CSAE WPS/2004-32

Firm Productivity, Wages, and Agglomeration Externalities*

Marcel Fafchamps — Oxford University

Said El Hamine — Ministry of Commerce and Industry

June 2004

Abstract

This paper investigates the existence of local externalities in manufacturing. In contrast to many other studies that focus on aggregate employment growth, we examine the effect of externalities on firm-level productivity and wages. Our empirical results show that agglomeration externalities occur through both productivity and wage effects. Returns to specialization are strong and large in magnitude. In accordance with the views of Marshall, Arrow and Romer, the net effect of competition on productivity and wages tends to be negative. Large firms facing no local competition have higher revenues and pay lower wages. Competition tends to lower wages, however, probably because of thick labor market externalities. We also find some limited evidence in favor of the diversity argument put forth by Jacobs.

.

*We are very grateful to the World Bank for financial assistance. We thank Peter Lanjouw for his constant support and Albert Zeufack for being instrumental in getting access to the data. This paper only represents the views of the authors, not those of the World Bank or of the Moroccan Ministry of Commerce and Industry.

1. Introduction

Enquiries into the reasons for differences in prosperity levels and economic activity between geographical locations has long ascribed a role to agglomeration externalities. The basic underlying insight is that, without some form of agglomeration externalities, it is difficult to explain the existence of many cities: since wages and land rents are typically higher in cities, employers would not locate there unless they were deriving some other benefit from their urban location. Some cities may nevertheless exist because of a geographical advantage, e.g., a natural harbor or waterway. Political and administrative reasons may also matter, as when a capital city concentrates much of the civil service employment, hence creating a market for industrial products.[1] Before ascribing the concentration of economic activity to externalities, it is therefore important to recognize the possible role of natural or political factors.

Empirical evidence on the precise nature of agglomeration externalities remains elusive. Agglomeration externalities are typically thought either to raise the productivity of individual firms directly, or to raise profits by reducing costs and raising the price firms can charge for their products. The first case corresponds to Marshallian externalities, the second to pecuniary externalities. With a few exceptions such as Ciccone and Hall (1996), much of the empirical work does not seek to document externalities directly but focuses instead on employment growth as well as firm entry and exit (e.g. Glaeser, Kallal, Sheinkman and Shleifer 1992, Ellison and Glaeser 1997, Henderson 1997, Combes 2000). The literature also encounters difficulties in disentangling pure locational advantages from agglomeration effects.

This paper tests the effect of various sources of agglomeration externalities on directly on total factor productivity and labor costs while controlling for unobserved heterogeneity across

[1] Braudel (1986) argues that many pre-industrial cities only existed by extracting massive surplus from surrounding rural areas and small towns.

firms and locations.[2] We also test for the presence of spatial spillovers between locations. The density of economic activity within the same sector is found to have the strongest and most robust effect, raising productivity while at the same time reducing wages. Competition has a negative effect on productivity but is also associated with lower wages. The net effect of local competition on returns to capital is negative. We find some evidence of spatial spillovers across neighboring locations but the effect is small.

Our paper differs from previous work in several important respects. First, our work seeks to measure productivity and labor cost advantages directly, not indirectly through employment growth as is typically done. Most theoretical explanations for agglomeration externalities focus on level effects – e.g., on productivity or prices. Although it is possible to imagine disequilibrium stories in which externalities affect the speed with which firm productivity rises over time, focusing on firm growth and entry is not a fully satisfying way of testing levels effects. Factors that affect the speed at which firms grow need not have a similar effect on their performance level.

Second, our analysis is conducted at the firm level, not at the aggregate level of the district or metropolitan area. As shown by Manski (1993), identifying external effects from aggregate data is inherently difficult because externalities compound individual effects at the aggregate level. Operating at the firm level enables us to control for individual firm size separately from hypothesized agglomeration effects. Third, our analysis controls for a variety of fixed effects. Unobserved firm heterogeneity is controlled via firm fixed effects. We also control for sectoral shocks that affect industries in a given year by including time dummies separately for each

[2] Other types of externalities may also influence firm performance. Kraay, Soloaga and Tybout (2001) and Roberts and Tybout (1997), for instance, examine international technology diffusion at the plant level and its relation with international trade. In the case of Morocco, Clerides, Lach and Tybout (1998) find a strong positive relationship between productivity and exports. Fafchamps, El Hamine and Zeufack (2002) also find such a relationship but also demonstrate that the decision to export increases in the proportion of exporter among local firms. We abstract from these issues here.

sector. This approach controls for time-invariant location specific factors, whether physical or political. Identification of agglomeration effects is thus accomplished by comparing, for the same firm, how changes in local conditions relative to the national average affected changes in total factor productivity and wages. While very demanding in terms of data, this approach guarantees against many potential sources of bias.

There is a large literature on agglomeration externalities, much of it focusing on manufacturing. The theoretical literature is particularly well developed and has identified many different types of externalities, some negative (e.g., congestion), some positive (e.g., shared infrastructure). Alfred Marshall, subsequently followed by Arrow (1962) and Romer (1990), identified knowledge spillover as an important source of externalities. To the extent that knowledge is transferred more easily through direct human contact, local information sharing is thought to give rise to agglomeration externalities of the 'Silicon Valley' type. The shared information need not be on technology; it may also include business opportunities or market relevant knowledge (e.g. Rauch and Casella 2003, Fafchamps et al. 2002).

Different views on what shared information is relevant and how it is exchanged have given rise to different theories regarding the nature of agglomeration externalities. One view, attributed to Marshall, Arrow and Romer and hence referred to as the MAR hypothesis by Combes (2000), claims that monopoly and market power are associated with more innovation and hence with larger externalities. The opposite view is championed by Porter (1990) who argues that monopolies are stultifying and that it is competition that spurs innovation and growth. Both these hypotheses are seen as emphasizing externalities within a sector. In contrast, Jacobs (1984) argues that it is the diversity of industries within cities that is a source of externalities, as industries borrow ideas from each other. The empirical evidence is contradictory. Using US data, Glaeser et al. (1992) find in general that local competition and urban diversity, but not specialization, encourage employment growth. In contrast, Henderson (1997) finds that both specialization and diversity have positive effects on firm growth but that the former is larger. Using French data, Combes (2000) finds the opposite result that competition and specialization reduce employment growth while diversity is negative for most industries and positive for services.

Pecuniary externalities have also been proposed as possible explanation for spatial concentration (e.g. Henderson 1988, Fujita, Krugman and Venables 1999). For instance, in a large labor market, it is easier and faster for employers to find the specialized manpower they need. This phenomenon is called thick labor market externalities by Glaeser et al. (1992). Forward and backward linkages as initially proposed by Hirschman (1958) are another possibility. Rodriguez-Clare (1996), for instance, construct a model where a larger market triggers entry in intermediate input production, thereby generating gains from specialization (see also (e.g. Ciccone and Matsuyama 1996, Fafchamps and Helms 1996, Fafchamps 1997)). Market size also matters. Krugman (1991), for instance, illustrates how proximity to larger market may attract industries if transport costs are neither too high nor too low. In this paper, we examine both types of externalities.

The empirical literature on externalities and industrial development remains unsettled (Tybout 2000). Glaeser et al. (1992), for instance, conclude that competition and diversity favor firm growth. In contrast, Henderson (1997) and Desmet and Fafchamps (2005) conclude that own-sector externalities are much stronger than those generated by other sectors. In his study of French manufacturing and services, Combes (2000) concludes that competition and total local employment have a negative effect on firm growth. Using a different methodology, Ciccone and Hall (1996) find that employment density increases average labor productivity. Combes, Magnac and Robin (2004) argue that contradictory results may be driven by slight differences in methodology. They insist that a consistent set of regressors needs to be used to obtain meaningful results.

The paper is organized as follows. The conceptual framework is presented briefly in Section 2 together with our testing strategy. Data issues are discussed in Section 3. Empirical results are presented in Section 4 together with robustness checks.

