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Measuring Agglomeration Economies:
The Case of the Ethiopian Cut Flower Industry

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Abstract

Industrial clusters are ubiquitous, and the associated low transaction costs allow producers to benefit from information spillovers, interfirm division and specialization of labor, and the development of skilled-labor markets. Previous studies, however, have seldom quantified the benefits on business performance. Ethiopia's cut flower industry provides a rare opportunity to compare agglomerated with dispersed producers. Agglomerated farms frequently share technological knowledge and market information to decide when and even whether products are worth harvesting and shipping and to select product varieties. Econometric results indicate that agglomerated farms export higher valued flowers and achieve higher productivity and profitability. These findings imply that promotion of industrial clusters would further develop the industry.

(108 words)

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1. Introduction

The geographical concentration of production activity is often due to the exploitation of local natural advantages and benefits from social interactions among agglomerated producers (Ellison and Glaeser, 1997, 1999; Kim, 1999; Henderson, 2003). This latter advantage□i.e., positive external economy□is called agglomeration economies, and its first formal study dates back to the seminal work of Marshall (1890). Agglomeration economies can arise from various sources, such as information spillovers, division and specialization of labor among enterprises, and development of skilled-labor (and other specialized input) markets, which tend to be reinforced by the expansion of industrial clusters with the entry of new enterprises (Belleflamme *et al.*, 2000; Fujita, *et al.*, 2001; Fujita and Thisse, 2002; Duranton and Puga, 2004).[1] Understanding the mechanism and magnitude of agglomeration economies is expected to help in the formulation and implementation of effective industrial development policies (Rosenthal and Strange, 2004).[2]

The importance of agglomeration economies has been studied intensively and widely, often in the context of the diffusion of new products and improved production technologies: in urban economics (see, e.g., Jacobs, 1969; Glaeser *et al.*, 1992; Henderson *et al.*, 1995; Ellison and Glaeser, 1997, 1999; Duranton and Puga, 2004); agricultural economics (see, e.g., Foster and Rosenzweig, 1995; Conley and Udry, 2010); industrial organization (see, e.g., Greenstone *et al.*, 2010); growth theory (see, e.g., Arrow, 1962; Lucas, 1988; Romer,

[1] The industrial clusters can also grow in size by the entry of the spinoffs from incumbents and the diversified firms in the related industries (Buenstorf and Klepper, 2009, 2010) and foreign direct investment attracted by local supporting industries (Hilber and Voicu, 2010).

[2] Recent literature also emphasizes the role of agglomeration in ameliorating financial constraints (Huang et al., 2008; Ruan and Zhang, 2009).

1986, 1990); and development economics (see, e.g., Schmitz and Nadvi, 1999; Mano and Otsuka, 2000; Sonobe and Otsuka, 2006, 2011). In particular, spatial economics or the new economic geography explains the formation of industrial agglomeration with pecuniary externalities combined with increasing returns to scale and transportation cost (Fujita *et al*. 2001). Based on the collection and comparison of firm-level case studies in Asia and Sub-Sahara Africa, Sonobe and Otsuka (2006, 2011) suggest that an industrial cluster plays changing roles over the course of industrial development. Furthermore, there have been an increasing number of investigations into the process of information spillovers, which reveal that knowledge sharing tends to occur through direct interactions or linkages between firms both formally and informally (Sorenson, 2003; Boschma, 2005a,b; Torre and Rallet, 2005; Giuliani, 2007a,b, 2011; Morrison, 2008). The literature, however, has hardly quantified the effect of agglomeration economies on business performance and industrial development, probably because it is rare to find an opportunity to directly compare agglomerated producers with dispersed ones (ter Wal and Boschma, 2011).

The rapidly growing cut flower industry in Ethiopia provides us with such a unique opportunity. There are both 22 farms geographically concentrated and 42 farms dispersedly located (Figure 1), and the farms are exporting mainly to Europe. Exploiting this geographical feature of the industry, the current study directly measures the agglomeration economies on business performance of the flower farms. The export value of cut flowers from poverty-stricken Ethiopia grew at an annual rate of 120 percent between 2004 and 2008,[3] and in 2007 employed as many as 22,000 workers. To investigate the locational

[3]Source: UN COMTRADE (http://comtrade.un.org/db/default.aspx, accessed on March 9, 2010).

characteristics of the flower farms and the consequence on business performance, we intensively interviewed the managing directors of the flower farms, representatives of the government agency, and the industry association. We also conducted a census survey of the cut flower farms operating in Ethiopia from late 2007 to early 2008, collecting data for 2005 to 2007.

As a result of the interviews, we learned that agglomerated farms tend to frequently share technological knowledge and market information, both relatively specific to each variety of roses. This exchanged knowledge and information help the farms improve product quality, deal with diseases and insects, and decide when or even whether produced roses are worth harvesting and shipping. The flower industry is highly demand-driven, and a good grasp of knowledge on consumer preferences is critical to business success (Wijnands, 2005). In addition, with the permission of the National Bank of Ethiopia, some agglomerated farms also share orders from international buyers. Mano *et al*. (2011) observed the development of a skilled-labor market within the industrial cluster.

We used farm-level panel data to control for the local natural advantages (Manski, 1993). To confirm the robustness of our findings, we used two measures of industry agglomeration: (1) a cluster dummy indicating whether the farm is one of the 22 farms clustered in a district or *woreda* in Amharic (called Welmera) or dispersedly located elsewhere; and (2) the number of farms co-located in the same ward or *kebele*.[4] Our regression results show that farms located within an industrial cluster or farms co-located

[4] *Kebele* is the smallest administrative unit in Ethiopia. Each kebele consists of at least five hundred families, or the equivalent of 3,500 to 4,000 persons, while woreda is the second smallest administrative unit consisting of a number of kebeles.

by a larger number of farms in the smallest administrative unit tend to export 50 percent more high-value varieties of roses and that productivity and profitability of agglomerated farms nearly double and triple, respectively, that of their dispersed competitors.

The rest of the paper is organized as follows. Section 2 postulates our main hypotheses, while we describe the cut flower industry in Ethiopia in Section 3. Section 4 describes our data set and discusses the descriptive statistics. Our estimation strategy is presented in Section 5. The estimation results are examined in Section 6, and Section 7 concludes this paper.

