The Rise of the *Maquiladoras*: A Mixed Blessing[*]— model variant with informal sector production

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1 A simple model of production in the informal sector

1.1 General remarks

In the following we describe a model of a small open economy, Mexico, with a foreign-owned *maquila* and a domestically-owned standard manufacturing sector in the presence of a unified informal labor market for unskilled workers. The key difference to the model presented in "The Rise of the *Maquiladoras*: A Mixed Blessing" is that we allow unskilled workers in the informal sector to produce varieties of the standard manufacturing good, i.e. the good which is consumed in Mexico. The informal sector varieties are assumed to be non-tradeable. This is in line with evidence from recent representative surveys of small scale enterprises typically associated with the informal sector, which indicate that more than 99% of these enterprises do not engage in any exporting activities in Mexico.[1] Formal sector standard manufacturing varieties remain tradable.

Specifically, we model the informal sector as an endogenously determined mass of homogeneous firms à la Krugman (1980), which employ all the informal unskilled workers who did not get a job at a formal sector firm. The mass of firms is pinned down by a free-entry condition, which also implies that there are no profits in the informal sector.

1.2 Consumption

Mexican households only consume goods produced in the manufacturing sector, which means that *maquila* output is exported in its entirety. Consumers maximize

$$C_2 = M_2^{\frac{1}{1-\sigma}} \left[\int_{\omega \in \Omega_{2d}} [q_{2d}(\omega)]^{\frac{\sigma-1}{\sigma}} d\omega + \int_{\omega' \in \Omega_{2f}} [q_{2f}(\omega')]^{\frac{\sigma-1}{\sigma}} d\omega' + \int_{\omega'' \in \Omega_2^{inf}} [q_2^{inf}(\omega'')]^{\frac{\sigma-1}{\sigma}} d\omega'' \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

[1] Encuesta NAcional de MIcroNegocios, ENAMIN. This survey is comprised of a representative sample of Mexican enterprises with less than seven employees (including the owner).

where Ω_{2d} is the set of varieties produced in the formal manufacturing sector in Mexico, Ω_{2f} the set of varieties imported from the US, and Ω_2^{inf} the set of manufacturing varieties produced in the informal sector. $\sigma > 1$ is the elasticity of substitution and M_2 denotes the total mass of manufacturing varieties available in Mexico.[2] We follow Blanchard and Giavazzi (2003) and normalize utility by $M_2^{\frac{1}{1-\sigma}}$ in order to ensure that an increase in the size of the economy does not mechanically translate into a smaller informal sector.

Taking into account the existence of iceberg transportation costs $\tau_2 \geq 1$ for imported varieties, the price index corresponding to the composite C_2 is given by:

$$P_2 = M_2^{\frac{1}{\sigma-1}} \left[\int_{\omega \in \Omega_{2d}} [p_{2d}(\omega)]^{1-\sigma} d\omega + \int_{\omega' \in \Omega_{2f}} [\tau_2 p_{2f}(\omega')]^{1-\sigma} d\omega' + \int_{\omega'' \in \Omega_2^{inf}} [p_2^{inf}(\omega'')]^{1-\sigma} d\omega'' \right]^{\frac{1}{1-\sigma}}. \tag{2}$$

Inverse demand for formally produced domestic and imported foreign varieties from sector 2 is then given by:

$$p_{2d}(\omega) = \left(\frac{Y}{M_2}\right)^{\frac{1}{\sigma}} P_2^{\frac{\sigma-1}{\sigma}} q_{2d}(\omega)^{-\frac{1}{\sigma}}, \quad p_{2f}(\omega) = \left(\frac{\tau_2 Y}{M_2}\right)^{\frac{1}{\sigma}} P_2^{\frac{\sigma-1}{\sigma}} q_{2f}(\omega)^{-\frac{1}{\sigma}}, \tag{3}$$

where Y denotes total expenditure in Mexico. Note that we define $p_{2f}(\omega)$ as the cif price in the US and $q_{2f}(\omega)$ is the total quantity produced, including the quantity lost in transit due to the iceberg transportation costs.

