Chapter 3

The University and Sustainable Regional Industries

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Increasingly, metropolitan regions that have experienced the negative side effects of sprawl, congestion, superstores, and automobile-dependent transportation are turning toward transit-oriented development, mixed-used buildings, urban growth boundaries, compact development, and other goals associated with new urbanism and smart growth planning. Although changes in land-use and infrastructure policies are important developments, they would do little good if the major industries of a region remained unconnected to regional greening initiatives. A comprehensive approach to regional sustainability needs to examine the question of how regional industries can be brought into the process of building a sustainable metropolitan region. Because industries are increasingly linked to universities for research and development, the problem of developing new industries or changing old ones at a regional level is closely tied to the innovation potential of the region's universities.

Throughout the twentieth century universities have played a crucial role in developing new knowledges and technologies for both industry and the military (Kevles 1997, Leslie 1993, Noble 1977). However, the increase of global competition during the last decades of the twentieth century pressed manufacturing industries in high-income countries to focus on constant innovation and high technology, and as a result universities have increasingly emphasized research and teaching goals related to industrial innovation (Kleinman 2003). The passage of the Bayh-Dole Act of 1980, which allowed universities to capture revenue from patents and licenses, was an important historical marker of the increasing role that universities have played in economic development (Slaughter and Leslie 1997).

Both national and subnational regional policies have become oriented toward the model of the "technopole" or "triple helix," that is, the synergetic development of state, university, and industrial partnerships through dense networks and regional clusters (Leydesdorf and Etzkowitz 1997, Castells and Hall 1994; see also Schach's paper in this volume). The clusters link the strategic goals of universities with regional industrial strengths, and they provide a new source of state and industrial funding for university-based research. In turn, the advantages of dense informal networks, which the university-government partnerships can nurture, make it attractive for industries to locate in a particular region. The result is the paradoxical combination of globalization processes and a renewed emphasis on regional clusters.

Many regions across the world now hope to model their regional economies on Silicon Valley and similar high-technology clusters, such as Boston's Route 128 and the United

Cambridgeshire. To emulate those clusters and to create new variants of the triple helix, universities have developed strategic goals around emergent areas of high-technology research and development such as information technology, biotechnology, and nanotechnology.

To a large extent the emergent areas of research and industrial innovation have developed without significant concern for environmental issues. There is some interest in configuring the new technological innovation clusters in ways that may address environmental problems, such as the use of biotechnology in environmental remediation or of nanotechnology in fuel cells. However, frequently the new technologies have also been the target of environmental concerns, such as campaigns against the toxic metals in computers, protest against genetically modified food, and growing concerns about the environmental and health implications of some nanotechnological materials. Yet, there is also the potential for developing environmental technology as a focus of research, development, and regional industry. This essay will probe the concept of what a sustainable regional industry can mean through a comparative discussion of various models.

Conceptual Background

Before discussing various opportunities and problems that face the university in defining a sustainable regional economy, the concepts of sustainability and globalization need to be clarified. Like apple pie, "sustainability" is a value that few people oppose in principle. It points in the direction of a desirable future and a legacy that present generations would, in principle, like to leave to their progeny. However, the term is highly subject to greenwashing, and it has come to mean almost anything. As a result, I have found in beneficial, in both teaching and research, to break the concept down along two dimensions.

The environmental dimension spans a spectrum of positions from incremental remediation of environmental hazards and existing pollution problems to the upstream world of design innovation that has a goal of nearly zero waste across a product's life cycle. In other words, although most of the time "sustainability" is translated into incremental projects of amelioration or remediation, in some cases people and firms have accepted the more profound challenge of developing product life cycles that begin almost entirely waste products, consume few resources while being used, and can be converted to inputs into new products at the end of the life cycle (Pauli 1998, Todd and Todd 1993).

A second dimension of sustainability involves the argument that a truly sustainable society is not possible without addressing issues of social justice. In turn the "justice" dimension also spans a spectrum of positions advocating everything from incremental poverty alleviation and the remediation of rights violations to more profound changes in economic and political institutions to make them more inclusive and democratic (see Fischer's paper in this volume). Large corporations tend to work with a narrow

definition of sustainability that focuses on the remediation of existing environmental problems, such as emissions from fossil fuels, whereas social movement organizations tend to articulate a vision of "just sustainability" that combines environmental and justice issues (see Agyeman et al. 2003, McGranahan and Satterthwaite 2000).

As with the concept of sustainability, the concept of globalization needs clarification. Globalization as an empirical process that can be elucidated by research is frequently confused with globalism, a neoliberal political ideology that celebrates a corporate-led form of globalization as a political goal. In some cases, the social science literature falls prey to some of the assumptions of globalism, and the literature can become celebratory. In contrast, globalization will be understood here to mean historical changes that are continuous with the emergence of modernity in the fifteenth through eighteenth centuries but have taken distinct forms in the second half of the twentieth century.