2. Hypotheses

Imperfect information critically influence economic behaviors and resulting outcomes (see, e.g., Stigler, 1961; Akerlof, 1970; Nelson, 1970; Hirshleifer, 1971; Alchain and Demsetz, 1972; Spence, 1973; Milgrom, 1981; Arrow, 1984; Stiglitz, 2000). Since Marshal's (1890) original discussion on agglomeration economies, an extensive literature emphasizes that agglomerated producers benefit from information spillovers through frequent, face-to-face interactions (Fujita and Ogawa, 1982; Jaffe *et al.*, 1993; Sonobe and Otsuka, 2006, 2011; Giuliani, 2007a,b; ter Wal and Boschma, 2011).[5]

Our intensive interviews primarily with general and production managers show that agglomerated farms, especially those located within walking distances, tend to share technical knowledge and market information through frequent face-to-face interactions.

[5] Agglomeration can also promote labor mobility, and, consequently, spillovers of information embodied in these workers (Jacobs, 1969; Jovanovic and Nyarco, 1995; Combes and Duranton, 2006; Franco and Filson, 2006; Sonobe and Otsuka, 2006, 2010).

First, the agglomerated farms exchange technical knowledge on how to produce each variety of rose and deal with insects and diseases specific to each variety. Second, they share timely market information, including the recent history of the market price for each variety of roses, which is useful in predicting future prices and determining when or even whether, given the required cost, the roses under production are worth harvesting, storing, grading, bunching, packaging, and shipping. Third, they also share long-run market trend information helpful in the selection of rose varieties out of thousands of varieties.

To benefit from the potential localized positive externalities, the agglomerated farms tend to take joint action and realize collective efficiency (Schmitz, 1999). The sample farms produce eight varieties of roses on average, ranging from two to 35 varieties, and each rose variety requires different production processes and treatments. On the introduction of new varieties of roses, agglomerated farms are more likely to take account information spillovers listed above; this likely induces the agglomerated farms to select the same varieties as those of the neighboring farms.

Based on considerations of the collective efficiency of agglomerated flower farms, we postulate the following hypothesis:

Hypothesis 1: Agglomerated producers tend to produce higher value products than do dispersed producers.

In addition to the aforementioned collective efficiency of agglomerated farms, frequent face-to-face interactions among agglomerated producers are likely to reduce transaction costs (Hayami and Godo, 2004). As a consequence, the lower transaction cost is likely to improve the flexibility of business operation, for instance, by promoting order sharing among neighboring enterprises to meet the high volume demand that exceeds the capacity of individual producers (Marshall, 1890; Coase, 1937; Sonobe and Otsuka, 2006, 2011). Agglomerated producers can share fertilizers and other inputs relatively easily due to geographic proximity and meet a large volume of orders with high-quality products in a timely manner. Such coordination allows agglomerated producers to take orders in a more flexible manner and provides them with the means to mitigate risks from demand fluctuations.

Another advantage of industrial agglomeration is the development of a skilled-labor market. In the case of this particular cut flower-exporting industry, Mano *et al*. (2011) found evidence indicating that farms located within the industrial cluster benefitted from a greater supply of skilled production workers, which reduced the cost of search and matching for both potential employees and flower farms with vacant positions, and also lowered wage rates. Moreover, the highly skilled workers are more likely to contribute to the improvement in productivity and profitability from rose production.

These considerations lead to the following hypothesis.

Hypothesis 2: Agglomerated producers achieve higher productivity and profitability than isolated producers.

We test these hypotheses on the cut flower industry in Ethiopia in section four. The next section describes this industry in greater detail.

3. The Cut Flower Industry in Ethiopia

Rapid growth in the Ethiopian cut flower industry

State farms started to export cut flowers to Europe in 1980, but the scale of the cut flower industry expanded in the mid-2000s with the introduction of privately owned farms (Getu, 2009). Only 10 cut flower farms were operating in 2004; the number has increased to 81 by the end of 2008, employing as many as 50,000 workers (The Embassy of Japan in Ethiopia 2008).

Table 1 presents the cut flower export value (in million USD) by the top cut flower-exporting countries in Africa. Kenya is the largest cut flower exporter in Africa, the fourth largest in the world, after The Netherlands, Colombia, and Ecuador. Kenya's export value increased from USD 91 million in 2000 to USD 446 million in 2008. Ethiopia's cut flower exports have more drastically increased since 2004, from USD 2 million to USD 104 million in 2008. Although Ethiopia's export value is still only about one quarter of Kenya's as of 2008, Ethiopia has become the third largest cut flower exporter in Africa.

How did the young cut flower industry in Ethiopia achieve such rapid growth within this short period? First, Ethiopia has agroclimatic conditions well-suited for flower cultivation, even superior to those in neighboring Kenya (Bolo, 2007; The Embassy of Japan in Ethiopia 2008; Getu, 2009). Second, Ethiopia has extensive underdeveloped highlands around its capital city, Addis Ababa, with a climate of high daily temperature and cool nights and sufficient sunlight and rainfall, which are all favorable for flower production. Third, the country has abundant labor supply with a lower wage rate than in other African countries.

Policies by the Ethiopian government have also contributed to the development of the cut flower industry (The Embassy of Japan in Ethiopia 2008; Getu, 2009). The government gave tax exemptions (profit tax, export tax, and duties on imports of capital goods and raw materials) and revised the investment law to attract foreign investors. Furthermore, the government also provides generous long-term loans through the Development Bank of Ethiopia (DBE).[6] As a result, the investment climate in Ethiopia has tremendously improved over the mid-2000s, which has led to substantial capital inflow into the industry.

Furthermore, the Ethiopian government also leased land to the cut flower farms at rates as low as USD 4 per hectare per annum on average□land near the international airport in the capital city of Addis Ababa was leased at less than USD 20 per hectare per annum (The Embassy of Japan in Ethiopia 2008). Investors into the cut flower industry can request detailed information on several available locations from the government and other sources, and they eventually select a location.[7] In this process, more able investors may tend to make generally better location decisions. In the empirical analysis below, we will use the panel data to control for the individual effect of investors so that we can measure the effect of changing business environment in particular locations separated out from the investors' business ability.

[6] Investors can borrow up to the debt-equity ratio of 70 to 30 without collateral. According to our survey, 75 percent of the cut flower farms have a bank loan and 45 percent of the farms reported borrowing from DBE for their initial investment in particular. Two-thirds of the farms indicated that equity or the business project was the only collateral required for a bank loan.