Inverse demand for manufacturing varieties produced in the informal sector is given by:

$$p_2^{inf}(\omega) = \left(\frac{Y}{M_2}\right)^{\frac{1}{\sigma}} P_2^{\frac{\sigma-1}{\sigma}} q_2^{inf}(\omega)^{-\frac{1}{\sigma}}. \tag{4}$$

[2] The total number of manufacturing varieties available for consumption in Mexico is $M_2 = M_{2d} + M_{2x}^f + M_2^{inf}$ where M_{2x}^f denotes the mass of imported varieties, and M_2^{inf} the mass of varieties produced in the informal sector.

1.3 Production

Formal firms in both sectors are heterogeneous with respect to their idiosyncratic productivity φ as in Melitz (2003). Since each firm produces a unique variety, we index firm-level variables by φ.

Manufacturing firms

There is an unbounded mass of potential entrants in the domestic formal manufacturing sector. To enter, producers pay a sunk cost f_{e2}. All costs in the model are denominated in terms of the manufacturing good.[3] After incurring this cost, formal firms draw their productivity from a Pareto distribution with density $g(\varphi) = ak^a\varphi^{-(a+1)}$ for $\varphi \geq k$.[4] Formal firms that choose to operate need to pay a fixed cost f_2 per period. Having set up the plant, formal manufacturing firms produce their output by combining skilled labor s and unskilled labor l in a Cobb-Douglas form,

$$q_2(\varphi) = \varphi(s_2)^{\beta_{2s}}(l_2)^{1-\beta_{2s}}, \tag{5}$$

where β_{2s} is the labor cost share of skilled workers.

Formal firms sell their output domestically but can also incur an additional fixed cost f_{x2} to serve the foreign market through exports. We borrow the notion of a small open economy under monopolistic competition from Flam and Helpman (1987), and the extension to a heterogeneous-firm environment proposed by Demidova and Rodríguez-Clare (2009). This assumption implies that, despite the fact that formal firms located in Mexico face a downward-sloping demand schedule for their exports, their pricing decisions do not affect the price index, expenditure nor the mass of firms operating abroad, however, the subset of formal firms exporting to Mexico, M_{2x}^f, is endogenous.[5] Thus, foreign inverse demand for

[3] Note that this implies that not all output produced can be used for consumption.

[4] We also restrict $a > \sigma - 1$ to ensure that the variance of the sales distribution is finite.

[5] Demidova and Rodríguez-Clare (2009)'s framework needs an endogenous variable that clears the trade balance. In Demidova and Rodríguez-Clare (2009) the price index and expenditure abroad are unaffected

Mexican manufacturing exports by formal manufacturing firms is given by

$$p_{2x}(\varphi) = A_{2x}^{1/\sigma} \left(\frac{q_{2x}(\varphi)}{\tau_2} \right)^{-\frac{1}{\sigma}}, \tag{6}$$

where A_{2x} is a demand-shifter parameter that is taken as given by Mexican formal manufacturing firms. Hence, we define total revenue for a Mexican formal manufacturing firm with productivity φ as:

$$\begin{aligned} r_2(\varphi) &= r_{2d}(\varphi) + \mathbb{I}_x(\varphi) r_{2x}(\varphi) \\ &= \left(\frac{Y}{M_2} \right)^{\frac{1}{\sigma}} P_2^{\frac{\sigma-1}{\sigma}} q_{2d}(\varphi)^{\frac{\sigma-1}{\sigma}} + \mathbb{I}_x(\varphi) A_{2x}^{1/\sigma} \left(\frac{q_{2x}(\varphi)}{\tau_2} \right)^{\frac{\sigma-1}{\sigma}}, \end{aligned} \tag{7}$$

where $\mathbb{I}_x(\varphi)$ is an indicator function that takes the value one if a formal manufacturing firm with productivity φ exports and zero otherwise.

Maquiladora **firms**

We model *maquiladoras* in a similar fashion to formal manufacturing firms, therefore in this section we just highlight the differences between the two formal sectors, namely that (i) *maquila* plants are foreign-owned, (ii) export all their output and (iii) use foreign manufacturing goods as intermediate inputs for production.

