

Technological capacity-building in unstable settings: Manufacturing firms in Argentina and Brazil

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ABSTRACT

From the 1970s onward, the macroeconomic context in Argentina and Brazil was characterized by drastic economic changes and instability. Numerous studies have documented the generally negative effect of this environment on the innovation capacities of the manufacturing sector. This paper, however, analyses the possible emergence of new innovation capacities in the period, bringing two important phenomena to light. First, a quite substantial number of firms, even in unstable settings, redoubled their innovation efforts. Second, these firms are mainly found in a small group of sectors associated with the countries' static advantages or in sectors favoured by specific sectoral regimes. The findings, although exploratory, are a contribution to the debate on the development of innovative capacities in unstable macroeconomic contexts and the ability of sectors associated with the two countries' static advantages to generate spaces of innovation and value creation.

KEYWORDS

Industry, manufactures, economic conditions, technological innovations, research and development, statistical data, Argentina, Brazil

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I

Introduction

This paper studies the experience of Argentine and Brazilian manufacturing firms with the accumulation of innovative capacities over the past two decades. The time frame chosen coincides with a context of economic instability and changing economic policies in both countries. This is unusual in studies of innovative capacity-building in emerging countries, which have tended to analyse long periods of continuous accumulation covering two, three or more decades.¹ Such studies reveal long-term continuity on two levels. First, they usually show capacity development at the microeconomic level progressing without complications through successive stages of ever “deeper” innovation activities. Second, in the relatively few Asian countries where most of the knowledge about the long-term technological behaviour of industrial firms in emerging countries has been generated, institutional and political contexts evolved continuously and were fairly stable. Although there were changes in the main policy emphases and some political and economic shocks, crises were not far-reaching or damaging enough to destroy and disperse existing innovation capacities. Consequently, the main lines of technological development were rarely disrupted, let alone cut short or reversed.

The Latin American experience has been very different. Following a period of cumulative firm-level capacity-building in the context of the relatively stable regimes and policies of the import substitution industrialization (ISI) period between the 1950s and 1970s, instability and fluctuations in the business cycle became recurrent. Not only have most of the region’s countries been affected by acute economic and financial crises, but they have implemented far-reaching changes in the orientation of economic policy in the last few decades. Between the 1980s and 1990s, trade and finance were liberalized, State involvement in the economy was reduced, currencies appreciated and foreign investment was favoured. Thereafter, the State gradually recovered its influence on the economy and neoliberal policies began to retreat.

These fluctuations and sudden shifts in the political and economic context are at the centre of the present study on technological capacity-building in the region, which takes manufacturing industry in Brazil and Argentina as its case studies.² Many earlier works have characterized the innovation pattern of firms in the Latin American countries over the past few decades, including Katz (2001 and 2007), Cimoli and Katz (2003), Chudnovsky, López and Pupato (2006), Baer (1970 and 1972), Teitel and Thoumi (1987) and Erber, Guimarães y Tavares Araújo Jr. (1974). Most of these studies have analysed the generally negative repercussions of the economic reforms of the 1980s and 1990s for the innovation capacity of the manufacturing sector.³ However, this study adopts a rather different perspective. The question needs to be asked as to whether there has been any process of new innovation capacity-building in the manufacturing sector during this period of drastic economic change and macroeconomic instability (when the prevailing effect on firms’ innovation capacities has been negative), what the sectoral ecology of this process is, and in what types of firms these capacities have arisen. The focus of the present research is on the new clusters of innovative firms created following the structural transformations in these countries during the 1990s. It should be pointed out that the approach is dynamic and relative, not static or absolute. The focus is not on individual cases of successful firms at a given point in time but rather on the way the technological efforts and outcomes of the main clusters of innovating firms have evolved.

The empirical analysis is based on evidence from innovation surveys. In Argentina, the surveys available cover the period from the early 1990s to the mid-2000s, while in Brazil they cover a shorter period in the 2000s. The analysis centres on firms that were in the vanguard of innovation in the countries and periods analysed. These firms were identified by taking those that claimed to have introduced a product or process innovation (or

¹ For example, Amsden (1989) in the Republic of Korea between the 1960s and 1980s; Kim (1997) on accumulation processes in the Republic of Korea; Hobday (1995) in Singapore, Taiwan Province of China and the Republic of Korea in the 20 to 30 years after the 1970s; and Mathews and Cho (2000) in their study of the development of the semiconductor industry in Asian countries.

² A forerunner of this study is Marín and Bell (2012), centring on Argentina in 1992-2001.

³ Although some innovation activities were carried out with positive results, particularly productivity increases and a narrowing of the efficiency gap with leading countries as a result of technology investment in several areas of the economy, especially industries associated with the exploitation and processing of natural resources.

both) that was new to the world economy at the start of the period studied. This innovation outcome indicator, while subjective, does make it possible to identify the most significant end of the innovative firms distribution.

The evidence analysed reveals some striking (or not wholly foreseeable) facts. First, new clusters of innovative firms seem to have been emerging despite the crises and far-reaching changes in economic policy orientation that have characterized these countries in recent decades. This evidence, although preliminary, goes against a pessimistic view in the region that has mainly identified negative results. It is interesting to note, however, that these clusters of innovators are found in a small number of sectors protected by static location advantages (such as traditional sectors or those associated directly or indirectly with natural resources) and indeed some sectors favoured by public policies, such as the automotive sector, which benefits from a special protection regime in both Brazil and Argentina. Lastly, and once again challenging pessimistic notions about the innovation intensity and potential dynamism of sectors protected by static advantages (such as natural resource-linked and traditional sectors), it can be seen that firms in these sectors have been making substantial, above-average efforts to improve their innovation and technology performance, albeit from very low levels.

This research is wholly exploratory. No attempt is made to give definitive answers to all the questions

raised, the intention being rather to bring new empirical evidence to the debate about the generation of innovation advantages in the region's countries. The information analysed does not cover the past few years, since innovation surveys are unavailable from 2005 onward. However, that does not take away from the main conclusions of this study, since to a large extent the phenomena identified have longer-term repercussions. Lastly, it should be stressed that the purpose of this paper is to present Argentina and Brazil as two case studies, but not to draw a comparison between them. The difficulty of comparing lies in the fact that different samples of dissimilar firms are taken for different periods, and that the indicator used to identify innovative firms, being subjective, could be influenced by national biases in the way the information employed in it is interpreted and understood.