2. Conceptual framework and testing strategy

The starting point of our analysis is the standard producer model. Let Q, L, K, and S denote output, labor, capital, and intermediate inputs, respectively. We make the simplifying assumption that intermediate inputs are proportional to output, which is a fair approximation for manufacturing. Profit maximization can be written:

$$\begin{aligned} \max_{L_k, S_k, K_k} \Pi &= p_{ijt}Q_{kt} - w_{ijt}L_{kt} - r_{jt}K_{kt} - m_{ijt}S_{kt} \text{ subject to} \\ Q_{kt} &= A_{ijt}F(L_{kt}, K_{kt})\theta_{ik} \text{ and } S_{kt} = \alpha Q_{kt} \end{aligned} \tag{2.1}$$

where indices k, i, j and t stand for firm, location, sector, and time, respectively. The production function is assumed to have three components: A_{ijt}, which captures location and sector specific externalities; $F(L_{kt}, K_{kt})$ which depends on the standard labor and capital; and a fixed effect θ_{ik}. The location and firm-specific fixed effect θ_{ik} captures various time-invariant factors such as entrepreneurship, ownership structure, legal status, and the like, as well as location-specific time-invariant factors. We assume that the cost of capital is common across locations but that wages and the price of intermediate inputs (including industrial services) may vary across locations.

Agglomeration externalities can affect profits directly through A_{ijt} – a Marshallian externality – or indirectly through prices p_{ijt}, w_{ijt} and m_{ijt}. Models of agglomeration effects based on pecuniary externalities through intermediate input markets, for instance, operate through m_{ijt}

(e.g. Hirschman 1958, Rodriguez-Clare 1996, Ciccone and Matsuyama 1996). Location specific market power operate via p_{ijt} (Combes et al. 2004). Some of the thick labor market externalities are channelled through lower wages w_{ijt}. Market externalities that take the form of reduced search time and increased availability of inputs are indirectly captured in A_{ijt} as they make business more difficult and reduce the effectiveness of the firm.

We have data on revenues $p_{ijt}Q_k$ and on wages w_{ijt} for manufacturing firms. To investigate the nature and form of externalities, we use a two-pronged approach. We begin by estimating a model of the form:

$$\begin{aligned} p_{ijt}Q_{kt} &= B_{ijt}F(L_{kt}, K_{kt})\theta_{ik} \\ &= Z_{ijt}^{\gamma}F(L_{kt}, K_{kt})\theta_{ik} \qquad (2.2) \end{aligned}$$

where $B_{ijt} \equiv p_{ijt}A_{ijt}$ denotes firm productivity in value terms and Z_{ijt} is a yet-to-be-defined set of location and sector specific variables. Estimating equation (2.2) will enable us to identify the effect of Z_{ijt} variables on the value productivity B_{ijt}.

If workers are perfectly mobile and wages w_{ijt} are equalized across space, wages are not a source of local externalities. But if workers are imperfectly mobile and wages do not equalize across space,[3] agglomeration externalities take place through w_{ijt}. Estimating equation (2.2) alone would fail to to identify them. We therefore estimate another regression of the form:

$$w_{ijt} = Z_{ijt}^{\beta}\theta_{ik} \qquad (2.3)$$

where, as before, Z_{ijt} are agglomeration variables and θ_{ik} is a location and firm fixed effect. The

[3] Even if workers are perfectly mobile, wages may differ across locations to reflect differences in house rents and cost of living. Since in a spatial equilibrium house rents capture agglomeration externalities, equation () can be used as a basis for inference in this case as well.

third main avenue through which agglomeration externalities may arise, namely through the prices of intermediate inputs m_{ijt}, cannot unfortunately be estimated due to lack of information on input prices.[4]

We now turn to the determination of agglomeration variables Z_{ijt}. As discussed in the introduction, the literature has focused on three major concepts: specialization, diversity, and competition. A location is regarded as specialized if much of its industry is concentrated in a few sectors. According to the MAR hypothesis, specialization is expected to generate positive externalities on A_{ijt} through information sharing and thick market externalities (reduced search, larger variety of goods, services, and manpower). It may also reduce labor costs w_{ijt} if workers prefer to locate where job opportunities are plentiful in their employment sector of choice.

To a large extent, diversity is the opposite of specialization: the more specialized a location is, the less diversified it is. For a given level of specialization, however, diversity increases with the number of sectors present in that location. Given the number of sectors, diversity also increases the more equally activity is distributed across sectors. Jacobs hypothesizes that diversity is a source of positive agglomeration externalities because ideas and technologies developed in one sector spread to others. Industrial diversity also generates pecuniary externalities in the form of input-output linkages (e.g. Hirschman 1958, Thompson 2004).

Competition is also thought to affect agglomeration externalities, although the relationship between the two is a complex one. Schumpeterian competition ideas suggest that monopoly is a strong incentive to innovate. Unless an existing monopoly is constantly threatened by new entry, however, Schumpeterian innovation is likely to cease. The right mix of competition and monopoly thus appears to be required for productivity to be high. Different ways have been used in the literature to measure local competition. Two main ideas emerge. First, the

[4] Thompson (2004) seeks to identify inter-industry externalities that take place through input-output quantity linkages.

degree of competition is likely to increase with the number of firms operating in the same sector. Second, given the number of firms, competition is expected to be larger if industry is not highly concentrated.

To capture the above ideas, we proceed as in the rest of the literature and use labor as a measure of size. Let I_{ijt} be the set of firms present in location i and sector j at time t. Following Combes et al. (2004), six variables are used to measure the different forces thought to be associated with agglomeration externalities: the total size of a sector $L_{ijt} = \sum_{k \in I_{ijt}} L_k$; total employment in the location $L_{it} = \sum_j L_{ijt}$; the total number of firms in the sector N_{ijt}; the total number of sectors present in the location M_{it}; a diversity index D_{it} defined as

$$D_{it} = \frac{1}{\sum_{j \in I_{it}} \left(\frac{L_{ijt}}{L_{it}} \right)^2}$$

where I_{it} is the set of sectors present in location i at time t; and a competition index C_{ijt} defined as

$$C_{ijt} = \frac{1}{\sum_{k \in I_{ijt}} \left(\frac{L_k}{L_{ijt}} \right)^2}$$

Both D_{it} and C_{ijt} are Herfindahl indices. Complete concentration in a single sector (D_{it}) or firm (C_{ijt}) yields a value of 1. In contrast, if employment is equally shared among sectors, the diversity index becomes:

$$\begin{aligned} D_{it} &= \frac{1}{\sum_{j \in I_{it}} \left(\frac{L_{it}/M_{it}}{L_{it}} \right)^2} \\ &= \frac{1}{\sum_{j \in I_{it}} \left(\frac{1}{M_{it}} \right)^2} \\ &= M_{it} \end{aligned}$$

By the same token, when all firms are of equal size, $C_{ijt} = N_{ijt}$.

We also investigate possible neighborhood effects as follows. Let L_{ojt} denote sectoral employment in location o and let d_{io} denote the distance between i and o. Gravity models customarily predict proximity effects to decay at a speed inversely proportional to distance.[5] Consequently, define

$$V_{ijt} = \sum_{o} \frac{L_{ojt}}{d_{io}}$$

Variable V_{ijt} captures the effect of proximity to manufacturing employment in the same sector but in neighboring locations.

Taking logs, agglomeration effects in equation (2.2) are assumed to take the form:

$$\ln B_{ijt} = \gamma_{jt} + \gamma_1 \ln L_{it} + \gamma_2 \ln L_{ijt} + \gamma_3 \ln N_{ijt} + \gamma_4 \ln C_{ijt} + \gamma_5 \ln M_{it} + \gamma_6 \ln D_{it} + \gamma_7 \ln V_{ijt} \quad (2.4)$$

where γ_{jt} is a sector and time fixed effect to capture productivity shocks shared by all firms in a sector. Given the inclusion of sector-time fixed effects, the issue of normalization of D_{it} and C_{ijt} does not arise (Combes 2000). A relationships of the same form albeit with different coefficients is posited for w_{ijt}.