[7] While land sale is prohibited in Ethiopia, Pender and Fafchamps (2006) find that the land lease market operates relatively efficiently.

Another factor relating to the growing competitiveness of the Ethiopian industry is the international shift of production sites of international investors from Kenya as a result of water pollution in Naivasha Lake in Kenya and the expiration in 2008 of the ACP/EU Cotonou Partnership Agreement for Kenya (Bolo, 2007). The growers in Kenya have to bear additional costs to avoid further environmental deterioration, resulting in a decline in the competitiveness of the Kenyan cut flower industry, whereas Ethiopia soon adopted a code of conduct to conserve the environment for the sector in 2007 before its environmental effect becomes a serious issue (The Embassy of Japan in Ethiopia 2008; Getu, 2009). Furthermore, the exemption of EU tariffs on flower exports from Kenya expired in January 2008, whereas Ethiopia is still exempt from the tariffs. In addition, after the presidential election in December 2007, Kenya experienced political violence in many areas, including Naivasha, where many flower farms operate (Yamano and Tanaka, 2010). Some experts also believe that the violence has caused some flower farms in Kenya to relocate their production sites to Ethiopia.

Production technology

The distinct features of this industry are the sensitivity of product quality to temperature and the perishability of the product once harvested. Therefore, in addition to the critical importance of farm altitude, which is closely associated with temperature, initial capital investments in air-conditioned greenhouses and refrigerated storehouses and trucks are indispensable (Bolo, 2008). As the majority of these cut flower farms entered the industry during the mid-2000s, they adopted the common state-of-the-art production technologies at that time (The Embassy of Japan in Ethiopia 2008).

Although the tasks required of production workers are relatively simple, high educational background and long experience in the sector are invaluable for efficient operation at the supervisory and management levels (Whitaker and Kolavalli, 2006; Mano, *et al*., 2011). Here again, agglomeration can help new enterprises employ managers and supervisors through headhunting from incumbent farms, thus acquiring information embodied in these employees (Jacobs, 1969; Jovanovic and Nyarco, 1995; Combes and Duranton, 2006; Franco and Filson, 2006; Sonobe and Otsuka, 2006, 2011). Indeed, the Golden Rose, a pioneering cut flower farm in Ethiopia, lost most of its skilled managers and supervisors to newly established farms by 2004 at the same time it contributed to the development of this sector as a whole. Headhunting is still a common practice in this sector.

The flower market

There is virtually no domestic market for roses and other flowers in Ethiopia. The cut flowers, mainly roses, are sold on the world market, where market prices of high-end flower varieties particularly fluctuate following the lead taken by internationally prominent flower designers.[8] The average expenses for marketing and transportation are estimated to account for more than 70 percent of the total variable cost (Joosten, 2007). The major international markets include Europe, the U.S., the Middle East, and Japan, where only high-quality flowers are traded, and consumers are willing to pay a substantial premium (Wijnands 2005). The producers penetrate these markets initially through the world's

[8] According to an expert at the Ethiopian Horticulture Producer Exporters Association (EHPEA), these high-end flowers account for around one-fourth of the total value of flower transactions.

largest auction market held in Holland, but they are gradually shifting towards direct contracts with international buyers, allowing generally more stable and higher prices (Hughes, 2000). Furthermore, in addition to regular demand fluctuations, the demand seasonally reaches its peak on Christmas and Valentine's Day and is lowest in mid-August. Under these circumstances, flower farms can improve profitability by keeping up with the market trends and by adopting improved marketing strategies such as sharing orders and shifting towards direct sales.

Agglomeration of cut flower farms

As the flowers are air-freighted, the flower farms are located within a distance of a few hours of driving to the international airport in Addis Ababa (see the map of the location of cut flower farms in Figure 1). Some of them agglomerate in several particular locations, while the other farms are relatively dispersed and geographically isolated. During our intensive interviews, a large number of general managers and farm managers of agglomerated firms stressed that they often shared technical knowledge and market information with neighboring farms, most frequently with those farms located within walking distances. This helped them to select which profitable rose varieties to plant, decide when or even whether produced flowers should be harvested and shipped, properly treat harmful insects and diseases specific to each variety of roses, and maintain and improve product quality. The agglomerated farms also borrow fertilizers and various other inputs from each other. They also share high volume orders, help each other to fulfill orders for diverse varieties, closely coordinate the transport of the flowers, and jointly invite technical consultants from the Netherlands, Israel, and India. These agglomeration economies are likely to enable the agglomerated farms export relatively higher value flowers (Hypothesis 1) and achieve higher productivity and profitability (Hypothesis 2) compared with the dispersed farms.

4. Data and Descriptive Analyses

Data

The primary survey data used in this paper came from interviews with staff of 64 out of the 67 cut flower farms operating in Ethiopia in January 2008.[9] The interviews were conducted by the Ethiopian Development Research Institute in collaboration with the National Graduate Institute for Policy Studies, Japan.[10] The survey took place from late 2007 to early 2008. Because there is virtually no domestic market for this industry, all the cut flower farms are necessarily registered enterprises to make them eligible exporters. The information collected from the interviews indicated no bankruptcies.

Descriptive Analyses

To facilitate our understanding of the nature of agglomeration in the cut flower industry, we divided our 64 sample farms into two groups: those operating inside Welmera District and those outside. The land size of Welmera District relative to the country is

[9] Three farms refused to take part in our survey.
[10] Three parent firms owned two farms, and one parent firm owned three farms, respectively. The farms belonging to the same parent firm were located in different areas. Taking account of these linkages does not qualitatively affect the empirical results below, which are available upon request.

0.06% (= 736 km^2/1,104,300 km^2). We considered the group of 22 farms concentrated in Welmera as a cluster, compared with 42 other farms dispersed across 19 different districts (Figure 1). The average number of these farms per district was 2.21 (minimum, 1; maximum, 8). No farm has changed location since its entry into the industry.