The article is structured as follows. Section II briefly describes the context of instability in which manufacturing firms in Argentina and Brazil have operated since the relatively stable period of protection during ISI. Section III lays out the data and methodology. Section IV presents the first set of findings, identifying the sectors to which the most innovative firms belong. Section V concentrates on characterizing particularly innovative firms, identifying their origins and history and their patterns of technological behaviour. Section VI presents the implications of all this and provides some reflections based on the findings.

II

The context: from protection to exposure in a setting of profound instability

1. The beginnings of industry: the protectionist stage

The industrial and technological development of manufacturing in Argentina and Brazil began almost spontaneously in the late nineteenth century, when the agricultural export model was dominant in both countries. In the 1930s, however, the State began to actively promote industrialization by implementing policies to protect the domestic market (i.e., tariff barriers), creating State institutions (lending institutions and development banks) and providing infrastructure. As a result of these policies, four decades later Argentina and Brazil had developed a

diversified and fairly sophisticated manufacturing sector that had begun to act as a driver of their economies.

However, industrialization in Argentina and Brazil was heavily dependent on imported inputs and capital goods from the start. This characteristic, combined with weak export growth, led to recurrent balance-of-payments deficits which fed through to the main macroeconomic variables, creating regular crises, instability and inflation.

Many authors saw the inability of the manufacturing sector to generate exportable growth, reduce import dependence and secure steady as opposed to stop-start growth as being due particularly to certain limitations and imbalances that characterized technological learning and

industrial capacity-building (Katz, 1972, 1987, 2001 and 2007; Katz and Kosacoff, 1989 and 2000; Dahlman, 1984; Dahlman and Fonseca, 1987; United Nations, 1969). It has been argued that there was substantial growth in the manufacturing sector during the period, accompanied by steady increases in aggregate productivity and significant technological learning, particularly in some low- and medium-technology sectors (Teitel and Thoumi, 1987).

However, there were two major constraints. First, excessive vertical integration and limited specialization in engineering, combined with an abundant supply of skilled labour, resulted in an excessive domestic focus on adapting and incrementally improving technologies at the expense of investment in incorporated technological change or research and development (R&D) aimed at significantly reducing costs and developing more “radical” innovations and new products (Teitel, 1981; López, 1996). Indeed, the evidence is that spending on R&D, royalties, patents and franchises was low by international standards for the time (Katz, 1972). Second, inward technology transfer within sectors was very limited (Dahlman and Frischtak, 1990). In each sector, a small set of firms that had succeeded in attaining global standards of productivity through innovation efforts in engineering, quality, design and organization usually coexisted with a mass of firms characterized by low productivity, little innovation effort, obsolete equipment and products that were of low quality by international standards. It has been argued that the lack of external competition was a decisive factor in discouraging technological modernization and innovation across much of the production spectrum.

2. Structural reforms: destruction and resurgence

The progressive industrialization that took place, with fluctuations, throughout the twentieth century came to a sudden halt in the mid-1970s as economies were opened up and regulations and subsidies protecting the industrial sector were removed (Katz and Kosacoff, 2000). The economic instability and debt crisis of the 1980s further entrenched the process of economic and industrial stagnation. In consequence of these contextual and policy changes, manufacturing in Argentina and Brazil underwent the deepest crisis in the history of the industrial sector in the late 1970s and early 1980s. This crisis manifested itself, among other things, in the exit of firms from the market, a sharp fall-off in investment and the increasing obsolescence of capital equipment (see, among others, Katz, 2001; Kosacoff, 1996; Ferraz, Kupfer and Serrano, 1999; Baer, 2001).

In the 1990s, the liberalization and deregulation process initiated in the mid-1970s was carried further, although some novel elements also emerged: the privatization of most public-sector enterprises, price stabilization⁴ and currency appreciation. These elements imposed a new competition environment on industry. Studies carried out in the late 1990s and early 2000s identified the following trends as a consequence of the transformations wrought in the 1990s:

- (i) A slowdown in industrial growth: in Argentina, the contribution of the industrial sector to gross domestic product (GDP) fell from 19% in 1990 to 16% in 2000, while in Brazil industry grew at a slower rate even as it maintained its GDP share at a similar level throughout the 1990s (Barros de Castro, 2003; Ferraz, Kupfer and Iooty, 2004).
- (ii) Changes at the sectoral level: some industries shrank,⁵ some new ones were added to the industry mix and others disappeared. Industrial and natural resource-based commodities increased their presence (Cimoli and Katz, 2003; Ferraz, Kupfer and Iooty, 2004).
- (iii) Increased heterogeneity and concentration: some firms, mostly large ones and subsidiaries of multinationals, substantially raised their productivity and matched international best practices by investing in equipment and implementing organizational changes (introducing process automation, for example). However, a great many firms, particularly small and medium-sized ones (SMEs), were unable to implement these changes and disappeared, while others simply hung on, improving their productivity essentially by shedding employees (Kosacoff, 1996, 2000a and 2000b; Ferraz, Kupfer and Iooty, 2004; Katz and Bercovich, 1993).
- (iv) The closing of the productivity gap: in many sectors, modernization was carried out by rationalizing costs and acquiring technologies from abroad. Tie-ups with international suppliers, licensing and online technical assistance became the preferred channels. At the same time, local equipment suppliers, engineering firms and R&D laboratories lost ground (Katz, 2001; Ferraz, Kupfer and Haguenuer, 1996; Ferraz, Kupfer and Iooty, 2004).
- (v) Transnationalization: Argentina and Brazil became the main destinations for foreign direct

⁴ Price stabilization following enactment of the 1991 Convertibility Act in Argentina and the 1994 Real Plan in Brazil.

⁵ In Argentina, the metallurgy and chemical industries, the two most dynamic during the 1st period, contracted in the 1990s.

investment (FDI) in Latin America. In Argentina, the foreign share of total sales by the 200 largest manufacturing firms increased from 43% in 1994 to 69% in 1998 (Kulfas, Porta and Ramos, 2002). In Brazil, multinationals increased their share of sales by the country's 300 largest firms from 14.8% to 36.4% (Rocha and Kupfer, 2002). Incoming capital was used mainly to acquire existing assets via privatization, mergers and acquisitions. Thus, the incorporation of foreign capital tended to take

the form of takeovers of existing firms rather than an increase in gross fixed capital.