Within the political system, the nation-state has become embedded in an increasingly dense political field of international governmental and nongovernmental organizations, regional trading blocs and superstates, and subnational regional political entities, including "global cities" (Sassen 2000). Within the economic system, the economy has become much more internationalized, but claims about internationalization of the economy can be overstated in comparison with earlier historical periods (Hirst and Thompson 1999). Among the more significant changes that occurred during the late twentieth century are the internationalization and digitalization of financial markets and manufacturing, the rise of post-Fordist production, and an increase in within-nation inequality in many countries, including the United States (Harvey 1989, Schmidt 2000). In the social and cultural systems, proportions of immigration to some countries may not have increased (Hirst and Thompson 1999), but the ethnic mix has often become more diversified in comparison with immigration patterns in the early twentieth century and nineteenth century. The diversification of national populations and the maintenance of diasporic ties through new information and communication technologies are among the factors that have contributed to a fragmentation of identity and a decline in the power of national identity as a mobilizing force in politics (Inda and Rosaldo 2001). Although there are many exceptions to the trends, they will be taken here as the points of departure for an empirically grounded concept of globalization (Hess 2007).

In the United States, as in many other countries, manufacturing and other industrial sectors face strong competition from low-income countries, including countries that also have better endowments of natural resources for some industries. As a result, the value of achieving "sustainability" is often framed in conflict with the value of economic viability and employment. The environment-versus-jobs framing of the issue tends to mobilize labor to the side of industry and therefore weaken the potential for blue-green coalitions (Gould, Lewis, and Roberts 2004). As a result, environmental values and politics tend to be championed by social movements, nongovernmental organizations, and community groups. Although everyone recognizes that sustainability, like universal health care coverage, would be "nice" to have, divisions occur over the extent to which

it is "too expensive," especially in an era of global competition and pressures on the revenue base for governments.

Social movements play an important role in the politics of sustainability by putting pressure on the state and large, publicly traded corporations to remediate their environmental practices. In addition, social movements place a role in pioneering new technologies, such as organic food production and renewable energy (Hess 2005). Movements can draw attention to the politics of design and create conflicts over the definitions of objects that the private sector is putting into circulation, such as over genetically modified food and nuclear energy (Hess 2004). Furthermore, movements can help create markets for alternative products and for alternative forms of organizational control, such as locally grown food from locally owned farms. They also help remind analysts that the greening of regional industries is not merely driven by the triple helix of university-industry-government partnerships, but it also can have a grassroots dimension that taps into the power of civil society organizations and articulates a "just sustainability" vision of sustainability.

By viewing the greening of regional industries as a complex political process that cannot be completely captured by the logic of industrial innovation policy, it is possible to see some opportunities that might not otherwise be evident. Among the opportunities are the potential for greening the regional economy not only through major industries but also through small businesses and the productive activity of the nonprofit sector. As will become evident, a localist model of regional sustainability emerges alongside a technopole model.

Greening Existing Industrial Clusters

Most regional economies have an industrial focus, such as automobiles, software, entertainment, finance, chemicals, food processing, defense, and tourism. One of the first challenges of a program to green the regional economy is to motivate existing industries to undergo a greening process. In some cases, such as the chemical industry of Louisiana, the greening of a regional industrial cluster is a contentious political issue (Allen 2003). Yet, even where there is not a widely recognized problem associated with existing industries, the firms are likely to resist proposals for the ecological modernization of their production practices, technologies, and products. For-profit firms tend to resist environmental changes in production because the changes are seen as expensive and unprofitable. Likewise, high levels of environmental regulatory scrutiny in high-income countries have been cited as a key factor behind the decision of some industries to relocate manufacturing to low-income countries with lax regulations. Because firms historically have viewed the relationship between environmentally oriented changes in production and profitability as a zero-sum trade-off, they have often resisted changes and only made them when social movement campaigns or state regulations have forced them to do so.

Comparative analyses have shown that regulatory push remains the crucial factor in motivating industries to undertake environmentally oriented changes in their production practices (Bayliss, Connell, and Flynn 1998a, 1998b). Although regulatory push (and behind it, social movement activity) has been and probably remains the main factor behind whatever trends toward ecological modernization of industry can be found in most countries, there is considerable variation across industries and countries. For example, in many countries the chemical industry has undergone significant regulatory scrutiny, and it has been subjected to greater pressure to change industrial practices than most other industries. Likewise, pressures to undergo environmentally oriented reforms in production technologies and products have been much stronger in Western Europe than in the United States. In cases such as the Dutch chemical industry, partnerships among civil society organizations, the state, and corporations have led to significant reforms (Mol 1995). Such reforms are to some extent reversible; that is, they are subject to retrenchment as political climates change, and consequently the role of civil society pressure on both industry and government regulatory policies is crucial to maintaining and deepening the ecological modernization of industry.

In addition to regulatory push, a second strategy for motivating the greening of existing industries is through the profitability pull of "eco-efficient" innovations. A growing literature challenges the assumption of a trade-off between the greening of industrial production and lowered profitability (DeSimone et al. 1997, Porter and van der Linde 1995). Likewise, a new industry of consultants, university researchers, and other specialists provides expertise for industries that are willing to view environmentally oriented changes as investments that bring direct financial returns as well as returns to brand and corporate image. For example, by "closing the loops" of manufacturing waste, firms may be able to reduce waste disposal costs and capture profits from waste reuse (Hawken et al. 1999).