Table 2 presents the timing of entry, by location. With only 10 farms operating in 2004, 54 new farms have since entered the industry between 2005 and 2007. Moreover, no systematic difference can be found in the timing of entry between the farms operating inside and those outside the Welmera cluster. Although there was a slight drop in the number of new entrants into the Welmera cluster in 2006, it recovered in 2007. The average length of operation as of 2007 was 2.3 years for the farms in the cluster compared with 2.7 years for the dispersed farms, which is not statistically significant. To investigate further into the farm's locational choice, we compared the geographic conditions and the human capital characteristics of the general managers between the farms inside and those outside the Welmera cluster.

We can see from Table 3 that the farms in the cluster are closer to the international airport and located at higher altitudes with a cooler climate. To scrutinize the locational characteristics more closely, we constructed an alternative measure of agglomeration, "co-location," using the number of the other farms located in the same ward or *kebele*, the smallest administrative unit. The flower farms were located across 20 different kebeles in 2005, 29 kebeles in 2006, and 33 kebeles in 2007. As expected, the degree of co-location was significantly higher inside the Welmera cluster (Table 3).

As the business environment improves partly because of government efforts to attract foreign investors, the percentage of foreign-owned farms increased from around 20 percent to 40 percent. But this percentage was not statistically significantly different between farms within and outside the Welmera cluster.

The average flower farms both within and outside the cluster produced over eight varieties of rose, selected from thousands of varieties. Turning to human resources, we found no significant difference in human capital characteristics of the general manager between the farms located within and those outside the Welmera cluster. The farms located outside the Welmera cluster employed statistically significantly more workers than the farms within the cluster.[11]

In terms of business performance, there was a stark contrast between the farms in the cluster and the dispersed farms (Table 4). The dispersed farms tended to produce more stems per worker. By contrast, the farms within the cluster produced significantly higher value flowers and achieved higher sales revenue per worker, gross profit per worker, and value added per worker (value added is sales revenue minus material cost and gross profit is value added minus labor cost).[12] In particular, the value added per worker and the gross profit per worker were significantly higher among the farms within the Welmera cluster in 2006, when a substantial number of new farms began operation outside the cluster (see Table 2). It is not unusual for new entrants to have more to learn the business, and their

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[11] The domestic input markets remarkably developed during this period. Mano *et al*. (2011) associated the emerging labor market with the development of the flower industry, particularly with the formation of the Welmera cluster. The domestic supply of seedlings, fertilizers, and chemicals accounts for around 40 percent of total use in 2007, compared with less than 20 percent in 2005.

[12] Here are more precise definitions of the value added and the gross profit. Value added = sales revenue – plant material cost – chemical and fertilizer cost – packaging material cost – transport cost – electricity and fuel cost – royalty – repair and maintenance cost. Gross profit = value added – technical advice fee – marketing (commissions and agent's fee) – labor cost (including wages, salaries, bonuses, and social payment).

productivity and profitability have not fully improved yet. These observations support Hypotheses 1 and 2. As to the result that farms within the cluster produced higher valued output, it may well be due to the fact that these farms are located at higher altitude (Table 3). We would examine this relationship more rigorously using regression analysis later on and would find that the unit value of output produced by the farms within the cluster was greater even after controlling for altitude along with other characteristics.

5. Estimation Strategy

To test our hypotheses, we estimated the agglomeration economies on the unit price, the stems per worker, the sales revenue per worker, the value added per worker, and the gross profit per worker. In particular, we controlled for altitude of the farm and the distance to the international airport. Controlling for these geographical characteristics will help us identify the agglomeration economies from correlated behaviors and performances among the agglomerated farms facing the same geographical conditions (Manski, 1993; Conley and Udry, 2010).

To measure the degree of agglomeration, we used a Welmera cluster dummy, and, alternatively, the number of other farms co-located in a same kebele. Our sample farms were distributed across 33 different kebeles in 2007; one kebele accommodated 15 farms, two kebeles four farms, another kebele three farms, nine kebeles two farms, and 20 kebeles one farm. This measure of agglomeration would particularly allow us to examine the agglomeration economies possibly changing with the size of agglomeration.

To test Hypotheses 1 and 2, we took a reduced-form approach. More specifically, we estimated the following regression models:

$$Y_t = \beta_0 + \beta_1 \mathit{Cluster} + \beta_2 \mathit{HAirport} + \beta_3 \mathit{Altitude} + \beta_4 \mathit{Operation}_t + \beta_5 \mathit{Foreign}_t + \beta_6 \mathit{School} + \beta_7 \mathit{Experience} + \beta_8 \mathit{Experience}_t^2 + v_t$$

where βs denotes the regression parameters, *Cluster* denotes a dummy variable indicating whether the farm belongs to the Welmera cluster or not, *HAirport* is the number of hours to reach the international airport from the farm, *Altitude* is the altitude of the farm, $Operation_t$ is the operation years of the farm, *Foreign* is the dummy variable indicating whether the farm is foreign-owned, *School* is the schooling years of the managing director, $Experience_t$ is the years of previous related experience of the managing director, and υ_t is the error term. In the alternative specification, term $\beta_1 Cluster$ will be replaced by α_1 *Co-location*. Dependent variable Y_t is either the unit price, the number of stems per worker per year, the sales revenue per worker per year, the value added per worker per year, or the gross profit per worker per year. Farms are assumed to be price takers in the international market, and their characteristics possibly affect the unit price of output, in particular, through their selection of the varieties of rose and production of high-quality products. The table of correlation matrix of explanatory variables is reported in the appendix. The correlation coefficient between the cluster dummy and the co-location variables was 0.829, which suggests the consistency of the two alternative measures of the degree of agglomeration. Furthermore, the correlation coefficient between altitude and number of hours to reach the airport was relatively high in absolute terms, -0.541. We would control for these two variables to maximize the accuracy and precision of estimated agglomeration economies.

Hypothesis 1 suggests that the agglomeration of farms increases the unit price of output. An EHPEA expert identifies three important determinants of flower prices□flower variety, bud size, and stem length. While technological information shared among the agglomerated farms might help improve the bud size and the stem length for a given variety of rose, better access to market information is expected to help the selection of profitable flower varieties. Hypothesis 2 suggests that the sales revenue per worker, the value added per worker, and the gross profit per worker increase with the degree of agglomeration□that is, estimates of β_1 and α_1 are expected to be positive.