These characteristics arose in a context of great macroeconomic instability: periods of stabilization and growth followed by others with negative growth rates, shocks from international crises and external vulnerability. The main focus of the present analysis is on the generation of innovative capacities in the manufacturing sector from the 1990s to the mid-2000s.

III

Data and methodology

1. Data

The data used are from innovation surveys carried out among manufacturing firms in Argentina and Brazil. In the case of Argentina, surveys covering the periods 1992-1996 and 2002-2004 were used, while for Brazil surveys from 2000 and 2005 were analysed. Because the samples of firms altered between one survey and the next,⁶ the data are based on a subsample of firms featuring in every survey considered in each country. This subsample contains 608 firms in Argentina and 3,890 in Brazil.

2. Methodology: selecting innovative firms

The study aims to identify firms in the vanguard of innovation activity in the Argentine and Brazilian manufacturing sectors over recent decades, i.e., the subgroup of the 608 firms surveyed in Argentina and the 3,890 in Brazil that can in some way be categorized as "particularly innovative". It was not considered appropriate to employ for this purpose either of the two indicators most commonly used to measure firms' innovation capacity, namely patents and R&D spending.

- Results indicators based on patents usually have limitations, as they reflect invention rather than innovation, and because they have a strong sectoral bias (Scherer, 1983; Harabi, 1995; Levin and others, 1987). Furthermore, indicators based on patents

are particularly inappropriate in contexts such as those of Argentina and Brazil, where firms rarely use patents to protect their new knowledge. This is mainly for two reasons: (i) firms are usually adopters of technologies at or close to the frontier; (ii) there is a sectoral bias in the region towards process industries, where there is usually less of a tendency to patent. In Argentina, for example, according to data from the National Institute of Statistics and Censuses (INDEC), the Secretariat of Science and Technology (SECYT) and the Economic Commission for Latin America and the Caribbean (ECLAC), between 1998 and 2001 just 10% of innovators patented (Chudnovsky, López and Pupato, 2006). In this study, the concern is to capture the general characteristics of all innovative firms, not just those that patent, meaning that indicators of this type are not wholly suitable.

- Indicators based on R&D reflect the efforts made by firms to create knowledge, but do not show how effective this activity is and, more importantly in this context, tend to reflect differences in R&D intensity between industries rather than specific differences in innovation intensity between firms. Furthermore, these indicators tend to underestimate innovation activities closely related to production and information processing (Patel, 2000).

As innovation surveys have spread in many countries, different measures have begun to be used in the past 15 years to evaluate the innovativeness of firms. The most popular, when the aim is to measure outcomes rather than efforts, has been the percentage of sales accounted for by innovative products. In principle, this

⁶ In Argentina, the 1992-1996 innovation survey covered 2,430 firms and the 2002-2004 survey 1,690. In Brazil, the 2000 and 2005 innovation surveys covered 10,328 and 12,172 firms, respectively.

is a good direct measure of innovation outcomes, but it discriminates against process innovation (which is particularly important in Argentina and Brazil). This is why a different measure was chosen for the present study. Following the standard distinctions of the Oslo Manual (OECD, 1997), innovation surveys ask manufacturing firms about the degree of novelty entailed in innovations to products or processes, or both, introduced by them into the market during the survey period. When firms are asked about their innovation performance, four possible answers are available:

- (i) no product (or process) innovations were introduced;
- (ii) product (or process) innovations new to the firm were introduced;
- (iii) product (or process) innovations new to the local economy were introduced; or
- (iv) product (or process) innovations new to the world economy were introduced.⁷

Firms answering yes to the last of these options in the first innovation survey carried out in each country were taken to be the most innovative. An obvious constraint is that the answers are subjective. Answers by firms claiming to have introduced this category of innovation may not be a very accurate reflection of what innovations actually are “new to the world market”. However, this kind of accuracy is not the main issue here, as the main concern is with the relative innovation capacity of firms within each country, rather than with the identification of global leaders. The firms surveyed have the option of selecting less novel forms of innovation, and it would seem that, at least in relative terms, this category does adequately capture the most significant end of the innovative firms distribution.

⁷ See the latest version of the Oslo Manual (OECD, 2005, pp. 46-47) for an explanation of these categories.

To avoid confusion, the term “significantly innovative firms” will be used in the rest of the analysis for firms replying that they had introduced product or process innovations or both that were new to the global economy. The rest will simply be termed “non-innovative firms”, even though the latter group includes firms claiming to have introduced innovations that were new to the firm or the country. In the samples analysed, 68 Argentine firms (11%) and 167 Brazilian firms (4.3%) were found to be significantly innovative. Of these, most innovated only in products (60% in Brazil and 67% in Argentina). A larger share of firms in Brazil (28.1%) than in Argentina (7.4%) introduced only process innovations into the market. Those introducing both product and process innovations amounted to 12.6% of the total in Brazil and 25% in Argentina (see table 1).

It should be pointed out that the subjective character of the indicators used means that the findings for Argentina and Brazil ought not to be compared, as they could reflect national biases in the way the question is interpreted.

TABLE 1

Types of innovative firms in Argentina and Brazil
(Numbers and percentages)

Type of firm	Argentina	Brazil
Non-innovative	540 (88.8)	3 723 (95.7)
Significantly innovative	68 (11.2)	167 (4.3)
Process innovation only	5	47
Product innovation only	46	99
Product and process innovation	17	21
Total	608 (100)	3 890 (100)

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996) and the National Survey of Firms on Innovation, Research and Development and Information and Communication Technologies (2002-2004) in Argentina, and the Survey on Technological Innovation (PINTEC) (2000 and 2005) in Brazil.

IV

Analysis I: sectoral distribution of significantly innovative firms

This section studies the sectoral ecology of firms identified as significantly innovative. In particular, the aim is to establish whether there is a set of sectors where these firms cluster, as this will reveal areas of dynamic comparative advantages. With this in view, manufacturing sectors were

classified into two groups using the three-digit International Standard Industrial Classification of All Economic Activities (ISIC): sectors including at least one significantly innovative firm, and sectors with no such firms. The latter were discarded for the purposes of the analysis.

