Netherlands also discovered oil and gas in the same period as Norway. While such discoveries were associated with harmful economic effects (to manufacturing) in the Netherlands, it actually strengthened manufacturing activities in Norway (Fagerberg *et al*., 2009).

The above reflects that the Norwegian state was actively building institutions and linkages to avoid "technological dependency". The institution-building facilitated processes of capability building in several complementary areas related to oil production. It is an example of how co-evolution between natural resource-based industry and manufacturing contributes to economic development, and where natural resource-based industry is actually "leading" the process.

3.3.2 Sugarcane in Brazil

The Brazilian experience in growing sugarcane and ethanol brings another perspective on linkages in natural resource-based industry. The industry is today heralded as a great example for biofuel production (Mathews, 2007).

Sugar production came to Brazil with the European colonization but remained enclaved for centuries. The first backward linkages appeared in the 1920s due to agricultural pests that forced the industry to develop a R&D defence system. This led to building linkages to agricultural research institutes, foreign researchers and creating a number of experimental stations to develop pest-resistant crops (Oliver and Szmrecsányi, 2003). Industrial growth and problems of importing machinery in the 1930s-40s led to the emergence of a local capital-goods industry that eventually supplied to the whole sector (Negri, 1977); it also in turn developed linkages to steel, pulp and paper, petroleum and automation industries (Andersen, 2011). Already in the 1900s, sugar producers experimented with sugar-based biofuels. A market for ethanol was created by government decree in 1931 (Moreira and Goldemberg, 1999) which linked the industry to the transport, chemical and energy industries. These linkages were up-scaled and gradually diversified during the 1960s when the military regime pursued agro-export led growth, and especially during the 1970s and 1980s when, as a response to energy crises, there was a large public investment programme on ethanol (Proalcool). Proalcool stimulated development of ethanol cars, ethanol-chemistry, vast infrastructure for transport and sale of ethanol, and innovation in production and processing of sugarcane (new cane varieties; new grinding systems, fermentation with larger capacity; use of vinasse as fertiliser; biological control of sugarcane beetle; optimisation of agricultural operations; automation of processes). The building and expansion of these linkages involved intensified interaction between sugar mills, universities, equipment producers and agricultural research institutes. As a result, mills have (in São Paulo) since the start of Proalcool achieved a 33% increase in sugar production per hectare; 8% more sugar extracted from cane; 14% efficiency improvement in conversion of cane sugar into ethanol and 130% productivity increase in the fermentation process (UNICA, 2007).

In the 2000s, further linkages were established: sugar mills became bio-electricity exporters (Goldemberg, *et al*., 2008); production of bio-degradable sugar-based plastics was initiated (Velho and Velho, 2006), ethanol-fuelled airplanes were marketed and experiments with ethanol as rocket fuel initiated (Silva and Fischetti, 2008; UNICA, 2009), application of modern biotechnology to develop better crop varieties, and experiments with 2nd generation ethanol technology forged links deep into R&D on enzymes, chemistry and plant genetics (Ragauskas *et al*., 2006). Sugarcane has developed a range of backward and forward linkages, and has thus, been able to stimulate learning and innovation activities broadly in the economy. It helps us acknowledge that natural resources are endogenous and that they can be created and extended via knowledge development.

3.3.3 Minerals and Oil in the US

According to David and Wright (1997) and Wright and Czelusta (2002, 2004) the US was in 1913 the world leader in mineral production. This was not because of a proportional endowment of natural resources – instead, it was a result of learning. Between 1900 and 1914, the US produced 10 times more copper than Chile even though Chile had, and has, a much larger geological endowment. The US mineral industries advanced in 1870s and 1880s due to huge capital investments, but the major breakthroughs took place in metallurgy and improved conversion processes such as the Bessemer process which allowed for a far higher exploitation rate of the mineral. Moreover, according to Wright and Czelusta (2002), there is reason to believe that the US leadership in minerals was a significant factor in shaping, if not propelling, the US path to world leadership in manufacturing. The US had significant "materials-using bias" in technical change in 9 of 20 manufacturing industries between 1850 and 1919 (Cain and Paterson, 1986):

> "*Nearly all US manufactured goods were closely linked to the natural-resource economy in 'one way or another': petroleum products, primary copper, meat packing and poultry, steel works and rolling mills, coal mining, vegetable oils, grain mill products, sawmill products, and so on. These observations by no means diminish the country's industrial achievement, but they confirm that American industrialisation was built upon natural resources*"(Wright and Czelusta, 2002: p. 5-6).