A foreign investor pays a sunk entry cost in Mexico to set up a *maquiladora* plant.[6] *Maquiladoras* draw their productivity from the same Pareto distribution as Mexican manufacturing firms. Since *maquiladoras* export all their output, there is no meaningful distinction between domestic and exporting fixed costs. We assume that *maquiladoras* use foreign manufacturing goods as intermediate inputs, denoted by i, for production along with skilled and unskilled labor. Thus, production of *maquila* output for a plant with productivity φ takes

by Mexican firms but the share of US firms exporting to Mexico is endogenous.

[6]The fixed costs of entry, operation and vacancy posting for unskilled workers are incurred in Mexico and are denominated in units of the Mexican manufacturing good.

the form

$$q_1(\varphi) = \varphi(s_1)^{\beta_{1s}}(l_1)^{\beta_{1l}}(i_1)^{1-\beta_{1s}-\beta_{1l}}, \tag{8}$$

where β_{1s} and β_{1l} are the skilled and unskilled labor cost shares for *maquila* plants, respectively.

Inverse demand for *maquila* variety φ abroad is given by

$$p_{1x}(\varphi) = A_{1x}^{1/\sigma}\left(\frac{q_{1x}(\varphi)}{\tau_1}\right)^{-\frac{1}{\sigma}}, \tag{9}$$

where A_{1x} is a foreign demand shifter that *maquiladora* plants take as given and has a similar interpretation to A_{2x} defined above. $\tau_1 > 1$ are the iceberg transportation costs to ship a *maquila* variety to the US. Total revenues for a *maquiladora* plant with productivity φ are given by

$$r_1(\varphi) = r_{1x}(\varphi) = A_{1x}^{1/\sigma}\left(\frac{q_{1x}(\varphi)}{\tau_1}\right)^{\frac{\sigma-1}{\sigma}}. \tag{10}$$

Unlike Mexican-owned plants in the formal manufacturing sector, profits derived from the operation of *maquila* plants are repatriated abroad.

Informal sector manufacturing firms

In contrast to formal sector manufacturing firms, informal sector firms are not heterogeneous in their productivity. Instead, we model firms as in Krugman (1980). This reflects the fact that informal sector establishments tend to be rather homogeneous in the sense that they are mostly small and unproductive. If an informal sector firm were very productive and hence very large, it would very likely be detected by government authorities. As we do not explicitly model any tax evasion incentives for firms in order to keep the informal sector production as simple as possible, our way of modeling informal sector firms as homogeneous should be seen as a reduced form way of capturing the stylized facts on informal sector establishments.

We assume that informal sector firms produce manufacturing good varieties which are only consumed in Mexico and which cannot be exported to the US market. In order to set up production, an informal sector firm has to pay a fixed cost f_2^{inf}. Once this cost is incurred, the production function is given by

$$q_2^{inf}(\omega) = \frac{1}{\varphi^{inf}} l_2^{inf}(\omega) \tag{11}$$

were l_2^{inf} is the labor demand of an informal sector firm, and φ^{inf} is a productivity parameter. This production function assumes that informal sector firms only use unskilled workers, reflecting the stylized fact that skilled workers are predominantly employed in the formal parts of the Mexican economy.

Profit maximization then implies that all informal firms charge the same price

$$p_2^{inf} = \frac{\sigma}{\sigma - 1} \varphi^{inf} b w_l \tag{12}$$

where $1-b$ is the now endogenous formal sector wage premium and w_l is the wage of unskilled workers in the formal economy. In the model version without informal sector production, $1 - b$ is exogenous.

We assume that there is free entry in the informal sector for additional establishments so that operating profits equal fixed costs in equilibrium, i.e.

$$\frac{p_2^{inf} l_2^{inf} / \varphi^{inf}}{\sigma} = f_2^{inf} P_2. \tag{13}$$

1.4 Labor market

Since most individuals employed in the informal sector are unskilled, we assume that search and matching frictions only affect these workers, whereas skilled workers face a perfectly competitive labor market. Thus in our model only unskilled workers are employed in the informal sector. Following Satchi and Temple (2009), unskilled individuals that are unable to get matched with neither a plant in the formal manufacturing sector nor in the formal *maquiladora* sector become informal workers. These individuals earn income bw_l, with $b \in (0,1)$, by working in informal sector manufacturing firms as described above, so we can interpret $1-b$ as the formality wage premium for unskilled workers.