There are 31 sectors with at least one significantly innovative firm in Argentina and 70 in Brazil. It should be stressed, however, that the distribution of significantly innovative firms between sectors is far from homogeneous. There are sectors with many more significantly innovative firms than others (see column 3 of tables 2 and 3). To identify the sectors where significantly innovative firms cluster, the sectoral distribution of these firms was considered and sectors were classified into two groups: (i) those where the concentration of firms is equal to or greater than the median of the distribution (“sectors with clusters of significantly innovative firms”), and (ii) those where the concentration of firms is below the median of the distribution (“sectors without clusters of significantly innovative firms”).⁸ From here onward, firms in the first group of sectors will be referred to as “clustered innovative firms” and those in the second group of sectors as “isolated innovative firms”.

Tables 2 and 3 show that clustered innovative firms are concentrated in a small set of sectors within manufacturing industry: five sectors in Argentina and seven in Brazil. These sectors account for 42% and 31% of firms of this type in Argentina and Brazil, respectively.

Some further observations should be made about the intrasectoral composition of the group of sectors

with clusters of significantly innovative firms. Clustered innovative firms represent 18% of all firms in these sectors in Argentina and 7% in Brazil (see the fourth column in tables 2 and 3), i.e., 82% and 93% of firms in sectors with clusters of innovative firms are not significantly innovative in Argentina and Brazil, respectively. This suggests that the selection in this study encompasses a fairly small group at the upper end of the corporate innovativeness distribution.

In terms of sectoral ecology, one important characteristic to highlight is that four of the five sectors with clustered innovative firms in Argentina and four of the seven with the same characteristics in Brazil are associated via input-output links with natural resource-based industries⁹ (see table 4). Argentina accounts for the bulk of innovative firms clustered in a group of sectors directly and indirectly linked to natural resources. The sectors directly linked to the exploitation and processing of natural resources are those that process agricultural and livestock products, while the sectors indirectly linked to the exploitation and processing of natural resources are those supplying inputs for agricultural production (fertilizer and machinery). These sectors involve the type of production activity for which Argentina has a historical competitive advantage. It should also

⁸ The list of sectors without clusters of significantly innovative firms is available from the authors on request.

⁹ See annex for the methodology.

TABLE 2

Distribution of significantly innovative firms between sectors in Argentina
(Three-digit ISIC categories)

Sector	(1)	(2) Firms (number)	(3) (percentages)	(4) (percentages)
			Significantly innovative firms in the sector as a share of all significantly innovative firms	Significantly innovative firms in the sector as a share of all firms in the sector
Clustered innovative firms		29	42	18
Manufacture of pesticides and other agrochemical products		9	13	17
Production, processing and preservation of meat, fish, fruit, vegetables, oils and fats		7	10	18
Manufacture of agricultural and forestry machinery		5	7	45
Manufacture of other food products		4	6	13
Manufacture of parts and accessories for motor vehicles and their engines		4	6	24
Isolated innovative firms		39	58	9
Total		68	100	11

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996).

ISIC: International Standard Industrial Classification of All Economic Activities.

TABLE 3

Distribution of significantly innovative firms between sectors in Brazil
(Three-digit ISIC categories)

Sector	Firms (number)	Significantly innovative firms in the sector as a share of all significantly innovative firms (percentages)	Significantly innovative firms in the sector as a share of all firms in the sector (percentages)
(1)	(2)	(3)	(4)
Clustered innovative firms	50	31	7
Manufacture of pharmaceuticals and medicinal chemicals	12	7	13
Manufacture of footwear and parts of footwear	8	5	4
Manufacture of parts and accessories for motor vehicles and their engines	7	4	6
Manufacture of basic chemicals, fertilizers, nitrogen compounds, plastics in primary forms and synthetic rubber	6	4	17
Manufacture of agrochemical products	6	4	24
Manufacture of pumps, compressors, taps and valves	6	4	12
Manufacture of plastic products	5	3	3
Isolated innovative firms	97	69	3
Total	167	100	4

Source: prepared by the authors, on the basis of the Survey on Technological Innovation (PINTEC) (2000 and 2005) in Brazil.
ISIC: International Standard Industrial Classification of All Economic Activities.

be emphasized that a large part of the rationale for the ISI regime was to shift production specialization away from sectors of this type, in part because they were regarded as “low-technology” sectors that did little to further the incorporation of more important innovative activities within the economy (especially in the case of the industries most directly linked to natural resources).

In Brazil, sectors with clustered significantly innovative firms are more diversified between sectors connected and unconnected to activities based on the exploitation and processing of natural resources. Nonetheless, more than half of all clustered innovative firms (60%) are involved with natural resource-based activities, typically as suppliers. Particularly prominent among sectors linked to natural resources as suppliers are those involved in the “manufacture of basic chemicals, fertilizers, nitrogen compounds, plastics in primary forms and synthetic rubber”, “manufacture of agrochemical products”, “manufacture of pharmaceuticals and medicinal

chemicals” and “manufacture of pumps, compressors, taps and valves”. It is important to clarify that while the sectors just mentioned are linked via input-output relationships to activities based on natural resource processing (see annex), it would be a mistake to think that the whole set of firms belonging to these sectors are necessarily related. For example, the “manufacture of pharmaceuticals and medicinal chemicals” sector may include both innovative firms supplying inputs to natural resource-based activities and others not connected to natural resources (such as pharmaceutical firms working in the area of human health).

Other sectors in which innovative firms cluster but which are not connected to natural resources are traditional ones such as “manufacture of footwear and parts of footwear” and “manufacture of plastic products”. Clustered innovative firms that are not linked to natural resources also appear in Argentina and Brazil in sectors connected with automotive production (sectors 343 and 344). These reflect what

TABLE 4

**Classification of sectors with clusters of significantly innovative firms
in Argentina and Brazil**

	Sectors linked to natural resource-based industries		Sectors not linked to natural resource-based industries
	Directly	Indirectly	
Argentina	<ul style="list-style-type: none"> - Production, processing and preserving of meat, fish, fruit, vegetables, oils and fats (151) - Manufacture of other food products (including bread, biscuits, sugar, cocoa, tea and maté, among others) (154) 	<ul style="list-style-type: none"> - Manufacture of pesticides and other agrochemical products (242) - Manufacture of agricultural and forestry machinery (292) 	<ul style="list-style-type: none"> - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers (343)
Brazil		<ul style="list-style-type: none"> - Manufacture of basic chemicals, fertilizers, nitrogen compounds, plastics in primary forms and synthetic rubber (241) - Manufacture of agrochemical products (242) - Manufacture of pharmaceuticals and medicinal chemicals (245) - Manufacture of pumps, compressors, taps and valves (291) 	<ul style="list-style-type: none"> - Manufacture of footwear and parts of footwear (193) - Manufacture of parts and accessories for motor vehicles and their engines (344) - Manufacture of plastic products (252)

Source: prepared by the authors, on the basis of input-output matrices for Argentina and Brazil.

remains of the flourishing automotive metallurgy industry that was nurtured during the ISI period and that since the early 1990s has been at the centre of a system of sectoral policies which includes a special trading regime between the two countries and incentives for producers.