Among key explanatory factors for the US's experience in minerals are; (a) liberal and "softly" enforced legal environment; (b) investments in infrastructure and public knowledge as geological surveys; (c) education and research in mining, minerals, geology and metallurgy in which the US was world leader at that time.

Oil is an extreme example of the mechanisms just described. The discovery of oil as a valuable natural resource was made in the US despite the country's relatively poor natural endowment of oil. The first oil well was established in 1859. Gradually, the US built up the "American way of life" based on cheap oil and automobiles. By 1913, the US production of oil amounted to a little more than 60% of world production though majority of known oil resources were located in the Middle East (Mousdale, 2008). Often, American geologists were employed as consultants by oil firms to help locate deposits of oil in the ground. The industry quickly saw the value of scientific knowledge which created linkages between academia and industry. Young geologists used the national US geological survey to apply the novel anti-clinical theory to successfully locate oil deposits. The new theory led to better search methods. In sum, the oil industry invested in knowledge in geology to serve its activities which is reflected by the establishment of Berkley and Stanford Universities that born out of the oil boom in California. Also, there emerged an important linkage to the chemical industry. Actually, with the development of petrochemicals in the 1920s, oil became instrumental in the transition of manufacturing from traditional mass production to science-based technologies in the United States. Until the 1920s, the base material in chemical industry had been mostly coal but this changed radically in the following years. The shift from coal to oil as a principal raw material made the United States a world leader in chemical industry. A drive for diversification created important forward linkages wherein new industries were created on the basis of new knowledge.

Thus, it was not the abundance of natural resources per se (in terms of deposits) that propelled the United States to world leadership, but learning and capability building; in addition, the development of manufacturing industry was directly related to the development of natural resource-based industries.

3.4 Different Approaches

The empirical examples and theoretical arguments support the notion that natural resource-based industries can play an important role in development. The different perspectives on natural resources are consequences of different analytical foci. If one perceives natural resources as exogenous and finite, then an obvious analytical focus would be to discover the most efficient use of these scarce resources. On the other hand, if one perceives natural resources as endogenous and non-finite such that scarcity changes with knowledge accumulation, the analytical focus would also include a search for understanding the processes of resource creation. To understand long-term development, it seems less important to study allocation of current resources than taking a dynamic perspective in which resources are both created and utilised. The difference between the approaches can be conceptualised as an "endowment approach" (static) and a "process approach" (dynamic) to economic development.

In the endowment approach one focuses on the given stocks of resources at disposal. These are subject to prices that are mainly set by conditions of scarcity. Considering current and estimated future consumption together with current and estimated decrease in global supply, it is possible to establish a scenario whereby one can determine when a specific resource will be depleted, and the nature of price movements. Based on this information, it is possible to calculate an 'optimal' extraction and sales rate of energy resources, which maximises income from deposits (see e.g. Hotelling, 1931). This view implies that given endowments and demand, the price of energy will rise continuously as will the share of GDP going to energy consumption. Based on such a view, W.S. Jevons (1866) argued:

> "*I draw the conclusion that I think anyone would draw, that we cannot long maintain our present rate of increase of consumption; that we can never advance to the higher amounts of consumption supposed. But this only means that the check to our progress must become perceptible considerably within a century from the present time; that the cost of fuel must rise, perhaps within a lifetime, to a rate threatening our commercial and manufacturing supremacy; and the conclusion is inevitable, that our present happy progressive condition is a thing of limited duration*" (p. 242).

The situation would look different in a process approach where it is recognised that (a) deposits of energy often increases significantly via improved search, (b) sources of energy has often changed (in modern economies), (c) it is often possible to find substitute sources, (d) the ability to change energy sources is partly determined by prior innovation and capabilities, (e) energy is a source of competitiveness making productivity in extraction and conversion important and, (f) experiences and incomes from the process of energy resource utilisation may be used to build new competences in activities which are not immediately related to these resources (Rosenberg, 1976). A process view thus implies an active rather than passive approach to the economic exploitation of energy deposits even when there are vast reserves. The different perspectives and analytical consequences are summarised in Table 2.

Table 2: Endowment versus process approach to natural resources.