Several of the above variables have been used in one form or another in the literature before. For instance, own sector employment L_{ijt} is referred to by Henderson (2003) as a localization effect while L_{it} is said to capture urbanization effects. Sometimes similar variables are given a different interpretation. Henderson (2003), for instance, uses N_{ijt} as the number of sources of local information spillover while Combes et al. (2004) regard N_{ijt} alone as a measure of competition. In the work of Glaeser et al. (1992), it is N_{ijt}/L_{ijt} that is used as a measure of competition. The reason for these discrepancies is that authors have different types of data at their disposal and consequently use different set of agglomeration variables. It is important

[5] We tested other rates of decay but a -1 exponent on distance gives the best fit.

to recognize that the variables can only be interpreted in conjunction with each other. Their meaning depends on the presence or absence of the others.

With these caveats in mind, interpretation of equation (2.4) is straightforward. Parameter γ_1 captures global agglomeration externalities. If it is positive, it means that locating close to other manufacturing firms raises productivity. Conditional on L_{it}, parameter γ_2 captures specialization effects. This can easily be seen by defining specialization as L_{ijt}/L_{it}, in which case γ_2 is the coefficient of the specialization variable. Parameters γ_1 and γ_2 should thus be interpreted together. If, for instance, specialization does not matter but proximity to other manufacturing firms does, $\gamma_2 = 0$ and $\gamma_1 > 0$. If, in contrast, only proximity to firms in the same sector matters, $\gamma_2 > 0$ while $\gamma_1 = 0$. When proximity to other firms matters but proximity to firms in the same sector matters more, $\gamma_2 > 0$ and $\gamma_1 < \gamma_2$.

Competition is captured by two variables, N_{ijt} and C_{ijt}. If competition generates positive agglomeration externalities, as suggested by Porter, then $\gamma_3 > 0$ and $\gamma_4 > 0$. By combining N_{ijt} and C_{ijt} we can control for various configurations of competition. We have seen that $\max C_{ijt} = N_{ijt}$: if all firms are of equal size, $C_{ijt} = N_{ijt}$. Consider the following parameter configuration: $\gamma_3 < 0$, $\gamma_4 > 0$, and $\gamma_3 + \gamma_4 > 0$. This configuration implies that, if C_{ijt} increases at the same pace as N_{ijt}, externalities are positive. But if N_{ijt} grows much faster than C_{ijt} – e.g., because new firms are smaller – then externalities are negative. In this hypothetical example, competition is good for productivity only if additional firms are of equal size; adding a competitive fringe reduces productivity.

Diversity is also captured by two variables, M_{it} and D_{it}. The effect of these variables must be interpreted as conditional on specialization L_{ijt}/L_{it}. Put differently, these two variables measure the effect of diversity in sectors other than j. If diversity is good for manufacturing firms, then we expect $\gamma_5 > 0$ and $\gamma_6 > 0$. As for competition, different combinations of γ_5 and γ_6 capture different types of diversity effects. Parameter γ_7 captures possible neighborhood effects, which we expect to have the same sign as γ_2.

3. The data

To implement the above testing strategy, we use manufacturing census data from Morocco. The data were collected by the Moroccan Ministry of Commerce and Industry every year over the period 1985 to 2001. Coverage is universal and includes all manufacturing enterprises in all sectors and all parts of the country. Given that answering the annual census questionnaire is a legal obligation, the rate of non-answer is fairly small – 12% over the entire period.[6] These data have already been studied by others. The first years of this data set have been used by Clerides et al. (1998) to examine export behavior. The relationship between exports and productivity is also studied by Fafchamps et al. (2002).

The sectoral decomposition identifies 17 different sectors corresponding roughly to the 2-digit ISIC classification. Because 3 of the sectors have very few firms, for the sake of the analysis we combine them with other similar sectors, bringing the total number of sectors to 14. Data is available for all years on output, employment, wage payments, investment, and disbursed capital (a balance sheet equity concept). Capital stock information is available for the year 2001. Employment figures are separated into permanent and casual workers, the latter figure being given in total number of days per year. We divide the number of man-days by 256 to transform man-days of casual labor into permanent employee equivalent.[7] To facilitate comparison, we deflate all output figures using sector-specific GDP price deflator. Investment

[6] For the purpose of generating national and regional statistics, the Ministry of Commerce and Industry imputed values individually for each non-responding firm. Imputation was typically done using previous year information. Imputed firms are ignored in the regression analysis but to minimize measurement error imputed employment figures for non-respondent firms are used in computing the agglomeration variables described in the previous section.

[7] This corresponds to 365 - 52 x 2 (week-ends) - 6 (public holidays).

data is deflated using the price index for machinery.[8]

Location information varies over time. From 1985 until 1993, the manufacturing census only recorded the province in which the firm was located. This period correspond to a trade liberalization phase (Haddad and de Melo 1996). From 1994 until 1997, the data also recorded the city code and from 1998 on the precise commune location of each firm was recorded. Morocco is divided into 70 provinces, 67 of which count at least one manufacturing firm over the study period. Starting from 1993, the data distinguishes between 242 cities. From 1998, firm location data is available at the commune level. There are approximately 1300 communes in Morocco, 689 of which had at least one manufacturing firm over the study period.

For each commune, we computed the latitude and longitude of the central town or village. These coordinates are used to compute distance 'as the crow flies' between each commune. Based on these distances, we construct variables that capture neighboring effects. These variables are described more in detail at the end of the paper when we discuss neighboring effects. For cities and provinces, the average latitude and longitude are obtained by taking an average over all communes in the province, weighted by the population of each commune in the 1994 population census. The resulting latitude and longitude approximate the center of gravity of each city or province.

Descriptive statistics for our main variables are given in Table 1. We see that the majority of surveyed firms is small. The largest enterprise in the survey has the equivalent of 8000 full-time employees. Except for a handful of microenterprises,[9] all firms in the sample have at least one employee. Similar size differences are observed in output, with the median representing roughly one tenth of the sample average. The share of wages in total revenues is 28% on average – 17%

[8] Since we include sector-specific year dummies in all regressions, deflating is not really an issue. But it matters for back-predicted capital stock, as explained below.

[9] 39 observations out of 98000.

at the median. Unfortunately, we do not have data on intermediate input purchases and thus cannot compute value added.[10] Investment represents on average one forth of the book equity value of the firm, but in any single year the median firm invests nothing. The infrequent nature of investment is typical of datasets including small firms (Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Oduro, Oostendorp, Patillo, Soderbom, Teal and Zeufack 2004).

The second part of Table 1 presents capital stock information available for the year 2001 only. The figures represent the book value of machinery and equipment, gross and net of depreciation, and the book value of all firm assets, again gross and net of depreciation. Book value is often criticized as a poor approximation of the economic value of capital because the gross value overstates its true economic value while net value understates it. In 2000, information was collected on the economic value capital for a sample of 859 manufacturing firms (Fafchamps et al. 2002). Respondents were asked to estimate the resale and rental value of various components of their capital. Comparison of the different capital variables suggests that, in the case of Morocco, respondents have great difficulty estimating the economic value of their capital. For the purpose of calculating total factor productivity, the book value of capital appears to be a less imperfect measure of capital than alternative measures based on subjective evaluation as it yields a coefficient for capital that is both more precisely estimated and closer to the share of profits in value added.

Agglomeration variables are presented in Table 2. Reported figures are weighted by the number of firms in each commune. Consequently, they correspond to the environment faced by the average firm. The three panels correspond to the varying level of geographical detail available in the census data. From 1998 onwards, location variables can be defined down to the level of communes. The average firms operates in a commune where average sectoral employment is

[10] The data set contains a 'value added' variable that was computed by the Ministry on the basis of estimated fixed input-output coefficients. Since the variable does not contain any actual information, it is not used here.

around 1400 workers.[11] The median is much lower at 343. Total manufacturing employment is around 10000. The average firm operates in a commune where 11 of the 14 sectors of activity are represented and it is surrounded by 17 other firms in the same sector of activity. The competition index faced by the average firm is 7.1. This falls roughly between 1, which corresponds to complete concentration, and N_{ijt} which correspond to complete equality conditional on N_{ijt}. The equivalent figure for the diversity index is 4.4, which similarly falls between 1 and M_{it}. For the average firm, the proximity variable V_{ijt} is roughly of the same order of magnitude as sectoral employment.

The second and third panels show similar statistics when geographical location is defined at the level of the city and province, respectively. Figures suggest that, for the average firm, location and proximity variables are fairly similar whether location is defined by commune or city. But there are more than twice as many usable observations when using provinces. Not surprisingly, as the size of the location increases, the proximity variable falls as other locations tend to become more distant.