Sectors with clusters of innovative firms were deemed more innovative, since firms of this type represent a larger percentage of all firms in these sectors than in sectors without such clusters (see the fourth column of tables 3 and 4). It must be stressed, however, that among the latter are a number of sectors where significantly innovative firms represent a larger proportion of the total than in the group of sectors where significantly innovative firms cluster. However, these sectors contain very few firms, and they appear rather to be isolated instances of innovation than areas of sectoral clustering. Some sectors with these characteristics are the “processing of nuclear fuel” sector in Argentina and Brazil (100%), the “manufacture of insulated wire and cable” sector in

Argentina (50%) and the “service activities incidental to oil and gas extraction excluding surveying” sector in Brazil (33%).

In summary, it transpires that firms identified as significantly innovative in the countries analysed are clustered in a small group of sectors. In Argentina, four of the five sectors concerned are directly or indirectly linked to natural resource exploitation and processing activities. There is more variability in the case of Brazil, with none of the sectors being directly connected to natural resources as customers, but there are some sectors that are clearly associated with natural resources as suppliers and, strikingly, some traditional sectors too. Featuring in both countries is the automotive sector, which has a special protection regime. Since both natural resource-linked activities (particularly those identified as having a direct link) and traditional ones are regarded as low-innovation and low-value added activities, this result, taken by itself, is surprising. The next section goes into this in depth.

V

Analysis II: characterization of clustered innovative firms

This section looks more closely at the characteristics of clustered innovative firms. The first aim is to understand the structural characteristics of these firms, such as the origin of their capital, their size and their patterns of innovation behaviour. To this end, clustered innovative firms are compared with other groups of firms such as isolated innovators, non-innovators, firms in “high-technology” industries,¹⁰ the subsidiaries of foreign companies and the whole manufacturing establishment in general. This is followed by an exploration of the way firms’ innovation behaviour changed over the period studied, with their technological behaviour being evaluated using two types of innovation effort indicators:

- (i) the intensity of firms’ R&D spending (R&D spending as a share of total sales), and
- (ii) the intensity of investment in capital goods for innovation (spending on capital goods as a share of total sales).

The evidence is presented first for Argentina and then for Brazil. It is important to clarify that the data on firms’ innovation behaviour in the two countries are not comparable, as they cover different years and were collected from different samples. The greatest difference is that in Brazil the averages are calculated with reference to a sample of innovative firms (firms replying that they have not innovated during the period are excluded), while in Argentina the averages are calculated from the total sample of firms interviewed, innovative or otherwise.

1. Clustered innovative firms in Argentina

The majority of clustered innovative firms connected to natural resources in Argentina¹¹ are independent (52%), while smaller proportions are subsidiaries of international companies (31%) and local business groups (17%) (see table 5). The composition of this set of firms differs from that of the whole set of Argentine manufacturing firms in that it includes a smaller share of independent firms (71% of the manufacturing sector is composed of

independent firms) and a larger share of subsidiaries of foreign companies and local business groups (accounting for 17% and 11% of the manufacturing total, respectively). As regards size, clustered innovative firms are larger than the mean for the manufacturing sector (see table 6), with 48% of clustered innovative firms having over 200 employees, as against just 39% of the whole set of manufacturing firms.

In terms of innovation behaviour, in the early 1990s clustered innovative firms in Argentina as a group made greater efforts in capital investment (1.33%) than in R&D (0.10%). The pattern observed for firms of this type was also seen for the other types of firms considered (see categories 2 to 6 of table 7). However, the difference between the intensity of spending on capital goods for innovation and spending on R&D was smaller for clustered innovative firms (taken all together) than for the other groups of firms. Another interesting point to come out of the analysis is that clustered innovative firms, together with those in high-technology sectors, are the ones that invested most in R&D as a proportion of sales, although it might be noted that levels of R&D spending were generally quite meagre.

When innovation behaviour is analysed separately between the different groups of clustered firms, there are found to be substantial differences between them that are worth highlighting. The innovation activity of clustered firms linked to natural resources as customers was mainly based on investment in new technologies already incorporated into capital goods. Internal R&D spending, on the other hand, ranked among the lowest, along with that of non-innovative firms. Conversely, clustered firms indirectly linked to natural resources, along with high-technology firms, were among the types of firms investing most in R&D in the early 1990s. They spent 0.17% of sales on R&D activities, whereas manufacturing firms as a whole invested 0.06% of sales in the period.

As for innovative firms clustered in industries linked directly to natural resources, the pattern almost exactly matches the observations made in earlier studies of innovation activity in the 1990s. Innovation largely consisted in investments that were intensive in

¹⁰ Using the high-technology firms classification of the Organization for Economic Cooperation and Development (OECD).

¹¹ In Argentina, the focus is essentially on firms clustered in natural resource-linked sectors, as they account for the bulk of the total.

TABLE 5

Firms in Argentina by ownership type
(Numbers and percentages)

	Innovative firms clustered in natural resource-linked industries	Isolated innovative firms	Non-innovative firms in all industries	Manufacturing sector total
Local business groups	5 (17)	7 (18)	57 (11)	69 (11)
Independent local firms	15 (52)	24 (62)	395 (73)	433 (71)
Subsidiaries of multinationals	9 (31)	8 (21)	88 (16)	105 (17)
Total	29 (100)	39 (100)	540 (100)	608 (100)

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996) and the National Survey of Firms on Innovation, Research and Development and Information and Communication Technologies (2002-2004).