In order to hire unskilled workers, firms in the formal sectors need to post vacancies v at a cost c per vacancy. As is common in the search and matching literature, we assume that the matching technology is a constant returns to scale Cobb-Douglas function, $m(\theta) = \overline{m}\theta^{-\gamma}$, with $\gamma \in (0,1)$ and where $\theta \equiv v/u$ is the vacancy-informality ratio, and $\overline{m}$ determines the overall efficiency of the matching process in the economy. The probability that a vacancy is filled is given by $m(\theta)$, which is decreasing in θ, and the probability that an unskilled individual in the informal sector finds a job in a formal plant is $\theta m(\theta)$ which is increasing in θ. We follow Keuschnigg and Ribi (2009) and consider a one-shot, static version of the search and matching framework in which the entire population of unskilled workers has just one opportunity to get matched with formal sector firms.

The optimal labor demand decision for a formal manufacturing firm solves the following program:

$$\pi_2(\varphi) = \max_{l_2,s_2}\left\{r_2(\varphi) - w_l l_2 - w_s s_2 - cP_2\left(\frac{l_2}{m(\theta)}\right) - f_2P_2 - f_{x2}P_2\mathbb{I}_x(\varphi)\right\}, \tag{14}$$

where we have also made use of the fact that a formal manufacturing plant wishing to hire l_2 unskilled workers needs to post $l_2/m(\theta)$ vacancies.[7]

The solution to program (14) yields two policy rules, one for skilled labor demand, which is the usual condition that the marginal revenue product of skilled labor has to be equal to the skilled wage, w_s, and a second one for formal unskilled employment that shows that firms have monopsony power and take into account that their vacancy posting has an impact on

[7]The labor demand program for *maquila* plants is almost identical to equation (14), the only difference being that *maquiladoras* also need to choose how much foreign intermediate inputs to use for production.

the wage rate for formal unskilled workers:

$$\frac{\partial r_2(\varphi)}{\partial l_2} = w_l + \frac{\partial w_l}{\partial l_2} l_2 + \frac{cP_2}{m(\theta)}. \tag{15}$$

As in Stole and Zwiebel (1996) we assume that unskilled workers bargain individually with their formal employers (in both formal sectors) about their wage and are all treated as the marginal worker. Total surplus of a worker-employer match is split according to a generalized Nash bargaining solution in each sector j, i.e. $(1-\mu)[E(\varphi) - U] = \mu \partial \pi_j(\varphi)/\partial l_j$ where $E(\varphi)$ denotes the income of an unskilled worker being employed at a plant with productivity φ, U is the income of a worker in the informal sector, and $\mu \in (0,1)$ measures the bargaining power of a worker.

Following the same procedure as Felbermayr, Prat, and Schmerer (2011) and Larch and Lechthaler (2011), i.e. combining the first-order conditions for unskilled employment by plants in both sectors together with the surplus-splitting rule yields a set of two job-creation conditions (one for each sector):

$$w_l + \frac{cP_2}{m(\theta)} = \left[\frac{\beta_{1l}(\sigma-1)}{\sigma - \beta_{1l}\mu + \beta_{1l}\sigma\mu - \sigma\mu}\right] \varphi p_{1x}(\varphi) s_1(\varphi)^{\beta_{1s}} l_1(\varphi)^{\beta_{1l}-1} i_1(\varphi)^{1-\beta_{1s}-\beta_{1l}}, \tag{16}$$

$$w_l + \frac{cP_2}{m(\theta)} = \left[\frac{(1-\beta_{2s})(\sigma-1)}{\sigma + \beta_{2s}\mu - \mu - \beta_{2s}\sigma\mu}\right] \varphi p_{2d}(\varphi) \left(\frac{s_2(\varphi)}{l_2(\varphi)}\right)^{\beta_{2s}}, \tag{17}$$

and the wage curve is given by:

$$w_l = \frac{\mu c P_2}{(1-\mu)(1-b)} \left[\theta + \frac{1}{m(\theta)}\right]. \tag{18}$$

Note that since we assume that wages for unskilled formal workers are the same in manufacturing and *maquiladora* firms, we assume that the labor market for unskilled workers is unified. The same holds for skilled workers.