However, in practice eco-innovation can have very ambiguous environmental implications. For example, a furniture factory may invest in new cogeneration technology that allows it to divert wood shavings from a landfill by recycling them on-site for heating and electricity generation via incineration. The ultimate environmental effects (landfilling versus burning) may be ameliorative or destructive, depending on how clean the wood shavings are and the quality of emissions controls in the cogeneration plant, and how the emissions and greenhouse gases compare with the displaced, grid-based fuel sources. However, because the motivation is more cost-savings than environmental amelioration, the broader environmental impacts are not crucial to the decision to "green" the technology. It is a cost-reduction decision that may have environmental benefits, but it may not.

Unfortunately, to date firms have not been convinced that a dramatic rethinking of product life cycles is in their best interest, and likewise governments have been unable to resist private-sector pressure to reverse or at the minimum enact weak environmental legislation. As a result, from the perspective of continued ecological degradation,

neither regulatory push nor profitability pull have been sufficient to result in widespread ecological modernization of industry. Although there are some success stories, to date technological changes in industry have not been able to keep up with increased overall production and consumption, and with them the "treadmill" of growing deposits and withdrawals into the environment (Schnaiberg and Gould 1994).

The various models discussed in the remainder of the essay need to be contextualized against the broader need to address unsustainable practices in a wide variety of existing industries, including existing regional industrial clusters. The net environmental impact of the various models discussed below, in terms of aggregate measures such as global greenhouse gas emissions or release of toxic chemicals into the global ecosystem, would only be environmentally significant if they were to achieve widespread adoption. However, the models do provide opportunities for new university-community-industry partnerships, new employment possibilities, and the enhancement of the quality of life at a regional level. The localist variants also begin to address some of the fundamental issues underlying patterns of ownership associated with the continued treadmill of economic growth and environmental destruction that industrial societies have generated.

The Green Technopole

The idea of a "green" technopole can be viewed as an extension of the pattern of university-industry-government partnerships that are occurring in other sectors, such as information technology, biotechnology, and nanotechnology. To date it is difficult to locate a "green technopole" in the U.S. that could be compared with the information technology and biotechnology clusters that have developed in the San Francisco Bay area and Boston. However, there are signs that energy innovation clusters are developing in some areas.

One cluster is developing in the San Francisco Bay Area. Stanford University has developed the Global Climate and Energy Project, which is supported Exxon Mobil, General Electric, Toyota, and Schlumberger. The $225-million project will develop "clean energy" technologies and technologies for controlling greenhouse gases (Blumenstyk 2003).

San Jose State University and the Redevelopment Agency of the City of San Jose have also sponsored an Environmental Business Cluster, which has assisted over eighty firms to develop new, environmentally oriented technologies, and there are other business incubators and support organizations for clean technology development in the region (Environmental Business Cluster 2005, WestStart-Calstart 2005). The rapid growth of the Bay Area cluster suggests the continued vitality of the entrepreneurial environment of Silicon Valley, which has been able to withstand various rapid transformations in the information technology industry (Saxenian 1996) and now is expanding into the environmental technology industry. In this context private investment from venture capital firms is crucial for the early capitalization of new firms, which develop according to entrepreneurial models established in other industries.

A similar cluster is also under development in the New York capital district (Albany-Schenectady-Troy-Saratoga), where the state government has played a significant role. The New York State Energy Research and Development Authority, the New York State government, University at Albany, and Saratoga Economic Development Corporation are among the partners who have contributed to the development of the Saratoga Technology + Energy Park, which will focus on clean energies (New York State Energy Research and Development Authority 2005). The state government has also partnered with Rensselaer Polytechnic Institute (2005) to open a $20 million Center for Future Energy Systems, which will focus on hydrogen fuel cells, energy conservation, and renewable energy technologies. Synergies are also developing with firms such as Plug Power, MTI MicroFuel cells, and General Electric's Global Research center, which is headquartered in the region.

Although evidence is still sketchy for the existence of a "green technopole" of similar scope to the more established technopoles in information technology, in general the model for advanced energy technology development appears to follow the key elements of other technologies. First, research funds draw on partnerships among state governments, universities, large corporations, and federal funding agencies. Second, technology development and diffusion occurs either through development by existing corporations, such as General Electric under its "eco-imagination program," or from start-up companies that shift from venture capital to public stock offerings as they develop. Third, the manufactured products may be sold on local markets, especially during early testing and market development stages, but the intention is to develop industries that are "export-oriented" in the sense of marketing products beyond the region to national and global markets.

Opportunities for the development of regional industry clusters around innovative energy technologies can encounter object conflicts, that is, definitional struggles over the boundaries of what a desirable alternative or new technology should encompass. Such conflicts emerge particularly when environmental organizations challenge state governments and federal funders over priorities for new energy research. Categories such as renewable, clean, green, and future energy capture different formulations of desirable industrial futures, and with them priority areas for research funding and technology development. For example, a region may focus on renewable energy that generates only minimal pollution or environmental side effects (e.g., solar and wind) versus the development of hydrogen-powered automobiles. The latter may significantly clean up carbon emissions at the tailpipe, but hydrogen production is likely to be based on distributed reformulation from natural gas rather than renewable energy sources, and consequently the efficiency and net environmental impact is dubious. Nevertheless, in order to get the industrial buy-in that will be needed to move hydrogen beyond the demonstration project stage, it is likely that natural gas companies will need to be enrolled to provide backing from an influential part of the energy industry.