TABLE 6

Firms in Argentina by size
(Numbers and percentages)

	Innovative firms clustered in natural resource-linked industries	Isolated innovative firms	Non-innovative firms in all industries	Manufacturing sector total
SMES	15 (52)	27 (69)	327 (60)	369 (61)
Large firms	14 (48)	12 (31)	213 (40)	239 (39)
Total	29 (100)	39 (100)	540 (100)	608 (100)

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996) and the National Survey of Firms on Innovation, Research and Development and Information and Communication Technologies (2002-2004).

Note: small and medium-sized enterprises (SMES) are those with 200 employees or less and large enterprises those with at least 200 employees.

TABLE 7

Argentina: innovation behaviour in the manufacturing sector, 1992

Types of firms	R&D intensity	Capital investment
	Average values per firm (percentages)	
1. Innovative firms clustered in sectors:	0.10	1.33
- directly linked to natural resources	0.01	1.49
- indirectly linked to natural resources	0.17	1.23
- not linked to natural resources	0.12	-10.16
2. All other innovative firms	0.09	1.97
3. Firms in "high-technology" industries	0.20	1.57
4. Subsidiaries of foreign multinationals	0.06	3.17
5. Non-innovative firms	0.01	1.47
6. All firms	0.06	1.81

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996) and the National Survey of Firms on Innovation, Research and Development and Information and Communication Technologies (2002-2004).

R&D: research and development.

technologies already incorporated into capital goods, and production capacity was substantially enhanced as a result. However, there was virtually no sign of R&D within firms themselves, and innovative knowledge creation capacity was hardly in evidence. In the case of firms clustered in sectors indirectly linked to natural resources, on the other hand, the findings suggest that even in the darkest periods of innovation capacity destruction in the late 1980s and early 1990s, the agricultural sector sustained a group of chemical and machinery suppliers that formed a locus of clustered innovative firms in the vanguard of innovation activity as creators of knowledge within the Argentine manufacturing sector.

It is also interesting to supplement the above data with others that reflect developments in firms' innovation behaviour during the period analysed from 1992 to 2004. Table 8 shows the findings for the indicators analysed. Over more than a decade, innovative firms clustered in sectors both directly and indirectly linked to natural resources were distinguished by the growing intensity of R&D investment. In particular, firms in the former sectors increased the intensity of this spending almost three times as fast as the manufacturing sector average, i.e., by considerably more than non-innovative firms, which, along with this group of firms, were the ones that invested least in R&D at the start of the period. As regards innovative firms clustered in sectors indirectly linked to natural resource-based activities, these increased the intensity of R&D spending more quickly than other groups with a comparable intensity of R&D expenditure at

the start of the period (such as firms in high-technology sectors). Clustered firms not linked to natural resources, conversely, were the only ones to show negative rates of increase in R&D spending.

In 1992-2004, investment in capital goods for innovation fell in all the groups of firms considered. However, innovative firms clustered in sectors linked to natural resources were the ones that reduced their investment in this area least as a percentage of sales. In particular, innovative firms clustered in sectors directly linked to natural resources were alone in practically maintaining their investment in capital goods for innovation at the levels of the start of the period, even though their sales increased substantially.

In summary, taken together for the whole period analysed, the two groups of innovative firms clustered in sectors linked to activities based on the exploitation of natural resources constituted, by virtue of their relative efforts in innovation activities, an important locus of knowledge creation and usage capacity in Argentine manufacturing industry. This was a substantial and potentially important contribution, particularly at a time of great instability and upheaval like the one considered.

2. Clustered innovative firms in Brazil

Among clustered innovative firms in Brazil, whether or not linked to natural resource-based activities, local business groups are more heavily represented and

TABLE 8

Argentina: changes in innovation behaviour in the manufacturing sector, 1992-2004

Types of firms	R&D intensity	Capital investment
	Average values per firm (percentages)	
1. Innovative firms clustered in sectors:	17.12	-4.29
- directly linked to natural resources	31.84	-0.38
- indirectly linked to natural resources	16.25	-8.96
2. All other innovative firms	8.69	-7.40
3. Firms in "high-technology" industries	10.83	-10.59
4. Subsidiaries of multinationals	11.02	-14.95
5. Non-innovative firms	23.41	-7.50
6. All firms	11.57	-7.34

Source: prepared by the authors, on the basis of the Survey on Technological Behaviour of Argentine Industrial Firms (1992-1996) and the National Survey of Firms on Innovation, Research and Development and Information and Communication Technologies (2002-2004). R&D: research and development.

independent local firms less so than in the manufacturing sector as a whole. However, the composition of the group of innovative firms differs substantially depending on whether or not they are linked to natural resource-based activities. Among those so linked, 44% are subsidiaries of foreign companies, a relatively strong presence, while among those that are not, foreign firms are not heavily represented (5%). In addition, local business groups and independent local firms are more to the fore among natural resource-linked firms (45% and 40%, respectively) than among firms not linked to natural resource-based activities (23% and 33%, respectively), as can be seen in table 9. In terms of size, clustered innovative firms are larger on average than manufacturing firms generally, isolated innovative firms and non-innovators, and 87% of innovative firms clustered in natural resource-linked industries and 100% of clustered firms not linked to natural resources have over 200 employees. Firms of this size represent 56% of all firms in the manufacturing sector (see table 10).

As regards innovation behaviour, the figures presented in table 11 show that clustered innovative firms as a group made greater R&D efforts relative to sales (0.91%) than none-innovative firms (0.36%) and the subsidiaries of multinationals (0.79%) in 2001, but made less of an effort than other innovative firms (1.30%) and high-technology firms (2.06%). It should be noted that innovative firms clustered in sectors indirectly linked to natural resource-based activities made more than twice

as large an R&D effort as clustered firms not linked to natural resource-based activities (1.17% and 0.52%, respectively). In addition, clustered innovative firms linked to natural resources as suppliers rank alongside high-technology firms as those making the greatest R&D efforts relative to sales in the year analysed.

Observing the evolution of firms' innovation activity indicators brings some other interesting findings to light. Between 2000 and 2005, in a context where R&D investment intensity generally declined in the Brazilian manufacturing sector, clustered innovative firms were the only ones to increase their R&D effort year by year (see table 12). Clustered innovative firms not linked to natural resource-based activities made most progress, increasing R&D investment intensity by 16.15%. Other innovation efforts, such as the acquisition of knowledge incorporated into capital goods, were generally negative during the period analysed. However, clustered innovative firms linked to natural resources showed the smallest decline in capital investment of any type of firm (4.64% a year).