4. Productivity

We now turn to the econometric estimation. Before reporting estimates of equations (2.2) and (2.3), we must tackle is the absence of capital stock information for years other than 2001. To solve this difficulty, we estimate a predictive equation using capital stock data for 2001, and use the estimated coefficients to predict the capital in other years.[12] The predictive regression is presented in Table 3. A small number of firm characteristics such as age, legal status, foreign

[11] Measured in full-time employee equivalents.

[12] In their study of Moroccan manufacturing exports, Clerides et al. (1998) reconstruct capital stock data from investment information and assumptions about depreciation. We believe the approach used here is more accurate although, ultimately, it also relies on investment data to project capital stock information. In a firm-level fixed effect context, most of the intra-firm variation in predicted capital is accounted for by investment and lagged investment.

or public ownership, sectoral dummies, and location dummies are included as regressors. These variables tend not to vary over time and cancel out in subsequent regressions when we include firm-specific fixed effects. Time varying predictors include lagged labor and share of casual workers, investment and lagged investment, dummies for whether the firm invested in the current and previous period, and a dummy for whether is in its first year of existence, in which case all lagged values are set to zero. This parsimonious model explains two third of the variation in capital stock across firms. Capital stock values are then predicted for all years using the estimated coefficients reported in Table 3.[13]

Turning to our estimates of equation (2.2), a first set of results is presented in Table 4. All regressions reported in Table 4 and subsequent tables include a firm-specific fixed effect as well as sector-year dummies. This means that all effects are identified by comparing revenue changes in a given firm over time relative to average revenue changes at the sectoral level. The first column reports coefficients obtained using the finest level of geographical differentiation that our data allows, that is, commune data on the years 1998-2001. The second column uses agglomeration variables calculated at the city level for the years 1994 to 2001 while the last column uses province agglomeration variables and the whole 17 years of available data. For now we omit neighboring effects.

Results show that capital and labor have the anticipated effects on revenues. Implied labor and capital shares are low, but this is a standard result in firm fixed effect models. Firm revenues increase with age but the effect eventually taper off. A larger share of casual workers in total firm employment is associated with lower revenue. This was expected since casual workers tend to be less qualified and have had less time to adapt to the specific needs of the firm.

We find some evidence of agglomeration effects but, in spite of the large number of observa-

[13] Investment and equity values are deflated by the gdp deflator for machinery and equipment goods. Capital values cannot be predicted for 1985 because we do not have information on lagged labor and investment.

tions at our disposal, t-statistics are in general much smaller than that of firm-specific variables. This suggests that agglomeration effects on firm productivity and revenues are inherently difficult to measure. We observed a sign reversal for $\ln L_{ijt}$ between the first and second columns and the third column. If correct, this results seems to imply that at the very local level proximity to other firms in the same sector is detrimental while at the provincial level the effect is beneficial. The difference appears rather large: the results mean that a one standard deviation increase in $\ln L_{ijt}$ (keeping L_{it} constant) translates into a 5.7-6.2% fall in revenue at the commune and city level but a 2.4% increase in revenue at the province level. It remains to be seen whether this result is robust.

Other results of interest are the negative agglomeration effect associated with total employment $\ln L_{it}$. The effect is only significant at the city and province level, but it is quite large: a one standard deviation increase translates into a 7.5% fall in revenue. Since the negative effect of L_{it} is much stronger than the positive effect of L_{ijt}, the net combined effect of an increase in L_{ijt} remains negative – unless L_{it} is very much larger than L_{ijt}. As discussed in the conceptual section, the strong positive coefficient on L_{ijt} implies that aggregate returns to specialization are strongly positive.

The competition index $\ln C_{ijt}$ is positive but only significant in the province regression. This result is consistent with the view that competition raises productivity – a one standard deviation increase in $\ln C_{ijt}$ raises revenue by 3.7%. Our other competition variable $\ln N_{ijt}$ is not significant, however. This is in contrast with Henderson (2003) who finds that N_{ijt} has strong productivity effects. This effect, however, is only noticeable in high tech but not machinery industries. Since most Moroccan industries would be described as low tech, this may explain why N_{ijt} is not significant here. The number of sectors $\ln M_{it}$ is significant in the city and province regression but the diversity index never is. The effect of diversity is a 1.5-3% increase in total factor productivity (in revenue term) for a one standard deviation rise in $\ln M_{it}$.

These first results are consistent with the view that competition and diversity are mildly beneficial to productivity, as hypothesized by Porter and Jacobs. But the presence of other firms in the same location also exerts a strong negative influence on firm revenue, possibly because of congestion.

It is important to verify whether these results are robust. In particular, we worry that the labor variables may capture some of the productivity effects of agglomeration variables. Indeed, a rise in productivity should induce the firm to expand production and hire more workers. To eliminate this possible source of bias, we instrument the labor variables. Instrumenting equations are presented in Table 5 for total employment and in Table 6 for the share of casual workers in firm employment. Instruments are the same as those used for capital. A joint significance test shows that they are highly significant. Firm specific fixed effects are included as well.

We then reestimate Table 4 with instrumented labor. Results are presented in Table 7. The labor variable remains strongly significant. Agglomeration effects are now larger and more significant, suggesting that indeed prior to instrumentation labor variables were capturing some of the variation in revenue driven by agglomeration effects. We now find a very strong positive externality associated $\ln L_{ijt}$. The effect is extremely large: a one standard deviation increase raises total factor productivity (in value terms) by 12.6% at the commune level, 18.1% at the city level and 26.4% level at the province level. Total employment $\ln L_{it}$ remains negative, however.

The positive effect of competition on revenue is confirmed while diversity remains non-significant with the exception of the $\ln M_{it}$ variable at the province level. In contrast with Table 4, we now find a strong negative effect of $\ln N_{ijt}$ on revenue. The magnitude of the effect is quite large: a one standard deviation rise decreases productivity in value terms by 14.6-23.6%, depending on the level of geographical aggregation. This seems to indicate that competition has a complex effect on productivity: the presence of more firms in the same location depresses productivity measured in value terms but, conditional on the number of firms, less concentration among firms raises it. Our approach does not separate pure productivity effects on A_{ijt} from price effects on p_{ijt}. It is conceivable that competition raises the first while lowering the second. It is reasonable to expect a rise in N_{ijt} to depress prices. It is also possible that the fall in price is larger if at least one of the firms is large and forces smaller firms to follow its lead. If this were the case, an increase in N_{ijt} would result in a lower price fall if all firms are small and C_{ijt} increases at the same pace as N_{ijt}.[14]

The possibility remains that, when labor variables are instrumented, contemporaneous agglomeration variables proxy for labor, resulting in an overestimation of agglomeration externalities. To investigate this possibility, we reestimate Table 7 using lagged agglomeration variables instead. Doing so results in a loss of observations which is particularly damaging in the commune regression. At the province level, regression estimates presented in Table 8 are by and large similar to those in Table 7. But for the commune and city regressions, most coefficients become non-significant, probably because of the loss of observations. One result of interest is that the diversity variable $\ln D_{it}$ is now significant in the province regression. This could be because diversity effects may take more time to materialize.

Before turning to wages, we introduce neighboring effects $\ln V_{ijt}$. Other regressors are as in Table 8 and, as there, we lag all agglomeration variables, including $\ln V_{ijt}$. Results, presented in Table 9, show a strong negative neighboring effect that is significant at the commune, city, and province level: productivity in value terms is lower when sectoral employment is high in neighboring locations. The effect remains fairly small, however: a one standard deviation increase in $\ln V_{ijt}$ is associated with a 1-2% fall in total factor productivity. Combined with a

[14] Remember that C_{ijt} is basically measured in the same units as N_{ijt}. As N_{ijt} increases, so does the maximum possible value of C_{ijt}.

strong positive effect for sectoral employment in the same location, this finding suggests that agglomeration effects are non-linear. A similar finding is reported for the US by Desmet and Fafchamps (2005) using a different methodology.