More broadly, "green" energy research and development can run the spectrum from wind-powered electric vehicles to plug-in electric hybrids with biofuels, natural-gas powered vehicles, hydrogen fuel cells, carbon sequestration technologies for "clean" coal, and the rebirth of nuclear energy as a "clean" energy. Within this field of contenders for the banner of "green" or "clean" energy, environmental movement organizations have divided over various issues, including the need to resurrect nuclear energy and the impact of wind farms on human viewsheds and avian fly-ways. Yet, it is clear that funding agencies and some firms are investing in research and development for the new technologies, and universities will play a key role in generating the research needed to overcome technical barriers.

The Green Technopole and Import Substitution

The concept of "import substitution" is well known in economics, and it has also been employed in the regional and urban studies literature for some time (e.g., Jacobs 1969, Shuman 2000). In this context import substitution implies developing a regional economy by replacing goods that have been produced elsewhere with goods that have been produced locally. The locally produced goods may be sold locally, or they may be marketed more broadly. As applied to the advanced energy technologies of the green technopole, import substitution can be a valuable resource for capitalization and testing in the early stages of a product's development. By developing local markets for a new product, firms can stay close to users, work out problems, and have an incipient revenue stream. Primary examples of import substitution in the energy field involve substituting fossil fuels that are imported into a region for greener fuels that are produced locally.

Perhaps the most successful example of import substitution and green technopole development is the solar industry of Freiburg, Germany. Activism surrounding the Whyl nuclear power plant eventually led to a solar-oriented urban policy that directed the municipal utility to develop greater solar energy use. Triple-helix dynamics emerged in 1981 with the founding of the university-affiliated Fraunhofer Institute for Solar Energy Systems (2005), which works closely with the Albert Ludwig University. The city government spurred development by purchasing solar units in municipal buildings, and in 1992 it required future housing and municipal buildings to use passive and active solar energy (Solar Region Freiburg 2003). In 1995 the International Solar Energy Society (2005) moved its headquarters to the city, and in 1997 Solar-Fabrik, a solar module manufacturer, also moved to the city (Solar Region Freiburg 2005). A major shift in scale occurred in 1999, when the Federal Ministry of Economics and Technology inaugurated the 100,000 Roofs Solar Energy Power Program, which provided loans for solar panels. The program lasted until 2003 and resulted in about 345MW of new solar capacity, an impressive quantity that established Germany as the leader of solar energy in Europe (International Energy Association 2004, German Solar Industry Association 2004). Once again, the role of government—here both national and local—was crucial for the development of the industry.

In the U.S., some states have renewable energy portfolio standards, and an increasing number of utilities have optional green pricing programs. By increasing the demand for renewable energy through mandates or voluntary price premia, utility companies can develop a revenue stream that helps pay for a shift of their energy mix to renewable sources. In cases where the utility is publicly owned, the new energy sources can be owned by the public utility. For example, Sacramento Municipal Utility District owns wind and solar farms that produce energy for its customers (Hess and Winner 2005). In addition, even investor-owned utilities can be pushed to develop local renewable energy sources. For example, in the case of San Francisco, the investor-owned utility fought a grassroots effort to convert ownership to a public utility, and as a result of the defeat the city is now developing a "community choice" program (Hess and Winner 2005). The program aggregates all consumers, then seeks bids from energy providers that meets not only price guidelines, but guidelines for new renewable energy sources.

In many cases new renewable energy sources are purchased through contracts with energy generating facilities that are not locally owned. In other words, there is no necessary link between import substitution and the development of new firms in the region, let alone new manufacturing firms. Local firms can develop around installation of distributed energy, such as solar panels, and around ownership of wind farms. In San Francisco, the proposed community choice contracts will be combined with the city bond authority to mandate 360MW of new capacity and load reductions, including new solar and wind generation. Assuming that new firms arise from the mandate, it is likely that solar installation companies and other service provision firms will be the primary new industry. However, as in the case of Freiburg, it is possible also that solar manufacturing firms may relocate to the region.

A similar pattern of import substitution can occur with regional transit companies. For example, Alameda County Transit of the East Bay of California has been developing hydrogen fuel-cell powered buses that, while still in the experimental stage, have helped to develop a California business in partnership with the state of California, Chevron-Texaco, and an international bus manufacturer (Hess and Winner 2005). Likewise, in Chattanooga a cluster emerged around the regional transit agency, an electric vehicle research institute (now the Advanced Transit Technology Institute), the Tennessee Valley Authority, research programs at the University of Tennessee, and an electric vehicle manufacturer that originated with contracts from the city to make electric buses instead of purchasing new diesel buses made elsewhere. The eastern Tennessee cluster has some significant innovations, including the all-electric downtown circulator in Chattanooga, which runs on electricity that is primarily generated from hydropower. In both cases, transit agencies leveraged their procurement power to help establish new regional businesses via import substitution. In the Chattanooga case, the electric bus company eventually failed, but our research indicates that the failure occurred after it attempted to expand too rapidly from its original manufacturing niche (Hess and Winner 2005).