In summary, according to the indicators analysed, clustered innovative firms in Brazil (whether or not linked to natural resource-based activities through input-output relationships) form an important locus of innovation in the Brazilian manufacturing sector. It is interesting to note that these firms stand out throughout the period studied as the ones making the greatest innovation effort (such as R&D), of which there is little in the manufacturing sector of the region's countries.

TABLE 9

Brazil: innovative firms by ownership type
(Numbers and percentages)

	Innovative firms clustered in natural resource-linked industries	Clustered innovative firms not linked to natural resources	Isolated innovative firms	Non-innovative firms in all industries	Total
	Number of firms and proportions of column totals (percentages)				
Local business groups	7 (23)	9 (45)	29 (25)	486 (13)	522 (13)
Independent local firms	10 (33)	8 (40)	43 (37)	2 677 (72)	2 730 (71)
Subsidiaries of multinationals	13 (44)	3 (5)	45 (38)	559 (15)	617 (16)
Total	30 (100)	20 (100)	117 (100)	3 722 (100)	3 889 (100)

Source: prepared by the authors, on the basis of the Survey on Technological Innovation (PINTEC) (2000 and 2005).

TABLE 10

Brazil: firms by size
(Numbers and percentages)

	Innovative firms clustered in natural resource-linked industries	Clustered innovative firms not linked to natural resources	Isolated innovative firms	Non-innovative firms in all industries	Total
SMES	4 (13)	0 (0)	17 (15)	1 680 (45)	1 701 (44)
Large firms	26 (87)	20 (100)	100 (85)	2 042 (55)	2 168 (56)
Total	30 (100)	20 (100)	117 (100)	3 722 (100)	3 889 (100)

Source: prepared by the authors, on the basis of the Survey on Technological Innovation (PINTEC) (2000 and 2005).

Note: small and medium-sized enterprises (SMES) are those with 200 employees or less and large enterprises those with at least 200 employees.

TABLE 11

Brazil: innovation behaviour in the manufacturing sector, 2000

Types of firms	R&D intensity	Capital investment
	Average values per firm (percentages)	
1. Clustered innovative firms:	0.91	2.09
- indirectly linked to natural resources	1.17	1.74
- not linked to natural resource-based industries	0.52	2.61
2. All other innovative firms	1.30	3.56
3. Firms in "high-technology" industries	2.06	2.01
4. Subsidiaries of multinationals	0.79	6.03
5. Non-innovative firms	0.36	4.72
6. All firms	0.97	3.89

Source: prepared by the authors, on the basis of the Survey on Technological Innovation (PINTEC) (2000 and 2005).

R&D: research and development.

TABLE 12

Brazil: changes in innovation behaviour in the manufacturing sector, 2000-2005

Type of firm	R&D intensity	Capital investment
	Average values per firm (percentages)	
1. Clustered innovative firms:	5.72	-12.99
- indirectly linked to natural resources	1.50	-4.64
- not linked to natural resource-based industries	16.15	-26.95
2. All other innovative firms	-14.84	-10.80
3. Firms in "high-technology" industries	-1.22	-8.66
4. Subsidiaries of foreign multinationals	-3.89	-7.34
5. Non-innovative firms	-2.14	-27.32
6. All firms	-8.23	-12.72

Source: prepared by the authors, on the basis of the Survey on Technological Innovation (PINTEC) (2000 and 2005).

R&D: research and development.

VI

Discussion and final reflections

This paper has studied the evolution of innovation capacity in the Argentine and Brazilian manufacturing sectors during a period characterized by great economic instability and changes in economic policies in both countries. Many studies have documented the destruction of firms and technological capacities that prevailed at this juncture in the region. What has been investigated here, though, is the possible resurgence of innovation capacities and their sectoral distribution. The analysis has used intertemporal data from innovation surveys in Argentina and Brazil covering the period from 1992 to 2004 in the former and from 2001 to 2005 in the latter. The findings are not definitive because they are based on analysis of such evidence as exists, which is imperfect and fragmented. Nonetheless, they provide grounds for some reflections and suggestions that are potentially important for future research. Two in particular are worth mentioning and discussing.

First, a substantial number of clustered firms are found in a small group of sectors, which were identified as being at the vanguard of innovation and which greatly increased their innovation efforts during the period under study. The evidence analysed does not suggest that these firms are world leaders, one indication of this being their low levels of R&D expenditure, which is well below global standards; in relative terms, however, they stand out from other firms in each country, and it is thus interesting to analyse their characteristics.

Second, it should be stressed that the activities many of these innovative firms are clustered in are not the ones which would typically be expected. Firms clustered in sectors that are users of natural resources performed particularly well in Argentina, while this was true of firms clustered in traditional sectors in Brazil and of firms linked to natural resources as suppliers and clustered in sectors protected by special regimes in both countries. It is worth reflecting on the first two types: (i) firms clustered in sectors linked to natural resources, particularly as users, and (ii) firms clustered in traditional sectors.

(i) Connection to natural resources: industries connected to natural resources are usually regarded as having few technology opportunities. Since the 1950s, the development literature has argued that activities based on the exploitation and processing of natural resources have characteristics that do not make it easy

for firms to exploit the advantages of technological change and add value, in comparison with other activities such as industrial manufacturing (Prebisch, 1950; Singer, 1950; Nurske, 1958). Similarly, the innovation literature has identified manufacturing industries closely linked to natural resources as having few technology opportunities; indeed, they are classified as “low-technology” industries in industrial classifications (OECD, 1997). Consequently, the typical policy recommendation for countries with a marked specialization in natural resources has been that they should foster the development of other sectors associated with greater opportunities to add value, such as those activities grouped into the so-called “high-technology” segments. Recently, though, some authors have begun to stress that sectors based on the exploitation of natural resources are intensifying their use of knowledge and thus opening up opportunities for greater learning and innovation, and thence for the development of dynamic, innovative sectors associated with them (Marín, Navas-Alemán and Pérez, in press; Pérez, 1999, 2001 and 2010; Kaplinsky and Fitter, 2004). This is largely because of fundamental changes in historical conditions, together with demand shifts and the spread of new technological paradigms. The demand for foodstuffs, raw materials and energy has intensified in recent years due to the growing globalization of markets (and the incorporation of China into the world market), with a concomitant increase in the demand for variety and quality (such as the increase in demand for gourmet foods and safer or more environmentally friendly products). This is opening up opportunities that did not formerly exist to invest in knowledge and generate variety in conjunction with natural resources. Meanwhile, the spread of new technologies such as biotechnology and nanotechnology is multiplying the potential for innovation and differentiation, just as information and communication technologies (ICTs) are favouring and facilitating the incorporation of far-flung production zones into the global market (Von Tunzelmann and Acha, 2005; Marín, Navas-Alemán and Pérez, in press). The findings presented here may be beginning to capture these phenomena.