Parameter	Endowment approach	Process approach
Nature vs. natural resources	- Static, finite, zero-sum game - Physical perception like natural science - Land is fixed - Nature = natural resources	- Dynamic, alterable, non-finite, positive-sum - Functional perception in social science - Land-function can be extended via learning - Nature is converted to natural resources in processes of learning
Finiteness	Natural resources are finite and thus subject to 'decreasing returns to scale'.	Not necessarily finite. Important natural resources changes over time according to knowledge accumulation.
Linkages	Natural resources are freely available in nature - linkages	Not freely, they are produced. Creates linkages across the tripartite classification
Learning	Because of decreasing returns to scale and absence of linkages learning potential is limited.	Significant learning potential
Exogenous, endogenous?	Natural resources should be seen as an exogenous, independent stock of raw material	Natural resources are clearly endogenous because of their dependence upon stock of knowledge
Natural resources and development	Contradiction – natural resources are cursed, and will therefore block structural change.	Co-evolution – natural resources *can* serve as a base for diversification of the economy (structural change) via learning processes and linkage building
Policy consequences	Get out of natural resource-based industry, and into manufacture and services	Explore the role of natural resources in specific contexts. Focus on linkages and learning

A process approach takes on a dynamic perception of natural resources, and is thus, incompatible with both the resource curse and the tripartite understanding of structural change. It has been shown that manufacturing and services are not necessarily always "better" for development than natural resource-based industry. One flaw of the resource-curse argument is that it rests on an endowment rather than a process approach to economics. The latter seems better suited for understanding processes of change regarding natural resources. In the next section, an alternative conceptual model of structural change is presented which incorporates a process approach to natural resources and structural change.

4. A Process Approach to Structural Change

The observed structural changes are undeniable but the causalities involved and the underlying processes are not convincingly explained in the tripartite conceptual model.

Kuznets (1971) noted that in 1948, over a third of the total value of manufacturing was accounted for by economic activities that did not exist in 1880, or had such a limited size that they in total only produced 3.2% of total manufacturing output (p. 319). It is clear that the automobile industry together with some related industries[5] are very important growth industries in this period. Even though the growth rate of this subsector of manufacturing was higher in the period 1880-1914 than in 1914-1948, its increase in the share of the value of output grows more in the second period. Kuznets interprets this observation as a non-linear trend in the development of industries. An industry will make its growth potential count not in the early turbulent phases of its growth, but only when it has a sufficiently large volume for its above-average growth to make a substantial contribution to the aggregate income. In consequence, one has to pay attention to both volume and price movements in order to understand an industry's contribution to national GDP. The latter implies that economic growth does not emanate from a specific economic structure, but rather from shifts in it. Thus, which industries that can be identified as being "good" for aggregate growth change over time. Kuznets further argued that these changes in the economic structure were both outcomes and drivers of innovation. These findings indicate that it may be more interesting to focus on shifts in economic structure than to claim that there exists a best structure for development.

In accordance with these considerations Lundvall (1985, 1992) proposes that viewing the economic structure in terms of vertical connections instead of horizontal ones can improve our understanding of the underlying mechanisms of structural change and the interactions between industries[6] - i.e. by taking a process approach. In line with Kuznets, Lundvall argues that innovation is the main driver of structural change and development. In a vertical structure, every part interacts with its input producers and/or users of output. Innovation often emerges in the interaction between different actors that are part of the vertical chain – a user-producer approach where interactive learning is the key process. This entails interdependence between users and producers in a vertical relationship– and the performance of the vertical as a whole depends on each component within it, as well as the institutional framework it is situated in, which makes performance systemic. If problem-solving between users and producers is the main source of innovation, further innovation and structural change will be deeply rooted in the prevailing economic and institutional structures. Regarding the latter, Hidalgo et al. (2007) have argued that the level of sophistication of the present product mix in an economy affects the speed of structural adjustment towards higher productivity activities and hence, the speed of development. The sophistication of the product mix is characterised by how the products are related to each other. They may for example depend on similar infrastructures and institutions, use similar technologies and competences and deliver inputs to each other. It is a more abstract version of a user-producer approach where networks of related products and activities may be seen as drivers of development due to the systemic nature of economic performance.

The argument here is that primary production, manufacturing industry and services are interrelated and interdependent parts of an economic system (seen as consisting of verticals embedded in a larger structure), where changes in one part can stimulate changes in the other parts - they co-evolve. The previous section illustrates the latter. Hence, not only is it difficult to say that one part of the vertical is more important than another, but actually innovation often emerges from the interactions between these parts, which calls for a policy approach that focuses, not on "good activities", but on the systemic performance of national verticals. This understanding merges with the insight of Kuznets since innovation leads to changes in production structure, and supports growth and development. Actually, Kuznets himself argued that the growth and development of several now-developed countries were primarily based on the commercialisation and technological modernisation of agriculture rather than on manufacturing per se (Easterlin, 2008).