Biofuels are another example of import substitution that can help spur the development of regional industries. Federal mandates (such as the ethanol standard), state government mandates (such as those in Minnesota), and procurement policies (such as city fleet targets) all contribute to new demand for biofuels. By shifting a portion of fuel to biodiesel, public transit agencies can help develop a regional refining industry, and city and state fleets can utilize ethanol mixes in their gasoline-powered vehicles. Because biofuels are considered to be carbon neutral and to have lower and less toxic emissions than standard petroleum-based fuels, overall impact on the environment may be reduced. Even if their net environmental impact is moot, biofuels are currently considered advantageous because they reduce dependence on foreign petroleum and can help develop regional industries.

The three examples of energy-based import substitution are continuous with the triple helix structure of environmental technology manufacturing, but there are two significant differences. First, there is a greater diversity of ownership patterns. New, export-oriented manufacturing firms can emerge as biofuels refiners and bus and solar panel manufacturers. Their products may be consumed locally during initial phases but eventually are sold on national markets. In contrast, import substitution in the energy field can be linked to the development of locally owned energy production sites, such as locally owned distributed generation, a locally oriented installation industry, and publicly owned wind farms. Likewise, in some cases state governments have set up incentive programs that assist locally owned agricultural cooperatives to develop biorefining and wind farms (New Rules Project 2005).

A second difference is that the triple-helix dynamics of the technopole are less obvious in the more locally oriented forms of alternative energy production, except where manufacturing is involved, such as in the Chattanooga electric bus case. This is to be expected, because the state and universities are focused on developing high-tech industries that can produce new products for sale on global markets. As a result, the pattern of green energy development based on import substitution is continuous on one end with the green technopole and, on the other end, with a model of locally owned production for primarily local consumption, or what I term “green localism.” The latter model can also play a role in a general strategy of regional economic development, and it is especially prominent in the waste and food industries.

Waste-Based Import Substitution

Another type of import substitution converts waste products into inputs for a new production process or into reusable consumables. The remanufacturing industry is one example of waste-based import substitution, but to date the industry has not been configured into regional clusters with university-government-private sector partnerships. The demonstration projects of industrial ecology are perhaps the closest to a regional cluster of waste-based import substitution. The most well-known model of industrial ecology is the Kalunborg site in Denmark, where the by-products of a fossil-fuel burning electrical plant, such as ash, are utilized as inputs for other manufacturers

that are located nearby. Colocation does not require immediate proximity, as in the Kalundborg site, and it can be expanded to a regional level. Universities can assist regional cluster development by inventorying wastes and inputs at a regional level to determine where possible synergies for remanufacturing exist. Industrial ecology has created some excitement in North America, and there are some cases of cities that have developed eco-industrial parks (Chernow 2002). However, to date most of the North American eco-industrial projects are either agricultural (such as composting operations) or in incipient stages of development. One problem is that waste regulations in the United States have made it difficult for reutilization of some waste products. A more general problem is that changes in one firm's production technologies can alter its waste by-products, which then places another firm at jeopardy in obtaining supplies. In other words, the industrial ecology model rests uneasily with the emphasis on constant innovation, especially of production processes, that is required for survival in a global economy. Although the problems can be surmounted, they also point to some of the hurdles that an industrial ecology approach must overcome (Desrochers 2001).

Another example of a demonstration project around industrial ecology is biologically based waste-water treatment. The systems developed by John Todd and associates at Ocean Arks demonstrate how waste water can be treated by passing it through a variety of biological systems that eventually convert the waste products into life support (Todd and Todd 1993). In the process, a network of new businesses is made possible, including fish and other aquatic food, bait, decorative plants, edible plants, animal fodder, fertilizer, and water. By producing new plant and animal products from waste, it is possible not only to reduce the negative externalities caused by sinking waste into the environment but also to create a cluster of new businesses that substitute locally produced products from those obtained in distant markets.

A third opportunity for waste-based import substitution involves energy waste. A variety of businesses exist in this area, from the greening of new building construction to weatherization of existing buildings. Urban programs can be combined with poverty reduction goals such as those of the Green Affordable Housing Coalition (2004) and the home energy weatherization programs offered by some public utilities. Some states have public utilities dedicated to providing assistance for reduction in energy consumption (e.g., Efficiency Vermont 2003). To date, the programs have helped create a small-business sector of local contractors, but they have not yet moved to the next step of regional clusters with links to university research programs.

A fourth opportunity for waste-based import substitution involves the reuse of consumer products. An example is the resale industry, which is one of the most rapidly growing segments of the retail sector. Resale includes a variety of institutions: the informal economy of yard, rummage, and church sales; the 15,000 resale shops (including clothing, furniture, sporting goods, and electronic products); the thrift segment (such as Salvation Army and Goodwill Industries); and reuse companies, which sell reusable home construction products. Flea markets have also been used to redevelop urban

spaces, including abandoned big box stores (Christensen 2005), and they can be combined with farmers' markets, craft fairs, and small business districts to revitalize urban areas. By aggregating small-scale vendors and locating them in resale retail clusters, new possibilities for economic development emerge that require relatively little capital investment from a city government or non-profit organization. Resale clusters provide opportunities for entrepreneurship in the retail sector, and they provide opportunities for a regional economy to diversify its job base away from export-oriented manufacturing.