(ii) Traditional sectors: in the case of Brazil, areas of competitive advantage creation can also be seen in sectors that are not closely linked to natural resources but are traditional, such as the manufacture of footwear and plastic products. This may also be due to the penetration of new technologies in what are usually considered low- and medium-technology sectors (Von Tunzelmann and Acha, 2005) and to other emerging phenomena that the literature has begun to identify. Recent studies have shown, in fact, that traditional or low- to medium-technology sectors are not necessarily clusters of non-innovative firms (Kirner, Kinkel and Jaeger, 2009; Hirsch-Kreinsen, 2008). This is because products typically manufactured with old or mature technologies are beginning to be produced with technologies that are radically new or characteristic of some other industry (Kirner, Kinkel and Jaeger, 2009). The application of biotechnology to food processing is a clear example of how a sector regarded as being non-technology-intensive has begun to adopt what are identified as high-technology solutions and become increasingly dynamic. It is argued that this horizontal spread of technology between sectors will tend to blur the identification of industries with products and technologies and reduce the usefulness of certain sectoral classifications that are very widespread and heavily used.

Taken all together, these findings suggest that existing sectoral classifications may not be entirely relevant, or are not capturing recent phenomena such as intensified innovation in what are traditionally considered low-technology sectors, such as traditional ones and those linked directly to natural resources. They also suggest that industrial development policies that involve picking winners and are centred on identifying and strengthening isolated sectors may not be the most appropriate in the current context. On the contrary, in industrial policy terms it seems more promising to consider the interaction and interdependence between sectors (Hansen and Winther, 2010). It is known, for example, that firms in what are usually deemed low- and medium-technology industries are not only the most substantial in terms of output, employment and investment, but are the largest consumers of high-technology innovations (Robertson, Pol and Carroll, 2003). Consequently, the growth of high-technology activities largely depends on the growth of

other associated activities that are usually less intensive in R&D (Hauknes and Knell, 2009; Robertson and Patel, 2007). This interaction needs to be considered in the region's development strategies, avoiding excessive bias towards incentives for high-technology sectors that fail to take account of their links to and interactions with other production sectors.

Lastly, some questions, limitations and suggestions for future research may be noted:

The indicators used have some limitations. First, those measuring innovation focus almost exclusively on the manufacturing sector, preventing investigation of innovation patterns in other activities that are important to the region, such as primary activities and the service sector. Again, the innovation outcome indicators available present limitations when it comes to accurately capturing the innovation dynamic in these countries. Patents are a widely used and accepted indicator in more developed countries, but they have their limits, since the bulk of the innovation process in the region's firms consists of innovations that are incremental and adaptive or have a low degree of novelty, which means that the patenting system cannot be used to protect them. Other innovation outcome indicators available, such as the one used in this study, are based on subjective answers given by the firms surveyed as to whether they innovated or not in a given period and what degree of novelty was involved. The literature recognizes that this may lead to overstatement of firms' innovativeness. Consequently, the limitations of the indicators used and of the data available require caution when it comes to interpreting the findings and making hard and fast generalizations.

Second, this paper speaks of a resurgence, but the indicators of innovation efforts such as R&D are extremely low in some unexpected cases. It must be asked, then, whether they are low because the indicators available were unable to identify genuine innovators, or because the most significant innovators are in natural resource and traditional sectors where innovation is done differently (incremental and process innovation and engineering efforts are most important). More needs to be known in future about the characteristics of innovation in each sector, with a view to identifying indicators that serve to capture differences in the intensity of efforts and outcomes irrespective of sectoral characteristics. This will certainly enable more light to be shed on the questions raised in this study.

ANNEX

Identifying natural resource-related sectors

Two types of industries related to the production of natural resources are identified: consumers and suppliers. The classification was carried out using indices that measure the degree of connection to activities based on the exploitation of natural resources.¹² These indices use information on the value of transactions between industries drawn from each country's input-output matrix (IOM).

Because the activities in the IOM do not unequivocally match the three-digit International Standard Industrial Classification of All Economic Activities (ISIC), each sector's transactions were weighted by the sum of the value of production in the three-digit sectors corresponding to a given activity in the IOM.

The first index is the proportion of purchases from natural resource sectors made by each manufacturing industry as a share of the sector's total purchases. The larger the proportion, the greater the direct connection to natural resources.

The following procedure was applied for each sector j :

$$\text{Index natural resources Cons}_j = \frac{\text{sum}(IOM_{m = \text{natural resources}, n = j})}{\text{sum}(IOM_{m, n = j})}$$

An analogous procedure was applied to create the second index for natural resource sector supplier industries. The greater the index value, the greater their indirect connection to natural resources:

$$\text{Index natural resources Sup}_j = \frac{\text{sum}(IOM_{m = \text{natural resources}, n = j}^T)}{\text{sum}(IOM_{m, n = j}^T)}$$

The sectors identified as directly related to natural resources are those whose index values as consumers of these resources display above-average values, while sectors classified as indirectly related to natural resources are those whose index values as natural resource sector suppliers are above average. Sectors with above-average values in both groups were placed in the one for which they recorded the highest value.

¹² On the basis of the input-output matrix (IOM), natural resource sectors are: growing of cereals, oilseeds and fodder; growing of vegetables, flowers and ornamental plants; growing of fruit and nuts; growing of industrial crops; seed production; stockbreeding and production of milk, wool and hides; farm production; agricultural services; hunting; forestry and timber extraction; fishing; oil and gas extraction and coal and uranium mining; mining of metal ores; mining of other minerals.

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