Taking advantage of the panel data, we estimated the above models using panel-data methods as well as the pooled OLS. We report the estimation results of the pooled OLS and the random-effect models and the Hausman test on the random-effect models for the consistency of the estimates.[13]

6. Estimation Results

Unit price

Columns (1) to (4) in Table 5 present the determinants of the unit price of output. The estimation results, combined with the descriptive statistics reported in Table 4, indicate that farms located in the Welmera cluster tended to produce flowers with 50 percent higher values. Moreover, an additional farm co-located within the smallest administrative unit was associated with 0.04 to 0.09 birr increase in the average unit price of 2.1 birr in 2005 (see

13 The estimation results of the fixed-effect method will not be reported here as they are not informative about the effects of the variable of our interest, the cluster dummy, which is a time-invariant variable. They are available upon request.

Column 2 of Table 4). Although, strictly speaking, this effect of co-location within a ward cannot be directly compared with the effect of being located within the Welmera district because of the difference in the unit of area, the empirical results obtained by using the two different measures of agglomeration were not very different. Multiplying the OLS (or RE) estimated effect of co-location 0.09 (or 0.04) with the number of co-located farms in Welmera 22 in 2007 equals 1.98 (or 0.88), which is not very far from the OLS (or RE) estimated effect of the Welmera dummy 1.25 (or 1.12). These effects were statistically significant in all cases except Column (4), in which the coefficient was positive but not significant. It is also worth mentioning that, although the higher altitude possibly enables farms to produce particular varieties of roses with large buds and long stems (which tend to fetch higher prices), the altitude variable was not statistically significant in these models while the cluster dummies were. This indicates that holding the altitude of farm location constant, the farms within the cluster produced roses of higher values. In all the cases, the years of operation of the farm and the human capital characteristics of the general manager did not have significant effects, probably because of the small variation in these variables among farms. Furthermore, the estimated coefficient of foreign ownership was not statistically significant either.

Overall, these estimation results support Hypothesis 1 and are consistent with the possibility that technological knowledge regularly shared among agglomerated farms helps improve the bud size and the stem length of a given type of flower, while better access to market information within the cluster helps in flower selection and shipment decision.

Number of stems per worker

Table 5 also presents the estimated functions explaining the number of stems per worker (Columns 5 to 8). Interestingly, neither being located in the Welmera cluster nor having more co-located farms had any significant effect on the number of stems per worker.

What matters is the altitude of the farm, which was significantly and negatively associated with the number of stems per worker. This result is consistent with what we learned from interviews with farm managers. At lower altitudes under a warmer climate, bud size tends to be smaller, which allows roses to be more densely planted. Moreover, the roses grow faster, thereby shortening the production cycle. These contribute to having more stems per worker. But, as we discuss below, stems per worker plays only one role in profitability. According to the RE estimation, number of years of operation significantly increases the number of stems per worker too. This result implies that there is learning by doing at the farm level. Moreover, given the number of years of operation, the estimated coefficients of the dummy variables indicating years 2006 and 2007 were positive and was increasing over time, suggesting the development of the supporting industry in Ethiopia.

Productivity and profitability

Table 6 presents the estimated determinants of sales revenue per worker, value added per worker, and gross profit per worker. The estimation results suggest that being located within the Welmera cluster significantly increased average sales revenue per worker of 47,000 birr per worker in 2005 (see Column 2 of Table 4) by 43,000 birr per worker (91 percen; average value added per worker of 30,000 birr per worker by 63,000 birr per worker (210 percent); and average gross profit per worker of 23,000 birr per worker by 63,000 birr per worker (273 percent). Similarly, sales revenue per worker, value added per worker, and gross profit per worker significantly increased with the number of co-located farms in the smallest administrative unit, except in one case see Column (4) in Table 6. An additional co-located farm was associated with a 6 percent increase in the sales revenue per worker, 7 percent increase in the value added per worker, and 9 percent increase in the gross profit per worker.

In summary, while Table 5 reports that agglomerated farms received significantly higher unit price but no more stems per worker, Table 6 indicates that agglomerated farms received significantly greater sales revenue per worker. Furthermore, compared with the dispersed farms, the agglomerated farms tended to more efficiently utilize input materials and labor to realize the higher value added per worker and the higher gross profit per worker. These econometric results lend support to Hypothesis 2, which states that agglomerated producers achieve higher productivity and profitability.

The estimated coefficient of farm altitude was negative and significant in the regression function of value added per worker (Column 6 in Table 6). The production of roses at higher altitude likely requires greater expenses on materials because of the longer production cycle. It is also worth mentioning that the significance on the altitude variables disappear in the regressions for gross profit per worker. This may be because, given the limited employment opportunities at higher altitude, production workers are more willing to work for lower wages, and it compensates for the higher material costs required at higher altitude.

In all the cases, the years of operation of the farm and the human capital characteristics of the general manager did not have significant effects, probably because of the small variation in these variables among farms. More importantly, it is remarkable to find that foreign-owned farms are neither significantly more productive nor profitable than domestic-owned farms.

7. Conclusion

A large number of industrial clusters are observed in many different economies, including East and South Asia, Latin America, and Sub-Sahara Africa. Since the seminal work of Marshall (1890), there have been numerous studies on the agglomeration economies from diverse viewpoints. These studies have substantially improved our understanding of the formation process of these industrial clusters, the channels and mechanisms of agglomeration economies, and the changing roles of industrial clusters in the process of industrial development. However, few studies have measured the magnitude of agglomeration economies on business performance.

Exploiting the co-existence of geographically agglomerated and dispersed rose farms in Ethiopia, we attempted to quantify the agglomeration economies in terms of business performance. In particular, using survey data from 96 percent of cut flower farms in Ethiopia for 2005, 2006, and 2007, this study measured the effects of agglomeration economies on accounting measures of business performance. We learned through intensive interviews with managing directors of the farms that agglomerated farms tend to more frequently exchange technological knowledge of how to produce different varieties of roses, how to deal with various insects and diseases specific to each variety, and how to improve product quality. Furthermore, the agglomerated farms also tend to share market information that are particularly useful in deciding when and even whether produced flowers are worth harvesting and shipping. Because many of these benefits from sharing information are specific to each variety of rose, the agglomerated farms are also more likely to take the varieties of roses produced by neighboring farms into consideration when selecting the varieties to be planted in their own farms.