In some cases, reuse companies have developed a cluster of related businesses. For example, some of the used building materials or "reuse" centers have spun-off side businesses that make furniture from recycled wood. Some have also developed an alternative to building demolition, which accounts for about two thirds of all solid waste. Deconstruction involves the careful dismantling of buildings, usually by hand and sometimes with teams of paid staff and volunteers. By substituting deconstruction for demolition, reuse centers can save up to 90% of building materials. When the reuse centers are set up as nonprofit organizations, the materials can be donated to the center, and frequently the employees are offered job training and skills development opportunities. Once the materials have been processed for resale, the products are often offered at steep discounts in comparison with those in new home furnishing stores, thereby benefiting low- and moderate-income families. Finally, proceeds can be used to fund low-income housing, as is being done in some of the Habitat-for-Humanity reuse centers. The reuse center model is now spreading across the country, and it provides another way in which an economically viable organizational form can bring together environmental and social justice goals (Hess and Winner 2005).

The resale industry mixes goals of environmental amelioration and poverty reduction, but within this broader field there are differences in the way the object of a "used good" is constituted. Thrift stores and to some extent yard-sale economy are concerned with offering low-prices for low- and moderate-income families, whereas some of the building and construction reuse stores have a more environmental orientation. Some of the reuse organizations explicitly have missions that include both environmental and poverty-reduction goals. The variations in definitions of resale raise questions about what constitutes sustainability in these sectors. In the end, resale may result in little more than a delay of consumer goods on their trip to the landfill, particularly for clothing, sporting goods, and electronics. Resale generally does not address the fundamental issue of how to manufacture products so that they can be remanufactured easily or landfilled without toxicity, although as resale grows it may help raise awareness of these issues. For example, those who are experienced in building deconstruction note that the more recent buildlings, with their prefabricated materials and heavy use of glues, are much more difficult to deconstruct than older buildings. Their work provides insights into how the construction process upstream might be redesigned to make long-term recycling of building materials more viable.

There is little academic research on the resale sector, but the developments represent tremendous opportunities for universities that are engaged in thinking through the possibilities of sustainability at a metropolitan level. Citizens have become increasingly concerned with quality of life issues, and those concerns often come to a head over plans for new retail developments. Planning board meetings can become contentious events, where citizens on both sides line up either for or against the latest development plan. Yet, in the end the disputes do little to answer the siren song of low prices and one-stop shopping that the big box superstores can offer. A resale district or a large flea market can become a vital ingredient in a metropolitan sustainability project. Clusters of locally owned, small remanufacturing firms—such as the furniture manufacturing businesses that have spun off the reuse centers—provide another model of how the reuse economy can be developed.

In the waste-based examples of import substitution, capitalization can occur through "donated" waste products that have lost their value to the original user. Because donations have value as a tax write-off, non-profit organizations have flourished in this sector. There is also a vibrant informal economy around yard sales as well as a small-business sector around resale that can be self-capitalized through inventory growth of goods purchased at a steep discount or traded for future purchases. These alternative organizational forms co-exist with the larger and publicly traded businesses found in the remanufacturing industry.

Food-Based Import Substitution

The emergence of sustainable local agricultural networks is arguably the most well-developed form of a regional industrial cluster that is based on small, locally owned, privately held businesses and nonprofit organizations. Although not all of the food produced in such clusters is grown organically, in many cases food production utilizes fewer synthetic inputs, and in any case the environmental costs of long-distance transportation are reduced.

At a national and international level organic food production has become increasingly industrialized, but the locally oriented food networks have not disappeared. Instead, sustainable local food networks have grown alongside the nonlocal organic food industry (Guthman 2004, Hess 2004). Because consumers are concerned with food quality—due to preferences for food freshness, provenance, and safety—local food can command a price premium, as well as a shopping effort premium, in comparison with local manufactured goods. As a result, local ownership is more able to resist displacement by large, external firms that flood local markets with lower-priced products.

At an institutional level local agricultural networks include community gardens, school gardens, community-supported agriculture (CSA) farms, farmers' markets, retail food cooperatives, and restaurants and cafeterias that buy local food. Those organizations have become increasingly networked with anti-hunger and food security organizations,

such as food banks, pantries, shelters, and related organizations (Gottlieb and Fisher 1996). For example, community gardens and small farms donate excess food, farmers' markets offer food stamps and food education programs, and community-supported agriculture farms offer low-income scholarships and food donations. Some organizations are nonprofit, but even the private-sector organizations tend to be small businesses that are not oriented toward profit growth. As a result, conditions are established for a more robust understanding of sustainability along the lines of sustainability with justice outlined above and in Agyeman et al. (2003).

In addition to the broader interorganizational networks among the various types of local agricultural and food institutions, some of the institutions themselves are sites of interorganizational networking. For example, community gardens have frequently helped to revitalize a neighborhood, and they have become sites for political organizing (Hess and Winner 2005, Lawson 2005, von Hassell 2002). Likewise, farmers' markets and food cooperatives are not only sites of networking among farmers and local consumers, but they also can draw people into a neighborhood and be colocated with small businesses.