5. Wages

Total factor productivity is but one form of agglomeration externalities. Agglomeration effects can also manifest themselves through pecuniary externalities on wages. To this we now turn and estimate equation (2.3). Labor and capital do not appear in (2.3). Consequently, estimation is simplified since no instrumentation is necessary.

Estimation results are presented in Table 10. Neighboring effects are included as well. Results are broadly similar to those obtained for productivity, except in reverse. Since ceteris paribus high wages are bad for firms, sign interpretation is reversed. Here, sectoral employment $\ln L_{ijt}$ is associated with a dramatic fall in average wages paid by firms. The effect is strongest at the commune and city levels, where a one standard deviation increase in $\ln L_{ijt}$ leads to a 34% fall in wages. When agglomeration variables are measured at the provincial level (column 3), the effect falls to 19% – a much smaller figure but still large. In contrast, the effect of total employment is ambiguous: non-significant at the commune level, negative at the city level, and positive at the province level; t values are also much smaller than for $\ln L_{ijt}$.

These results a prima facie suggest that the concentration of sectoral employment in the same location are associated with a massive reduction in wage. We cannot say why this is the case based on the data at our disposal, but it is consistent with the hypothesis that a thick local labor market attracts workers with sector-specific skills.

The sign reversal of the neighboring employment variable can be explained as consistent with this interpretation. In the commune regression (column 1), $\ln V_{ijt}$ has the same sign as

$\ln L_{ijt}$ but in the city and province regressions (columns 2 and 3) its sign becomes positive and significant. The difference must be due to the fact that, when the geographical entity expands over which $\ln L_{ijt}$ is computed, workers included in V_{ijt} get absorbed in L_{ijt}. Consequently, V_{ijt} includes workers located further and further away. This is consistent with the idea that the availability of workers in the immediate vicinity of the firm is good, but the availability of workers further away is not. To the extent that locations compete to attract workers, the vicinity of an attractive location nearby would increase wages as workers relocate.

The above interpretation must be tempered by a close examination of the other estimated coefficients, however. We find a strongly significant positive association between wages paid and the number of firms operating in an area. The effect is large: a one standard deviation increase in $\ln N_{ijt}$ leads to a 27% increase in wages at the commune and city levels.[15] This means that $\ln L_{ijt}$ has a stronger negative effect on wages when these workers are employed by a small number of firms. We also find that firm concentration has a positive effect on wages: controlling for $\ln N_{ijt}$, wages fall when firms are more equal in size. The net effect of local sectoral employment on local wages therefore depends crucially on the way this employment is distributed across firms. Wages are lowest when sectoral employment is large but equally spread across a small number of large firms. In contrast, wages are much higher if the same level of sectoral employment L_{ijt} is distributed across a large number of firms of unequal size. These findings suggest that it is competition for workers between large and small firms that increase wages. When sectoral employment is concentrated in a handful of large firms, wages remain low. The presence of a competitive fringe seems to be what raises wages.

Competition for workers across sectors also has a positive effect on wages, as suggested by the positive and significant coefficient of $\ln M_{it}$. In contrast, diversity has no effect on wages.

[15] 17% at the province level.

This is consistent with Jacobs's view that diversity externalities operate via knowledge transfers and better availability of inputs and industrial services, not through wages.

It is useful to compare the magnitude of agglomeration externalities operating directly on productivity and those operating through wages. For the sake of illustration, let us define all payments to capital as

$$R_{kt} = p_{ijt}Q_{kt} - w_{ijt}L_{kt} - m_{ijt}S_{kt}$$

We want to estimate the effect of agglomeration variables Z_{ijt} on R_k keeping firm-level L_{kt}, K_{kt} and S_{kt} constant. Since we do not have information on input prices m_{ijt}, we can only estimate the effect of Z_{ijt} on revenues $p_{ijt}Q_{kt}$ and on wages w_{ijt}. Dropping subscripts to improve readability, the percentage change in return to capital can be written:

$$\frac{\partial R}{\partial Z}\frac{1}{R} = \left[\frac{\partial (pQ)}{\partial Z}\frac{1}{pQ}\right]\frac{pQ}{R} - \left[\frac{\partial w}{\partial Z}\frac{1}{w}\right]\frac{wL}{R}$$

Expressions in brackets represent percentage changes in revenues and wages due to changes in an agglomeration variable Z; they correspond to estimated parameters. To calculate the percentage change in R, all we need are estimates of pQ/R and wL/R. Using value added figures computed by the Moroccan Ministry of Industry, the medians of pQ/R and wL/R are 6.29 and 0.912. Using these figures, we report in Table 11 the effect that a one standard deviation increase in each Z variable would have on payment to capital R, assuming that firm-level L_{kt}, K_{kt} and S_{kt} are constant and that m_{ijt} does not change with Z. The results are indicative of the respective strength of agglomeration externalities on wages and productivity in value terms.

Results suggest that in many instances wage effects are at least as large if not larger than productivity effects. In the case of own sector employment $\ln L_{ijt}$, wage and productivity effects reinforce each other to result in very large predicted effect on the return to capital: at the province level, a one standard deviation increase in $\ln L_{ijt}$ results in a near doubling of R. Another result of interest is the net effect of the number of firms N_{ijt}: at the commune level, N_{ijt} raises productivity but also wages, so that the net effect on R is close to 0. At the province level, however, the productivity effect of N_{ijt} becomes negative so that both wage and productivity effects reinforce each other and generate a strong negative effect of N_{ijt} on profits. The reverse is true for the competition index C_{ijt}: at the commune level, the net effect of C_{ijt} on return to capital is negative – controlling for N_{ijt}, more concentration raises returns to capital. In contrast, at the province level the net effect is positive – more concentration reduces returns to capital. The effects of diversity on productivity and wages show no clear robust pattern.

Taken together, our results suggest that the effect of competition on profits is more complex than often anticipated. At the very local level, R increases with L_{ijt}, falls with L_{it}, does not vary with N_{ijt}, and falls with C_{ijt} and V_{ijt}. It follows that returns to capital are highest with a single large firm in a single sector with no similar firms in neighboring locations: L_{ijt} is large, L_{it} is small, V_{ijt} is small, and $C_{ijt} = N_{ijt} = 1$. This corresponds to what is often called a company town. Our figures further suggest that the presence of additional firms in the same location yields basically the same outcome as long as they remain small enough not to raise C_{ijt}. This zero net effect is achieved because productivity and wage effects cancel each other. In larger geographical units, the company town effect is even stronger: R falls strongly with N_{ijt} and this effect is only partly compensated by a positive C_{ijt} effect. Since $\max C_{ijt} = N_{ijt}$ always, the net effect of an increase in N_{ijt} obtained with equal size firms is negative.

Another useful thought experiment is to imagine a company town with a single firm of size L in a single sector and see what happens when a firm of equal size joins. Our baseline is $L_{ijt} = L_{it} = L$, $M_{it} = D_{it} = 1$ and $N_{ijt} = C_{ijt} = 1$. With the second firm, we have $L_{ijt} = L_{it} = 2L$ and $N_{ijt} = C_{ijt} = 2$. Let the baseline and experiment be denoted by the subscripts a and b. The percentage change in revenues is:

$$\begin{aligned}\frac{B_b}{B_a}-1 &= \frac{B(L_{ib})^{\gamma_1}(L_{ijb})^{\gamma_2}(N_{ijb})^{\gamma_3}(M_{ib})^{\gamma_4}}{B(L_{ia})^{\gamma_1}(L_{ija})^{\gamma_2}(N_{ija})^{\gamma_3}(M_{ia})^{\gamma_4}} \\ &= \frac{(2L_{ia})^{\gamma_1}(2L_{ija})^{\gamma_2}(2)^{\gamma_3}(2)^{\gamma_4}}{(L_{ia})^{\gamma_1}(L_{ija})^{\gamma_2}(1)^{\gamma_3}(1)^{\gamma_4}} \\ &= 2^{\gamma_1+\gamma_2+\gamma_3+\gamma_4}-1\end{aligned}$$

and similarly for wages. The net effect of such a change is illustrated in Table 11 under the company town experiment heading. We see that in all three cases, productivity effects are negative. At the commune and city levels, wages tend to fall, possibly because the presence of another firm generates thick labor market externalities. In contrast, at the province level the wage effect is reversed. In all cases, the predicted combined net effect on profit is negative.