According to our empirical results and controlling for other geographic and farm characteristics, the average unit price of roses produced by farms within a large industrial cluster is 50 percent higher than that of roses produced by dispersed farms. Furthermore, the clustered farms achieve 91 percent higher sales revenue per worker, 210 percent higher value added per worker, and 273 percent higher gross profit per worker. To confirm these findings, we used the number of co-located farms in the neighborhood as another measure of the degree of agglomeration and found that the unit price of output, sales revenue per worker, value added per worker, and gross profit per worker significantly increase as the number of co-located farms increases. These empirical results suggest that agglomeration economies, at least partly, explain the remarkably good business performance of Ethiopia's cut flower industry since the mid-2000.

But the positive technological external economies are likely to cause underinvestment because of the gap between private benefits and social benefits from agglomeration. More importantly, given the substantial agglomeration economies quantified by this study, one may wonder why many farms are dispersed while others are agglomerated. One possibility is that both currently operating farms and potential entrants may not necessarily fully recognize the significant magnitude of private as well as social benefits from agglomeration. The government may be able to promote industrial agglomeration by disseminating the information about agglomeration economies, preparing and distributing land within the agglomeration preferentially to the flower business, and providing credit with favorable conditions to potential new farms and incumbent firms planning to open additional farms within the industrial agglomeration. The government of Ethiopia has generally promoted the entry of new farms and has invited foreign direct investors by offering a variety of incentives. We suggest that the government puts location of farms among the highest priorities in those attempts.

One might also be concerned that the expansion in the size of an industrial cluster may eventually cause congestion (Mano and Otsuka, 2000). However, from our observation, it does not seem to be an immediate issue for the cut flower industry in Ethiopia. For example, Mano *et al*. (2011) found in a previous study that the cluster-based development of the cut flower industry in Ethiopia was associated with the development of the labor market. Workers have been increasingly mobile across locations; thus, competition for labor may not be a major problem. In addition, availability of land does not seem to be an immediate issue either since the average sample farms currently use 43 percent of the land under their use right for flower production, and the average farms located within the Welmera cluster use only 32 percent of land for flower production. But, in our intensive interviews with the managing directors and farm managers, 60 percent of the farms located inside the cluster expressed grave concerns about potential future water shortage, compared with 40 per cent of the dispersed farms. Although this is beyond the scope of the purpose of our paper, water shortage should be considered in the long run when formulating effective policies for further industrial development.

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Table 1. Exports of Ethiopia and Cut Flower Exports of Top African Exporters (million USD)

Year	Total	Coffee	Flower exports			
	Ethiopia	Ethiopia	Ethiopia	Kenya	Zimbabwe	South Africa
	(1)	(2)	(3)	(4)	(5)	(6)
2000	482	255	0	91	25	17
2002	415	160	0	100	60	14
2004	615	237	2	232	17	22
2006	1,043	426	25	275	765	22
2008	1,601	562	104	446	186	28

Source: UN COMTRADE (http://comtrade.un.org/db/default.aspx, accessed on March 9, 2010)

Table 2. Timing of Entry of Cut Flower Farms Within and Outside the Welmera Cluster

Year	Within	Outside	Total
	(1)	(2)	(1)+(2)
2004 or before	2	8	10
2005	9	11	20
2006	4	17	21
2007	7	6	13
No.of observations (%)	22 (34)	42 (66)	64 (100)

Notes: The farms agglomerated in Welmera District are defined as the cluster here. The other farms are scattered across different villages.

Table 3. Characteristics of the Farms Within and Outside the Welmera Cluster

	Within (1)	Outside (2)	*P* value for *t* test H_0: (1)- (2)=0
Geographic characteristics			
Travel time to international airport (h)	1.2	1.9	0.003***
Altitude (km above sea level)	2.4	1.9	0.000***
No. of farms co-located within the kebele			
2005	6.5	0.2	0.000***
2006	6.7	0.8	0.000***
2007	10.2	0.8	0.000***
Percentage of foreign-owned farms			
2005	18	26	0.628
2006	33	36	0.830
2007	45	38	0.576
Number of rose varieties produced	8.7	8.5	0.888
Human capital characteristics of the general manager			
Age	44.0	42.9	0.637
Years of schooling	15.9	15.8	0.859
Years of previous related experience	8.7	9.2	0.862
Number of workers			
2005	196.6	438.1	0.0003***
2006	222.1	337.6	0.025**
2007	261.4	381.8	0.041**

Note: ** and *** indicate statistical significance at the 5 and 1 percent levels, respectively.

Table 4.Performance of the Farms Within and Outside the Cluster

Parameter	2005			2006			2007		
	Within (1)	Outside (2)	*P* value for *t* test H_0: (1) - (2)=0	Within (3)	Outside (4)	*P* value for *t* test H_0: (3) - (4)=0	Within (5)	Outside (6)	*P* value for *t* test H_0: (5) - (6)=0
Unit price (birr/stem)	3.5	2.1	0.063*	3.1	1.7	0.014**	3.5	2.0	0.0002***
Stems per worker (thousand stems)	22.0	37.5	0.276	26.9	28.1	0.916	22.1	41.4	0.057*
Sales revenue per worker (thousand birr)	79.9	47.7	0.254	77.0	45.9	0.139	85.4	64.2	0.239
Value added per worker (thousand birr)	68.9	30.9	0.252	67.1	24.2	0.068*	62.4	34.8	0.162
Gross profit per worker (thousand birr)	61.9	23.9	0.240	60.7	15.1	0.051*	55.8	27.3	0.150

Notes: 1 birr = 0.1USD as of 2008.Value added = sales revenue – plant material cost – chemical and fertilizer cost – packaging material cost – transport cost – electricity and fuel cost – royalty – repair and maintenance cost. Gross profit = value added – technical advice fee – marketing (commissions and agent's fee) – labor cost (including wages, salaries, bonuses, and social payment). *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Table 5. Determinants of Unit Price and Stems per Worker for 2005, 2006, and 2007