City and regional governments can help develop local agricultural networks through a variety of strategies. For example, community gardens increasingly face land tenure issues as neighborhoods undergo revitalization and land values increase. Some cities are also finding that community gardening can be incorporated into the mission of parks and school grounds, where gardening can diversify park and recreational usage, increase the safety of publicly used areas, and contribute to the educational mission of public schools (Hess and Winner 2005). Likewise, in some cases city governments have encouraged the development of the networks by providing space and other resources for farmers' markets. In California local governments can also certify farmers as bona-fide local or state-level producers, and likewise they can certify farmers' markets to prevent resale from farmers and influx from out-of-state farmers. Federal legislation in the 1970s also allowed Cooperative Extension Services to help build farmers' markets, and their efforts helped spur the growth of the institution from about 300 markets nationally in 1970 to about 3000 thirty years later (Brown 2001, 2002).

The emergence of direct-to-consumer marketing will probably not be adequate to maintain small farms located close to suburban areas and subject to increasing land values. It is likely that the only solution for farms in such a situation is conversion to non-profit status, where the work of growing food is woven into other goals such as provision of food to the hungry, preservation of green spaces, and educational programs for schools. The emergence of nonprofit farming should be viewed not as the last gasp of the family farm but as the emergence of a new type of institution that could be an important player in a sustainable regional economy and an overall plan for green-space utilization. Not only are new technologies—organic and intensive food cultivation—necessary for the preservation of farms in areas proximate to large cities, but so are new organizational forms.

As in the other fields, in agriculture there will be ongoing definitional conflicts over what the "greening" of agriculture will mean. Again, object conflicts emerge among types of "green agriculture" and the choices involved in how one is to define and design a process for greening agriculture at an urban level. At one extreme, sustainable agriculture involves seed saving, composting, and organic and manual inputs, whereas at the other extreme there are incremental changes in the food production system that creates processed foods that are less unhealthy or more "natural." The later may include some organic ingredients, but more often it involves some claim related to food processing techniques, such as the absence of transfatty acids or partially hydrogenated oils.

Consumers face trade-offs among a range of products, from locally grown, fresh, whole foods to processed, frozen, nonlocal organic to processed "natural" foods. The point of consumption becomes a site where opportunities exist to embed local, whole, and organic foods in the regional economy, but ultimately those battles need to be carried from the farmers' market to the supermarket. For local, organic agricultural networks to survive and prosper, the purchasing policies of supermarkets will need to be redirected toward local, organic sources. This challenge is as true for the conventional supermarkets as it is for the new, upscale natural food supermarket chains. As a product, food is no longer merely a technology-driven entity that meets a code standard of organic or nonorganic; the challenge for a sustainable regional economy is also to define its provenance.

Opportunities exist for universities to define public missions around sustainability and agriculture. With some exceptions, at the major land grant universities organic agricultural research has remained a low priority, and social science research on local food networks can hardly be considered a high-prestige subfield in the social sciences. Unlike the energy field, where there are significant corporate and government investments being made in clean and renewable energy, the public domain quality of organic agriculture inputs has made the field relatively unattractive to corporate investors. As a result, there is little evidence for triple helix dynamics in this field, but there are significant educational opportunities for university programs oriented toward local networks of food, agriculture, and food security.

Other Sectors

Although it is not possible to cover in a comprehensive way the potential for building a sustainable regional economy across all industries, it is worth mentioning some of the possibilities in a few other, related sectors. In the three remaining sectors that will be mentioned here, it is more difficult to identify specific "greening" processes, but there are processes related to import substitution that provide some of the groundwork for a vision of a sustainable regional economy that includes a justice dimension.

Health issues intersect with sustainability in a variety of ways at a regional level. Health considerations, especially when industrial exposure is distributed unevenly across

ethnic and class divides, can provide a powerful framework to tip public opinion and political will in favor of changes that reduce exposure to toxic emissions from local brown industries. By aligning environmentally oriented import-substitution strategies with public health and environmental justice perspectives, it becomes much easier to mobilize the political will needed to develop import-substituting businesses and nonprofit organizations. In the health field itself, much of primary care delivery remains in the hands of locally owned, small provider practices, and consequently the opportunities for import substitution are less evident. However, the field of prevention, especially through dietary change associated with fresh (and local) food, might be conceptualized as a form of import substitution. In other words, through preventive health practices, dependency on drug-based imports to a regional economy can be reduced.

Media issues also intersect with local sustainability, largely through the politics of community diversity. The increasing control of electronic media in the hands of distant corporations has fueled a growing backlash in support of media reform as well as alternative media institutions such as community radio, Internet-based local media, public access television programming, and local alternative print media. Frequently, community media organizations are very concerned with building programming and coverage that represents the diversity of the community. Because environmental issues often have a significantly higher impact on low-income residents and ethnic minority communities, media that give them voice will tend to provide a forum for environmental, justice, and environmental justice discussions within the community.

Finally, locally oriented financial reform can have an impact on building a sustainable regional economy. Although the dominant institutions of the regional political economy will be focused on the publicly traded corporations associated with export-oriented manufacturing clusters, there are many other opportunities available for import substitution in the realm of finance. Institutions such as credit unions, local currencies, buy-local business organizations, and microfinance institutions provide another opportunity for financing the innovations of an import-substituting green regional economy. Many small businesses that are not publicly held can benefit from the marketing, expertise, and financial support that are provided by alternative financial institutions and often not available from the increasingly consolidated commercial banking industry.