6. Conclusions

In this paper we have examined the effect of agglomeration externalities on total factor productivity and wages in manufacturing. Many other studies have relied on aggregate employment growth to identify agglomeration effects (e.g. Ellison and Glaeser 1997, Combes 2000, Henderson 1997, Combes et al. 2004). We depart from this literature in several important ways. First, we focus on the effect of agglomeration not on growth but on levels. Doing so requires that we adequately address the Manski (1993) critique, namely, that we be able to disentangle externalities from group and scale effects. To this effect, we rely on firm-level data and control for firm-specific fixed effects and for sectoral-specific yearly dummies. Our results are thus entirely based on

Second, we focus our analysis not on firm employment or output, as in other studies, but directly on wages and total factor productivity (in value terms). Agglomeration effects are indeed hypothesized to affect employment through Marshallian externalities – e.g., sharing of knowledge – or pecuniary externalities – e.g., thick labor market. These externalities affect employment indirectly through total factor productivity and wages. By focusing on the latter, our estimates should be more reliable. Finally, we examine geographical reach of agglomeration effects by comparing results using three nested geographical units. We also account for neighborhood effects.

Our empirical results show that agglomeration externalities occur through both total factor productivity and wage effects. Both effects are quantitatively equally important. While they sometimes operate in opposite direction, their effect on returns to capital are strongest when they reinforce each other.

Three main hypotheses dominate economic thinking regarding agglomeration externalities. The MAR hypothesis, attributed to Marshall, Arrow and Romer, is that local monopoly helps productivity because it means that Schumpeterian entrepreneurs can reap the benefits of their innovation. The second, attributed among others to Porter, claims instead that it is competition that favors productivity, as firms fight with each other to survive. The third view, associated with Jacobs, focuses not on own sector effects but on cross-sector externalities. According to this view, sectoral diversity helps productivity because of the exchange of information it favors and because of the pecuniary externalities it generates.

Results suggest that localization externalities are strong while urbanization externalities are weak or negative. Our main findings support the MAR hypothesis: the net effect of competition on productivity and wages tends to be negative. Large firms that face no local competition tend to have higher revenues and to pay lower wages. Consequently, we find little support for the Porter hypothesis although competition tends to lower wages, a point that has largely been ignored in the literature. Why this is the case is not entirely clear but we believe this is due to thick labor market externalities: workers tend to relocate where the presence of many firms in the same sector guarantees more employment security. These results stand in contrast with Glaeser et al. (1992) who find that local competition encourages firm growth. Perhaps the channel through which competition favors firm growth is not productivity, as is often thought, but something else such as location specific factors. This issue deserves more research.

We find very strong evidence that returns to sectoral specialization are positive. Diversification per se is not, therefore, a source of agglomeration externalities. Conditioning on own sector employment, however, we find some evidence that diversity in other sectors is favorable. This results confirms earlier findings by Glaeser et al. (1992) for US metropolitan areas and by Henderson (1997) for capital good industries.[16] Our results further show that the beneficial effect of diversity is noticeable only at the city or province level, it operates only through total factor productivity, and it seems to take more time to materialize. It is of course conceivable that diversity generates pecuniary externalities through its negative effect on input prices. Thompson (2004), for instance, shows that input linkages matter. Unfortunately, in the absence of input price data, this hypothesis could not be investigated here.

It remains to be shown whether the effects we have documented here affect firm entry and firm growth and whether they lead to more or less geographical concentration over time. These questions are the object of future research.

References

Arrow, K. J. (1962). "The Economic Implications of Learning by Doing.", *Review of Economic Studies*, 29:155–173.

[16]Henderson (2003), however, finds little evidence of economies from the diversity or scale of local economic activity outside the own industry.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J. W., Oduro, A., Oostendorp, R., Patillo, C., Soderbom, M., Teal, F. and Zeufack, A. (2004), Adjustment Costs, Irreversibility, and Investment Patterns in Africa's Manufacturing Sector. (mimeograph).

Braudel, F. (1986), *Civilization and Capitalism*, Harper and Row, New York.

Ciccone, A. and Hall, R. E. (1996). "Productivity and the Density of Economic Activity.", *Amer. Econ. Rev.*, 86(1):54–70.

Ciccone, A. and Matsuyama, K. (1996). "Start-Up Costs and Pecuniary Externalities as Barriers to Economic Development.", *J. Devel. Econ.*, 49(1):33–59.

Clerides, S., Lach, S. and Tybout, J. (1998). "Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico, and Morocco.", *Quarterly Journal of Economics*, 113(3):903–947.

Combes, P.-P. (2000). "Economic Structure and Local Growth: France, 1984-1993.", *Journal of Urban Economics*, 47:329–55.

Combes, P.-P., Magnac, T. and Robin, J.-M. (2004), The Dynamics of Local Employment in France. (mimeograph).

Desmet, K. and Fafchamps, M. (2005). "What Are Falling Transport Costs Doing to Spatial Concentration Across U.S. Counties?", *Journal of Economic Geography*, . (forthcoming).

Ellison, G. and Glaeser, E. L. (1997). "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach.", *Journal of Political Economy*, 105(5):889–927.

Fafchamps, M. (1997). "Mobile Capital, Location Externalities, and Industrialization.", *J. Comparative Econ.*, 25(3):345–365.

Fafchamps, M., El Hamine, S. and Zeufack, A. (2002), Learning to Export: Evidence from Moroccan Manufacturing. (mimeograph).

Fafchamps, M. and Helms, B. (1996). "Local Demand, Investment Multipliers, and Industrialization: Theory and Application to the Guatemalan Highlands.", *J. Devel. Econ.*, 49(1):61–92.

Fujita, M., Krugman, P. and Venables, A. J. (1999), *The Spatial Economy: Cities, Regions, and International Trade*, MIT Press, Cambridge and London.

Glaeser, E. L., Kallal, H. D., Sheinkman, J. A. and Shleifer, A. (1992). "Growth in Cities.", *J. Polit. Econ.*, 100(6):1126–1152.

Haddad, M. and de Melo, J. (1996), Brendan Horton., *Morocco, 1984-89: Trade Liberalization, Exports, and Industrial Performance*, Mark J. Roberts and James R. Tybout (eds), Oxford University Press for the World Bank, Oxford and New York, pp. 285–313.

Henderson, J. V. (1988), *Urban Development: Theory, Fact, and Illusion*, Oxford University Press, New York.

Henderson, V. (1997). "Externalities and Industrial Development.", *Journal of Urban Economics*, 42:449–70.

Henderson, V. (2003). "Marshall's Scale Economies.", *Journal of Urban Economics*, 53(1):1–28.

Hirschman, A. O. (1958), *The Strategy of Economic Development*, Yale University Press, New Haven.

Jacobs, J. (1984), *Cities and the Wealth of Nations*, Random House, New York.

Kraay, A., Soloaga, I. and Tybout, J. (2001), Product Quality, Productive Efficiency, and International Technology Diffusion: Evidence from Plant-Level Panel Data. (mimeograph).

Krugman, P. R. (1991). "Increasing Returns and Economic Geography.", *J. Polit. Econ.*, 99(3):483–99.

Manski, C. F. (1993). "Identification of Endogenous Social Effects: The Reflection Problem.", *Review of Economic Studies*, 60:531–42.

Porter, M. (1990), *The Competitive Advantage of Nations*, Free Press, New York.

Rauch, J. E. and Casella, A. (2003). "Overcoming Informational Barriers to International Resource Allocation: Prices and Ties.", *Economic Journal*, 113(484):21–42.

Roberts, M. J. and Tybout, J. R. (1997). "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs.", *American Economic Review*, 87(4):545–564.

Rodriguez-Clare, A. (1996). "The Division of Labor and Economic Development.", *J. Devel. Econ.*, 49:3–32.

Romer, P. M. (1990). "Endogenous Technological Change.", *Journal of Political Economy*, 98 (5) pt.2:S71–102.

Thompson, F. (2004), Industry Interaction, Knowledge Spillovers and Employment Growth in Moroccan Manufacturing. (unpublished MPhil thesis).