1.5 Productivity cutoffs and entry

As described in Section 1.3, the production side of formal sector firms in our model closely follows Melitz (2003) and Bernard, Redding, and Schott (2007). Because $\pi_j(\varphi)$ is a strictly increasing function of φ, only plants with high enough productivity to earn non-negative profits will start production. Thus the usual productivity cutoff for production in sector j is defined implicitly by $\pi_j(\varphi_j^*) = 0$. In the formal manufacturing sector, where plants need to incur a fixed cost to serve the foreign market, an export cutoff is similarly defined as $\pi_{2x}(\varphi_{2x}^*) = 0$. We follow Melitz (2003) and define average productivity in formal sector j as:

$$\tilde{\varphi}_j \equiv \left[\frac{1}{1 - G(\varphi_j^*)} \int_{\varphi_j^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}, \quad j = 1, 2. \tag{19}$$

Using the cutoff productivity of the least productive exporting manufacturing firm φ_{2x}^*, we can define the average productivity for formal manufacturing exporters analogously. Finally, let $\chi_2 \equiv [1 - G(\varphi_{2x}^*)]/[1 - G(\varphi_2^*)]$ denote the ex-ante probability that a manufacturing plant exports, conditional on successful entry. Using these definitions we can write the free-entry condition for plants in sector j as $[1 - G(\varphi_j^*)]\overline{\pi}_j = f_{ej} P_2$.[8]

1.6 Aggregate variables

The equilibrium share of informal workers in the labor force follows from the one-period equivalent of the Beveridge curve and is given by $u = 1/[1 + \theta m(\theta)]$. The mass of formal firms operating in sector j in Mexico, M_{jd}, is pinned down by the labor market clearing condition for unskilled workers:

$$M_{1d} = \frac{L_1}{l_1(\tilde{\varphi}_1)}; \qquad M_{2d} = \frac{L_2}{l_{2d}(\tilde{\varphi}_2) + \chi_2 l_{2x}(\tilde{\varphi}_{2x})}, \tag{20}$$

[8]For *maquiladoras* $\overline{\pi}_1 = \pi_1(\tilde{\varphi}_1)$ and for manufacturing plants $\overline{\pi}_2 = \pi_{2d}(\tilde{\varphi}_2) + \chi_2 \pi_{2x}(\tilde{\varphi}_{2x})$.

with $L_1 + L_2 = (1-u)\overline{L}$, where L_j denotes total unskilled formal employment in sector j and $\overline{L}$ is the total endowment of unskilled labor in the economy. Market clearing for skilled labor is given by $M_{1d}s_1(\tilde{\varphi}_1) + M_{2d}\big[s_{2d}(\tilde{\varphi}_2) + \chi_2 s_{2x}(\tilde{\varphi}_{2x})\big] = \overline{S}$.

The overall mass of informal sector firms is then given by

$$l_2^{inf} M_2^{inf} = u\bar{L}. \tag{21}$$

Finally, the trade balance condition reads:

$$\underbrace{M_{1d}r_1(\tilde{\varphi}_1)}_{\text{value of } maquila \text{ exports}} + \underbrace{\chi_2 M_{2d} r_{2x}(\tilde{\varphi}_{2x})}_{\text{value of manufacturing exports}} =$$

$$\underbrace{\tau_2^{1-\sigma}\left(\frac{Y}{M_2}\right)\left(\frac{P_2}{P_2^f}\right)^{\sigma-1}}_{\text{value of manufacturing imports}} + \underbrace{\tau_2 P_2^f M_{1d} i_1(\tilde{\varphi}_1)}_{\text{value of intermediate imports}} + \underbrace{M_{1d}\pi_1(\tilde{\varphi}_1)}_{\text{aggregate } maquila \text{ profits}}. \tag{22}$$

We define the foreign price index for manufacturing goods, P_2^f, as the *numéraire*. Note that aggregate profits in the manufacturing sector remain in Mexico, since this sector is domestically owned.

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