	Unit price (birr/stem)				Thousand Stems per worker			
	OLS	RE	OLS	RE	OLS	RE	OLS	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cluster dummy	1.252**	1.127**	---	---	6.844	9.135	---	---
	(0.543)	(0.532)	(---)	(---)	(7.186)	(7.011)	(---)	(---)
Co-located farms	---		0.095*	0.040	---	---	0.599	0.217
	(---)		(0.051)	(0.039)	(---)	(---)	(0.561)	(0.452)
Hours to the airport	0.274	0.073	0.237	0.008	6.130	5.213	5.976	4.622
	(0.312)	(0.296)	(0.318)	(0.321)	(4.334)	(3.929)	(4.331)	(4.010)
Altitude	0.001	0.000	0.001	0.001	-0.035*	-0.035**	-0.034*	-0.031**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.019)	(0.017)	(0.018)	(0.015)
Years of operation	-0.029	-0.040	-0.026	-0.054	2.818	4.325*	2.887	4.191*
	(0.120)	(0.128)	(0.127)	(0.134)	(2.615)	(2.607)	(2.560)	(2.544)
Foreign-owned farms	-0.139	-0.069	0.019	0.059	-11.995	-10.958	-11.091	-9.888
	(0.442)	(0.429)	(0.414)	(0.418)	(10.109)	(8.794)	(9.758)	(8.422)
Years of schooling	-0.036	-0.017	-0.030	-0.010	0.702	0.602	0.730	0.655
	(0.067)	(0.066)	(0.072)	(0.077)	(1.684)	(1.636)	(1.699)	(1.684)
Years of experience	-0.076	-0.086	-0.100	-0.108	0.219	0.248	0.086	0.060
	(0.074)	(0.070)	(0.073)	(0.072)	(0.956)	(0.812)	(0.902)	(0.759)
$(\text{Years of experience})^2$	0.001	0.002	0.003	0.003	0.018	0.014	0.025	0.022
	(0.002)	(0.002)	(0.002)	(0.002)	(0.032)	(0.028)	(0.029)	(0.027)
Year 2006	-0.400	-0.241	-0.502*	-0.286	5.342	7.957*	4.811	7.598*
	(0.267)	(0.241)	(0.265)	(0.248)	(4.376)	(4.620)	(4.246)	(4.530)
Year 2007	-0.088	0.034	-0.346	-0.077	14.153**	19.477***	12.700**	18.761***
	(0.285)	(0.253)	(0.317)	(0.294)	(5.920)	(6.642)	(5.582)	(6.493)
Constant	1.501	2.043	1.206	1.566	61.627**	53.847**	60.178**	49.539**
	(1.907)	(1.912)	(1.941)	(2.113)	(24.644)	(22.022)	(22.793)	(21.212)
R-squared	0.217	---	0.183	---	0.299	---	0.298	---
Hausman test (p value)	--- (---)	1.64 (0.44)	--- (---)	3.40 (0.33)	--- (---)	-7.79 (---)	--- (---)	2.33 (0.50)

Notes: The dependent variables are *the unit price of flowers* (*birr/stem*) and *thousand stems per worker*. The number of observations is 119, and the number of sample farms is 57. Although the estimation results of the fixed-effect models are not reported, the results of the Hausman test are given. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. Clustered standard errors for OLS and robust standard errors for RE are in parentheses. --- means that the corresponding variable is omitted or the corresponding statistics were not calculated.

Table 6. Determinants of Productivity and Profitability of Flower Farms (thousand birr/worker) for 2005, 2006, and 2007

	Sales revenue per worker				Value added per worker				Gross profit per worker			
	OLS	RE	OLS	RE	OLS	RE	OLS	RE	OLS	RE	OLS	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Cluster dummy	43.120*	44.553**	---	---	67.927**	63.237***	---	---	68.414**	63.656***	---	---
	(23.323)	(22.607)	(---)	(---)	(25.568)	(22.959)	(---)	(---)	(25.628)	(23.241)	(---)	(---)
Co-located farms	---	---	4.101*	1.092	---	---	4.822**	2.631*	---	---	4.842**	2.590*
	(---)	(---)	(2.101)	(16.774)	(---)	(---)	(2.316)	(1.548)	(---)	(---)	(2.303)	(1.562)
Hours to the airport	15.269	4.652	14.286	1.733	13.128	3.409	13.794	2.285	14.237	4.861	15.042	3.717
	(16.201)	(15.778)	(16.033)	(16.774)	(15.590)	(15.074)	(16.656)	(13.673)	(15.575)	(15.517)	(16.763)	(13.865)
Altitude	-0.015	-0.038	-0.011	-0.020	-0.048	-0.067*	-0.021	-0.037	-0.042	-0.059	-0.014	-0.027
	(0.036)	(0.040)	(0.031)	(0.037)	(0.037)	(0.039)	(0.036)	(0.029)	(0.039)	(0.042)	(0.038)	(0.031)
Years of operation	4.449	6.582	5.055	5.775	4.978	6.512	3.660	4.249	5.378	7.116	4.147	4.934
	(5.344)	(6.181)	(5.163)	(6.332)	(5.288)	(5.757)	(5.104)	(6.554)	(5.511)	(6.014)	(5.380)	(6.736)
Foreign-owned farms	-16.622	-13.594	-10.805	-8.052	-16.557	-13.500	-15.668	-11.197	-15.734	-13.936	-15.059	-11.563
	(17.969)	(17.749)	(16.018)	(16.927)	(14.903)	(15.671)	(15.112)	(18.942)	(14.882)	(15.866)	(15.204)	(19.425)
Years of schooling	-3.335	-2.304	-3.180	-2.046	-3.055	-1.747	-2.728	-1.645	-3.382	-2.230	-3.068	-2.078
	(1.997)	(2.255)	(2.001)	(2.475)	(1.992)	(2.347)	(2.046)	(3.159)	(2.019)	(2.421)	(2.056)	(3.244)
Years of experience	-4.228	-2.936	-5.045	-3.838	-4.582	-2.964	-5.094	-3.436	-4.321	-2.660	-4.839	-3.154
	(3.284)	(3.049)	(3.169)	(3.081)	(3.258)	(2.988)	(3.364)	(2.850)	(3.250)	(2.983)	(3.362)	(2.872)
(Years of experience)^2	0.103	0.075	0.144	0.115	0.086	0.059	0.129	0.091	0.077	0.048	0.121	0.080
	(0.097)	(0.083)	(0.089)	(0.081)	(0.089)	(0.077)	(0.087)	(0.097)	(0.088)	(0.077)	(0.088)	(0.098)
Year 2006	3.684	14.061*	0.585	12.889	2.289	11.394	-2.486	9.120	0.545	8.913	-4.179	6.671
	(8.952)	(8.339)	(9.210)	(8.092)	(10.084)	(8.740)	(10.451)	(7.736)	(9.771)	(8.737)	(10.097)	(7.552)
Year 2007	25.39**	39.03***	16.44	36.09***	18.29	29.66***	5.19	23.85***	16.47	27.23***	3.76	21.64***
	(10.138)	(8.968)	(11.327)	(9.071)	(11.065)	(9.567)	(12.369)	(8.168)	(10.679)	(9.294)	(11.894)	(8.026)
Constant	105.050	126.902	98.739	107.164	151.517	161.091*	103.557	116.869	133.586	141.158	83.301	92.844
	(88.235)	(92.950)	(83.357)	(95.491)	(95.129)	(90.968)	(99.529)	(83.372)	(97.423)	(95.861)	(101.636)	(84.794)
R-squared	0.150	---	0.149	---	0.248	---	0.196	---	0.248	---	0.196	---
Hausman test (p value)	--- (---)	-1.86 (---)	--- (---)	3.37(0.33)	---	4.41 (0.11)	---	-0.39 (---)	---	3.98 (0.13)	---	-0.36 (---)