Conclusions

The logic of continued economic growth that underlies the ecological crises is driven by large, publicly traded corporations that must show continued short-term profitability in order to attract the continued interest and confidence of investors. The "green technopole" model of ecological modernization takes place largely inside the existing system. After initial start-up research and development funding from federal and state governments, sometimes in partnership with large corporations, it is expected that the next phase of development will be manufacturing firms that will require access to capital markets for growth and long-term viability. They may sell some products locally and

therefore utilize an import substitution strategy, particularly during the early phases of product development, but the long-term trajectory is toward export-oriented sale of manufactured goods. Although the publicly traded firm is not the only possible form for the green technopole firm, the industries will tend to be oriented toward patentable research, manufacturing for nonlocal markets, corporate forms of organization, and capitalization from public stock offerings or the cash coffers of large corporations.

There are many advantages to developing environmental technology as a regional industry cluster. The industries will develop new technologies and products and provide high-income jobs as well as a source of revenue for the region. Because the problems of global warming and related energy issues are not likely to be solved in the short-term, the industries are likely to offer a relatively stable economic base for the region. Furthermore, because the industries are in the business of making greener products, they are more likely to respond to threats to brand dilution caused by criticisms of pollution hazards from their production processes. As a result, they have the potential to generate not only greener products but greener production processes.

In other words, there is much to be said in favor of having a "green technopole" as the regional industrial base, especially in comparison with a brown or silicon technopole. However, because the industries of the green technopole will be oriented toward profit maximization, and because there is little or no regulatory push to ensure that the technological innovations and new products will be sustainable in a profound sense, the green technopole industries are likely to become caught in the contradiction of design choices that optimize profits and those that optimize environmental impact. As a result, the vision of environmental sustainability may become incremental and oriented toward remediation of existing environmental problems rather than a deeper rethinking of the entire product life cycle from a zero-waste perspective. Furthermore, because firms will focus on high-tech, high-skilled labor, providing employment opportunities to low-income neighborhoods will likely be a relatively low priority.

The strategy of import substitution in combination with local, small business ownership provides an alternative mechanism for capitalizing an alternative type of green industry clusters. Under green localism, the primary organizational form is the privately owned small business, nonprofit corporation, voluntary organization, and local government agency. Locally owned import substitution entails using local inputs in locally owned firms that produce primarily for the local economy (Shuman 2000, Williamson et al. 2002). Under localist economic organization, there is less emphasis on growth and production for profit and greater emphasis on staying in business to provide a living. The sector tends to be undercapitalized, but it tends to provide a wider range of employment opportunities and product access to a broader segment of the population.

Furthermore, in the green localist form of the greening of regional industry, the vision of sustainability tends to be much broader than the model of incremental amelioration found

in the corporate sector. The design of production practices can be altered dramatically—as in organic agriculture, distributed solar, and building deconstruction—to generate new products. Likewise, environmental concerns are often linked to community justice issues, such as through food security, energy assistance programs, and access to affordable home supplies and consumer goods. Because organizations are not dependent on short-term earnings reports for their continued existence, they are in a better position to resist the need for continued growth that is at the heart of the problem of the "treadmill" of ongoing economic growth and environmental degradation. With some help from local governments and universities, there is tremendous potential to develop clusters of firms and nonprofit organizations around the import-substituting, green, locally owned industries.

Although I have tended to emphasize the difference between the models of the green technopole and green localism, it should be clear that there are many interstitial forms and hybrids. For example, the Freiburg solar industry is an example of a green technopole that, at least initially, was producing for local markets via an import-substitution strategy. Likewise, through organizations such as the Business Alliance for Local Living Economies (2005), it is possible for small, locally owned businesses that have a sustainability and social justice mission to network with like-minded businesses to purchase products nationally and internationally. Regional governments do not need to choose between the green technopole or green localism; rather, they need to recognize the value of developing both simultaneously.

Likewise, the university has a role to play in each of the fields. The dominant attraction—what Bourdieu (1998) might call the "right hand" of the university—will be to the high-stakes finances associated with the green technopole and the development of partnerships with large corporations and the state to form new industries. The partnerships are very attractive to a university because they bring in revenue for applied research that has technology transfer potential. As a result, the university will tend to define sustainability and regional industrial development around some version of environmental technology, which to date has largely meant clean fuel and fuel cell research.

However, the role of the university in a sustainable regional economy can be much more broadly defined, and opportunities exist for the university to serve as the node in local networks around energy aggregation, public transit, resale, food, community health, community media, and community financial institutions. In an institution as diverse as the modern university, there is room for the left and right hand. Even if the portfolio of research projects on sustainability will be weighted toward the technopole projects, the university will serve itself and its community well by supporting a diverse range of research activities oriented toward sustainability and the metropolitan region.

For example, universities can play a role in facilitating network building among the various types of industries described here, they can provide inventories of waste products and needs, and they can build demonstration projects on the campus. Universities can also stretch easily downward in the educational system to the K-12 programs, where there

are tremendous opportunities for building demonstration projects that can also serve as the basis for community-based research and recruitment of students into the university's undergraduate and graduate programs. By thinking about the issue of sustainability and regional development in a broad way to include a diverse range of regional industries, it is possible for the university not only to help develop the high-tech, green technopoles of the future but also to help develop a vision of just sustainability that articulates goals of zero waste production and the democratization of political decision-making.

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