Tybout, J. R. (2000). "Manufacturing Firms in Developing Countries: How Well Do They Do and Why?", *Journal of Economic Literature*, 38(1):11–44.

Table 1. Descriptive statistics

(all values in '000 of 1974 Dirhams)	Number of obs.	Mean	Median	Sd. dev.	Minimum	Maximum
Variables available for all years						
Production	98121	5845	587	46812	0	3658655
Wage bill	98107	663	92	3618	0	379039
Permanent workers	98149	60	16	164	0	7416
Casual workers (in full employment equivalent)	98154	13	0	100	0	7813
Total employment	98149	73	18	208	0	8011
Share of wages in the value of production	98101	28%	17%	170%	0%	37133%
Investment	98154	306	0	2958	0	346227
Disbursed capital	98148	1264	112	25115	0	5591335
Variables available only for 2001						
Book value of machinery and equipment (gross)	6145	17219	167	502672	0	33100000
Book value of machinery and equipment (net)	5871	6363	66	194501	0	13600000
Book value of all assets (gross)	6238	26289	276	824950	0	59200000
Book value of all assets (net)	6010	13000	130	501713	0	38000000

Table 2. Agglomeration variables
(figures weighted by the number of firms in each commune)

	Number of obs.	Mean	Median	St. dev.	Minimum	Maximum
A. By commune (1998-2001)						
Sectoral employment in the location	22240	1411	343	2521	1	15478
Total employment in the location	22240	10290	6261	12291	1	59219
Sectoral number of firms in the location	22240	17	11	16	1	76
Number of sectors in the location	22240	11	13	4	1	14
Competitivity index	22240	7.16	4.48	6.88	1.00	34.24
Diversity index	22240	4.37	3.85	2.31	1.00	9.78
Proximity variable (see text for details)	22240	1771	280	3218	0	21863
B. By city (1994-2001)						
Sectoral employment in the location	39845	3217	1051	4423	1	24378
Total employment in the location	39845	28125	18788	29962	1	103629
Sectoral number of firms in the location	39845	39	22	39	1	163
Number of sectors in the location	39845	13	14	3	1	14
Competitivity index	39845	12.59	7.24	12.33	1.00	66.88
Diversity index	39845	5.48	5.22	2.66	1.00	10.94
Proximity variable (see text for details)	39845	1292	232	2342	0	13089
C. By province (1985-2001)						
Sectoral employment in the location	86058	3612	1651	4512	1	24378
Total employment in the location	86058	33621	19606	33285	2	116381
Sectoral number of firms in the location	86058	47	30	46	1	200
Number of sectors in the location	86058	13	14	2	1	14
Competitivity index	86058	14.43	8.52	14.14	1.00	75.05
Diversity index	86058	5.94	6.00	2.57	1.00	11.26
Proximity variable (see text for details)	85942	1178	296	2027	0	13768

Table 3. Predictive equation for capital stock

	Coef.	t-stat.
Firm characteristics		
Age of firm (log)	0.408	**4.10**
Age of firm (log squared)	-0.069	**-3.45**
Share of capital held by foreigners	0.002	**3.41**
Share of capital held by government	0.001	0.16
Limited liability (sole proprietor omitted categ	0.367	**8.11**
Corporation	0.590	**9.16**
Instruments		
Lagged labor (log)	0.355	**17.19**
Lagged share of casual workers	-0.267	**-2.17**
Disbursed equity (log)	0.508	**37.68**
Firm existed in previous year (yes=1)	-0.886	**-11.62**
Investment (log)	0.201	**15.16**
No investment (no=1)	0.377	**6.23**
Lagged investment (log)	0.049	**3.34**
No lagged investment (no=1)	0.043	0.63
Sectoral dummies	yes	
Regional dummies	yes	
Intercept	1.544	**4.34**
Number of observations	6106	
R-squared	0.666	

Table 4. Production function regressions
(the dependent variable is the log of output)

		Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
	Firm-specific variables	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
	Predicted capital stock (log)	0.134	**15.76**	0.169	**27.33**	0.173	**44.34**
	Firm age (log)	1.361	**15.09**	1.572	**31.29**	1.187	**49.20**
	Log of firm age squared	-0.351	**-11.62**	-0.381	**-25.96**	-0.278	**-43.49**
	Manpower (log)	0.396	**36.07**	0.480	**58.70**	0.570	**109.71**
	Share of casual workers	-0.230	**-6.68**	-0.342	**-13.29**	-0.388	**-22.68**
	Agglomeration variables (all variables in logs)						
1	Lit (total employment)	0.002	0.15	-0.044	**-2.46**	-0.052	**-4.99**
2	Lijt (sectoral employment)	-0.029	**-2.61**	-0.033	**-2.68**	0.014	**1.69**
3	Nijt (number of firms in sector)	0.016	0.72	0.025	1.13	-0.010	-0.68
4	Cijt (competition index)	0.020	1.26	0.007	0.56	0.037	**4.10**
5	Mit (number of sectors)	-0.017	-0.57	0.082	**1.71**	0.058	**1.66**
6	Dit (diversity index)	0.023	1.15	-0.001	-0.05	0.010	0.62
	Intercept	0.003	0.88	0.003	1.19	0.002	0.89
	sigma_u	0.051		0.060		0.075	
	sigma_e	0.426		0.506		0.578	
	rho	0.014		0.014		0.017	
	Nobs	21641		38784		84970	

Table 5. Instrumenting equation for labor

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Instruments	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Lagged labor (log)	-0.091	**-5.99**	0.074	**6.80**	0.162	**23.19**
Lagged share of casual workers	0.013	0.43	0.014	0.65	0.072	**5.36**
Disbursed equity (log)	-0.047	**-2.43**	-0.013	-0.89	0.009	0.98
Firm existed in previous year (yes=1)	0.210	**5.03**	-0.225	**-7.44**	-0.474	**-25.23**
Investment (log)	-0.021	**-2.65**	-0.001	-0.11	0.006	1.61
No investment (no=1)	-0.084	**-4.31**	-0.031	**-2.14**	-0.048	**-4.96**
Lagged investment (log)	-0.000	0.00	0.007	**2.75**	0.005	**2.99**
No lagged investment (no=1)	-0.014	-0.96	-0.007	-0.72	-0.021	**-2.94**
Exogenous variables						
Predicted capital stock (log)	0.161	**4.39**	0.098	**3.62**	0.072	**4.02**
Firm age (log)	0.740	**8.88**	0.785	**17.28**	0.590	**29.78**
Log of firm age squared	-0.166	**-7.84**	-0.179	**-16.49**	-0.124	**-27.53**
Intercept	1.790	**17.16**	1.919	**28.37**	2.049	**52.23**
sigma_u	1.419		1.239		1.088	
sigma_e	0.359		0.394		0.432	
rho	0.940		0.908		0.864	
	F statistic	p-value	F statistic	p-value	F statistic	p-value
Joint significance test of instruments	11.960	0.00	36.940	0.00	375.860	0.00
Nobs	21641		38784		84970	

Table 6. Instrumenting equation for share of casual labor

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Instruments	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Lagged labor (log)	0.002	0.45	0.006	**1.67**	0.002	0.91
Lagged share of casual workers	-0.120	**-12.75**	0.016	**2.43**	0.166	**40.87**
Disbursed equity (log)	-0.003	-0.46	0.001	0.15	-0.008	**-2.73**
Firm existed in previous year (yes=1)	0.013	1.00	-0.013	-1.37	-0.007	-1.25
Investment (log)	-0.002	-0.96	-0.000	-0.03	-0.002	-1.63
No investment (no=1)	-0.010	**-1.71**	-0.002	-0.44	-0.004	-1.24
Lagged investment (log)	-0.002	-1.47	0.000	0.10	-0.000	-0.84
No lagged investment (no=1)	-0.010	**-2.17**	-0.004	-1.30	-0.002	-0.80
Exogenous variables						
Predicted capital stock (log)	0.006	0.54	0.001	0.06	0.015	**2.78**
Firm age (log)	0.083	**3.21**	0.069	**4.86**	0.019	**3.26**
Log of firm age squared	-0.037	**-5.68**	-0.032	**-9.27**	-0.010	**-7.02**
Intercept	0.100	**3.10**	0.114	**5.37**	0.045	**3.77**
sigma_u	0.185		0.179		0.142	
sigma_e	0.111		0.124		0.130	
rho	0.734		0.677		0.543	
	F statistic	p-value	F statistic	p-value	F statistic	p-value
Joint significance test of instruments	25.510	0.00	3.670	0.00	278.880	0.00
Nobs	21641		38784		84970	