The historic process of structural changes can be understood as an increasing division of labour (inter alia) driven by innovation (and vice versa), which results in verticals of production consisting of interdependent parts. Innovation, which drives shifts in economic structure and development, emanates from the prevailing economic structure, which consists of the verticals crossing the whole tripartite classification. It is not possible to identify one part in a changing structure as generally and permanently more important than the others as they are all involved in generating development.

The information needed in interactive innovation cannot be communicated via price signals in a market – it also requires different kinds of qualitative, sometimes personal, interaction extended over time. Thus, it makes sense to distinguish between, on the one hand, linkages that only channel arms-length monetary transactions, and on the other, linkages that channel knowledge flows. Terms such as the quantity of linkages and the quality of linkages may become useful. From the perspective of interactive learning, it is relevant to reconsider Hirschman's observation that manufacturing has more linkage potential than primary production. Compared with other sectors, manufacturing has historically been very well connected and thus, a basic source of innovation. When interactive learning between firms is an important element in innovation processes the structure of linkages becomes important too. However, it is the quality of interactions, formed by an enabling institutional framework, that matters the most, not the quantity of transactions. Consequently, what constitutes a "developmental" or "sophisticated" production structure changes over time. Structure fundamentalism contains, like the other fundamentalisms we have identified, valuable insights, but it is too static and must be complemented with attention to the quality of linkages, innovation and structural change in order to be of much help for understanding development.

5. Fundamentalisms, Endowments and Processes

The alleged "deeper causes" of development, which characterise "fundamentalisms" can, as in the case of natural resources, be given both static and dynamic interpretations. The development factors can be understood from an endowment approach and a process approach (see Table 3).

The endowment view fits into the neoclassical theoretical framework in which endowments, and change of endowments, are exogenously given, trade is explained by comparative advantages and the pivotal reference point is an optimal equilibrium. The process view, in contrast, leans towards evolutionary and institutional economics with endogenous resource endowments, trade explained by dynamic comparative advantages and the focus is on a process of change with interaction and cumulative causation between the various factors of development.

Fundamentalism in development thinking is not always harmful. As the much used notions "knowledge-based development" and "resource-based development" indicate, (development based on but not exclusively depending on knowledge or natural resources) there also exists milder and less objectionable forms of fundamentalism, which only claim that from a development policy point of view, it may be a good idea to concentrate on a leading factor such as investment in human capital or utilisation of abundant and accessible natural

Table 3: Root factors of development: Endowments and processes.

Development factor	Endowment approach	Process approach
Markets	Transaction costs and macroeconomic balance determine development.	Stabilize, privatize and liberalize and let markets do their job to increase growth.
Institutions	The main characteristics of the institutional framework determine development, negatively and positively.	Institutional learning (i.e. adaptation and change of the institutional framework) determines development.
Knowledge	Stocks of knowledge (know how, know why, know what) drive development.	Growth and change of knowledge by learning (and forgetting) and innovation determines growth and development.
Economic structure	There is a close connection between economic structure and development. Development can be supported by getting the economic structure 'right', i.e. by increasing the share of 'good' (manufacturing and services) industries and activities and decreasing the share of 'bad' (primary) sectors.	Industries identified as good change over time. Development is driven by changes in economic structure resulting from learning and innovation rather than by a certain type of structure.

resources. Furthermore, each of the fundamentalisms may be given a more dynamic interpretation or at least connected to more dynamic arguments.

The problem with fundamentalism in development thinking is not the ambition to find the most important development factor but rather that the approach is often more in accordance with an endowment view than a process view. Furthermore, there is a tendency to overlook the other development factors and, especially, to neglect the interdependencies between the different factors. For example, that technological and institutional change interacts (sometimes harmoniously, sometimes contradictorily) with each other in the development process is so overwhelmingly documented in historic research that any attempt to depict one of them as the main cause of development at the expense of the other should be met with suspicion.

Generally, the development factors feed upon each other and set the stage for each other. Each of them is insufficient and appears "fundamentalistic" when it stands alone, but when they are combined in a process-oriented model of development, which focuses on their interactions, the importance of each of them is, in fact, enhanced.

The empirical examples illustrate the latter point very well. The observed interactions between several factors such as natural resources, institutions, knowledge, market form, entrepreneurship and "good" policy have over time generated beneficial shifts in the production structures. It is not possible to explain these processes in terms of monocausalism. They should rather be understood as evolution of economic systems via interaction between different activities (crossing the tripartite classification) and development factors.