Notes: The dependent variables are *the sales revenue per worker, the value added per worker,* and *the gross profit per worker (thousand birr/worker)*. The number of observations is 119, and the number of sample farms is 57. Although the estimation results of the fixed-effect models are not reported, the results of the Hausman test are given. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively. Clustered standard errors for OLS and robust standard errors for RE are in parentheses. --- meanss that the corresponding variable is omitted or the corresponding statistics were not calculated.

Appendix Table. Correlation Matrix of Variables used in the Regression

	Cluster dummy	Co-located farms	Hours to the airport	Altitude	Years of operation	Foreign-owned farms	Years of schooling	Years of experience
Cluster dummy	1							
Co-located farms	0.829	1						
Hours to the airport	-0.342	-0.267	1					
Altitude	0.476	0.365	-0.541	1				
Years of operation	-0.098	-0.124	-0.128	-0.066	1			
Foreign-owned farms	0.132	0.010	0.151	0.029	-0.164	1		
Years of schooling	0.030	-0.001	0.142	0.054	0.019	0.144	1	
Years of experience	-0.003	-0.135	0.271	-0.081	-0.151	0.090	-0.183	1

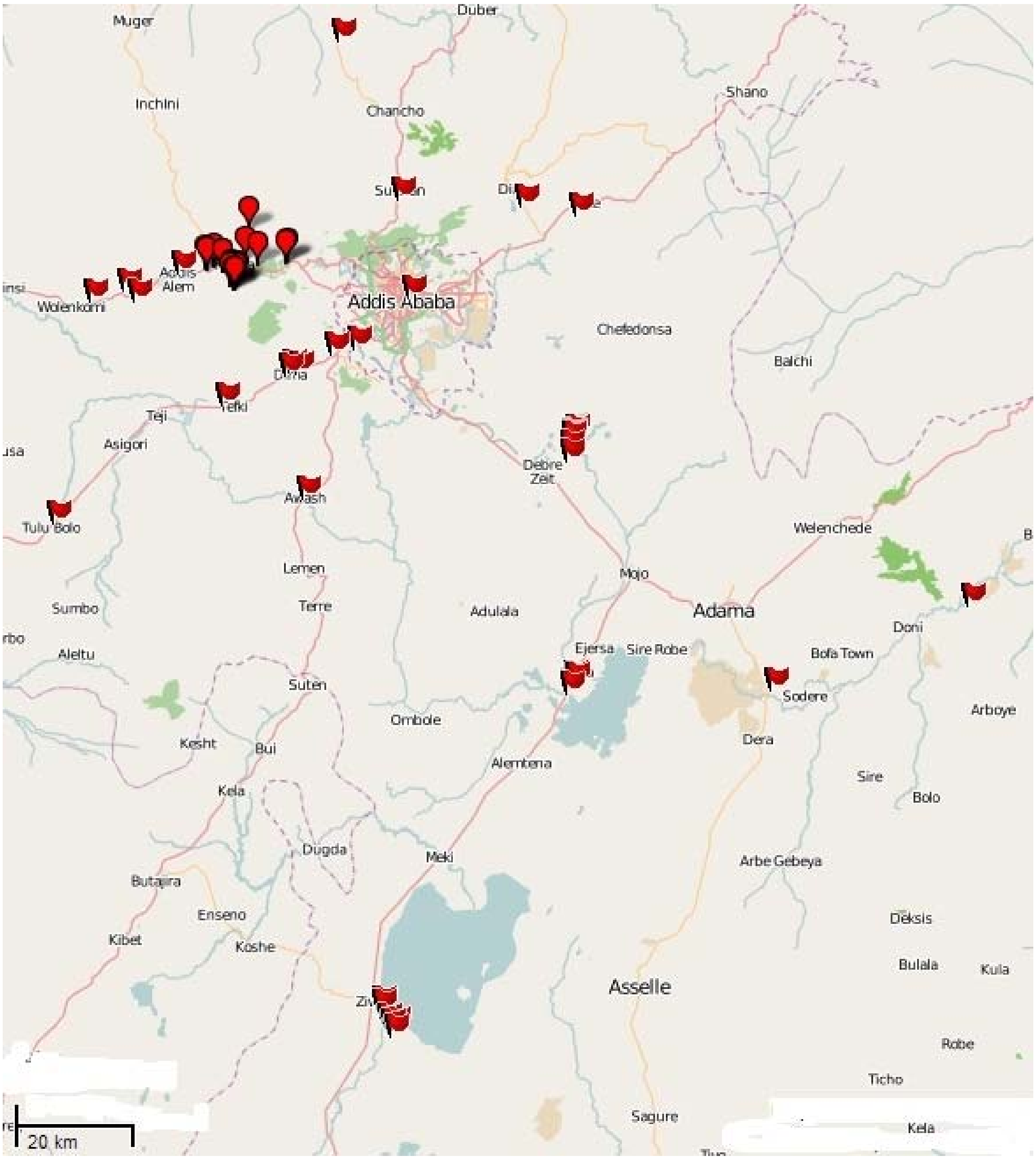

Figure 1. The locations of cut flower farms in Ethiopia.
Note. Teardrops indicate the 22 farms located in the Welmera cluster; flags indicate the other 42 farms.