Table 7. Productivity regressions with instrumented labor
(the dependent variable is the log of output)

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Firm-specific variables	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Predicted capital stock (log)	0.141	**12.07**	0.080	**6.20**	0.107	**16.35**
Firm age (log)	1.304	**9.87**	1.011	**12.31**	1.000	**34.13**
Log of firm age squared	-0.306	**-7.97**	-0.242	**-7.66**	-0.241	**-32.54**
Manpower (log) **	0.240	**1.88**	1.174	**10.03**	0.939	**31.29**
Share of casual workers **	1.024	**3.59**	-0.024	-0.02	-1.060	**-9.18**
Agglomeration variables (all variables in logs)						
Lit (total employment)	0.000	0.01	-0.031	**-1.65**	-0.064	**-5.77**
Lijt (sectoral employment)	0.063	**5.64**	0.095	**7.61**	0.152	**17.53**
Nijt (number of firms in sector)	-0.127	**-5.83**	-0.152	**-6.70**	-0.202	**-12.72**
Cijt (competition index)	0.089	**5.59**	0.082	**5.95**	0.122	**12.89**
Mit (number of sectors)	-0.032	-1.05	0.031	0.63	0.083	**2.25**
Dit (diversity index)	0.025	1.18	0.021	0.75	0.023	1.35
Intercept	0.003	1.00	0.004	1.63	0.003	1.24
sigma_u	0.054		0.064		0.081	
sigma_e	0.438		0.526		0.614	
rho	0.015		0.015		0.017	
Number of observations	21641		38784		84970	

**: instrumented

Table 8 Production function regressions, labor instrumented and agglomeration variables lagged
(the dependent variable is the log of output)

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Firm-specific variables	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Predicted capital stock (log)	0.120	**7.65**	0.045	**2.85**	0.026	**3.53**
Firm age (log)	1.483	**7.93**	0.689	**6.35**	0.279	**6.75**
Log of firm age squared	-0.452	**-7.87**	-0.192	**-4.90**	-0.108	**-11.19**
Manpower (log) **	0.369	**2.16**	1.341	**9.15**	1.521	**40.80**
Share of casual workers **	0.514	1.42	0.426	0.30	-1.581	**-12.91**
Agglomeration variables (all variables lagged one year and in logs)						
Lit (total employment)	-0.022	-1.20	-0.021	-1.19	-0.044	**-4.42**
Lijt (sectoral employment)	0.014	0.83	0.015	1.02	0.063	**6.98**
Nijt (number of firms in sector)	0.036	1.06	-0.017	-0.66	-0.064	**-3.90**
Cijt (competition index)	-0.045	**-1.86**	-0.013	-0.78	0.044	**4.42**
Mit (number of sectors)	0.056	1.18	0.091	**1.94**	0.094	**2.71**
Dit (diversity index)	0.002	0.07	-0.028	-0.92	0.049	**2.83**
Intercept	0.022	**3.53**	0.017	**4.86**	0.021	**9.17**
sigma_u	0.081		0.072		0.083	
sigma_e	0.445		0.518		0.587	
rho	0.032		0.019		0.019	
Nobs	13034		27582		68998	

**: instrumented

Table 9. Production function, including neighboring effects
(the dependent variable is the log of output; labor is instrumented)

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Firm-specific variables	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Predicted capital stock (log)	0.120	**7.64**	0.045	**2.83**	0.026	**3.49**
Firm age (log)	1.482	**7.92**	0.685	**6.32**	0.263	**6.34**
Log of firm age squared	-0.452	**-7.87**	-0.190	**-4.87**	-0.101	**-10.34**
Manpower (log) **	0.367	**2.15**	1.344	**9.17**	1.522	**40.82**
Share of casual workers **	0.531	1.47	0.380	0.27	-1.584	**-12.93**
Agglomeration variables (all variables lagged one year and in logs)						
Lit (total employment)	-0.026	-1.40	-0.022	-1.28	-0.048	**-4.80**
Lijt (sectoral employment)	0.016	0.91	0.014	1.01	0.064	**7.05**
Nijt (number of firms in sector)	0.031	0.90	-0.017	-0.65	-0.064	**-3.90**
Cijt (competition index)	-0.043	**-1.80**	-0.012	-0.75	0.046	**4.64**
Mit (number of sectors)	0.067	1.41	0.088	**1.86**	0.096	**2.75**
Dit (diversity index)	0.001	0.02	-0.026	-0.85	0.051	**2.95**
Neighboring effects (lagged one year and in logs)						
Vijt (employment/distance)	-0.033	**-2.40**	-0.014	**-2.10**	-0.014	**-4.37**
Intercept	0.022	**3.55**	0.017	**4.80**	0.021	**9.05**
sigma_u	0.081		0.071		0.083	
sigma_e	0.445		0.518		0.587	
rho	0.032		0.019		0.019	
Nobs	13034		27582		68942	

**: instrumented

Table 10. Wage effects

	Communes 1998-2001		Cities 1994-2001		Provinces 1985-2001	
Agglomeration variables (in logs)	**Coef.**	**t-stat**	**Coef.**	**t-stat**	**Coef.**	**t-stat**
Lit (total employment)	-0.003	-0.28	-0.037	**-2.45**	0.017	**2.08**
Lijt (sectoral employment)	-0.171	**-18.02**	-0.179	**-17.83**	-0.109	**-16.63**
Nijt (number of firms in sector)	0.236	**12.70**	0.225	**12.27**	0.149	**12.36**
Cijt (competition index)	-0.091	**-6.74**	-0.068	**-6.06**	-0.028	**-3.86**
Mit (number of sectors)	0.049	**1.87**	0.066	1.63	0.119	**4.28**
Dit (diversity index)	-0.025	-1.39	0.031	1.36	-0.004	-0.33
Neighboring effects (in logs)						
Vijt (employment/distance)	-0.020	**-2.64**	0.018	**3.66**	0.044	**17.83**
Intercept	0.000	0.01	0.000	0.00	-0.000	-0.01
sigma_u	0.047		0.076		0.092	
sigma_e	0.378		0.433		0.469	
rho	0.015		0.030		0.037	
Nobs	22230		39827		85992	

Table 11. Net effects on profits

(all effects refer to a one standard deviation increase in the agglomeration or neighboring variable; calculations assume no adjustment in firm location and size)

	Communes 1998-2001			Cities 1994-2001			Provinces 1985-2001		
Agglomeration variables	**via productivity**	**via wages**	**total**	**via productivity**	**via wages**	**total**	**via productivity**	**via wages**	**total**
Lit (total employment)	-30.1%	0.5%	-29.6%	-23.6%	5.6%	-17.9%	-43.6%	-2.3%	-45.9%
Lijt (sectoral employment)	19.4%	30.6%	50.0%	17.4%	31.2%	48.5%	69.9%	17.3%	87.2%
Nijt (number of firms in sector)	22.1%	-24.8%	-2.6%	-12.7%	-24.9%	-37.6%	-46.8%	-15.9%	-62.7%
Cijt (competition index)	-25.4%	7.8%	-17.7%	-7.8%	6.3%	-1.5%	29.6%	2.6%	32.2%
Mit (number of sectors)	23.9%	-2.5%	21.4%	20.2%	-2.2%	18.0%	15.2%	-2.7%	12.4%
Dit (diversity index)	0.3%	1.3%	1.6%	-9.1%	-1.5%	-10.6%	16.1%	0.2%	16.2%
Neighboring effects									
Vijt (employment/distance)	-14.4%	1.3%	-13.1%	-6.3%	-1.1%	-7.4%	-6.3%	-2.8%	-9.2%
Company town experiment	-1.6%	-2.0%	-8.0%	-2.5%	-4.0%	-12.1%	-0.1%	2.0%	-2.4%