6. Conclusion

Even though our discussion does not warrant anything near a full treatment of different approaches in development theory, our critique of "fundamentalism" cautiously points in a specific direction. As illustrated by our empirical examples, it is not the various endowments per se that are "fundamental" for development, but rather the by institutions sustained interdependency and interaction between the different types of development factors, and how these are managed or coordinated. Processes of cumulative causation between changes in development factors bring about contradictions and problems, which feed learning and innovation. Innovation is in the long run connected to structural change as new processes and products enter the economy. This implies that development is always and inevitably connected to structural change. It involves evolution of networks and other patterns of interaction between different production activities, which feed structural change towards activities with higher productivity.

We suggest that in order to grasp the nature of structural change and development, researchers must adhere to a process approach and reject the endowment approach and monocausalism. At the same time, researchers should avoid 'fundamental relativism' an approach where all development factors are considered of equal importance, regardless of time and space. Instead, we propose an approach which falls somewhere between monocausalism and fundamental relativism. Factors of development are not always equally important. In specific cases, it is possible to identify "leading" development factors. The example of the Brazilian sugarcane industrial complex shows that cane cultivation is a leading factor and therefore, it is justified to talk of natural resource-based development.

Still, there are no guarantees, and the crucial question in development policy therefore is whether you can make the development factors feed upon and support each other. It is obviously not enough to have access to abundant natural resources. But if you can build an institutional framework for the utilisation of specific natural resources, which supports development of new knowledge and competences that can be applied in a range of different activities, resource-based development may be possible.

It is interesting to note that Hirschman (1981) later acknowledged that the lack of linkages in natural resource-based industry compared with manufacturing was not a consequence of natural resources per se. It was rather because the actors involved in these industries were often not capable of establishing new activities related to, e.g., agriculture, and thus creating new linkages, that were significantly distant from the on-going activities in terms of knowledge and technology. Thus, according to Hirschman (1981), the real barrier to development was the inability to build capabilities and "strong" linkages around the resource base.

The importance of institutions and structures as well as their changes in this understanding of development points in the direction of a broad system of innovation approach to development theory and policy. The main reason is that a systemic approach necessarily focuses not only on factor endowments but rather on how the people controlling the endowments interact with each other and with other sectors of the economy. The fundamental insight of the innovation system literature is that economic performance is "systemic" which means that the whole is more than the sum of its parts, and that the interrelationships and interactions between elements are as important for processes and outcomes as are the elements themselves (Lundvall, 2007). The innovation system approach thus embraces a process view on development, but it also acknowledges that such processes are not automatic and need to be coordinated. It provides an analytical framework for understanding evolution of complex economic systems and hence, learning how to identify, diagnoses and prescribes medicine for economic development. The ability to capture the interdependencies, interactions and the respective endowments all together in the analysis is the crucial point here – a point, which is not compatible with an endowment approach to economics or monocausal explanations.

Notes

1 It should be noted, however, that "good governance" is hard to define and measure in a precise way, which makes it difficult to apply it in policy recommendations. It is, for example, not easy to define the rule of law unambiguously since there are different legal traditions in different countries. The meaning of political accountability, transparency and quality of bureaucracy also vary from country to country because of different traditions and different complimentary institutions.

2 "Rent-seeking is defined as the pursuit of uncompensated value from other economic agents, in contrast to profit-seeking, where entities seek to create value through mutually beneficial economic activity" (IMF, 2005:126).

3 However, as a whole, this simplistic view doesn't characterise the World Bank report, which recognises both the complexity of knowledge and the costs of knowledge transfer.

4 Still, the issue of finiteness must be considered in relation to the aspect of time. In the (very) long run availability of energy and matter to humans is finite, which ought to affect technical change in the direction of energy and material-saving production, and a higher

use of renewable sources (Georgescu-Roegen, 1975). This is an important perspective, but for understanding processes of economic development, we must focus on shorter time horizons.

5 As for example petrochemicals, oil, plastic and rubber in the US.

6 A horizontal view refers inter alia to the categorisation of primary, secondary and tertiary sectors. A vertical approach perceives the economic system as consisting of verticals (chains) of production that often cross the tripartite categorisation mentioned above. Economic systems in the "industrial age" are most often characterised by vertical structures, whereas in pre-industrial societies primary, secondary and tertiary production were not separated, but all exercised by the same unit of production – a farm growing corn (primary), processing it into bread (secondary) and bringing it to the market for selling (tertiary). During successive "industrial revolutions" the latter pattern of production was broken by an increasing division of labour and specialisation.

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