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Abstract

This paper studies the relation between foreign intellectual property rights affect exporting firms' productivity when industries have different technological complexity. Using simple functional forms, the dynamic model derives endogenous steady state distributions of exporting firms' productivity. Numerical simulations show a non-monotonic effect of complexity on productivity, and a positive effect of IPR. Empirical evidence using labor productivity measures support the findings of the theoretical model.

Keywords: Export-led growth, Intellectual Property Rights, Imitation, Patents, Productivity.

JEL: F12, O34

1. Introduction

How does foreign intellectual property rights (IPR) enforcement affect domestic innovation in industries with different technological complexity? Do firms in all industries respond in the same magnitude to the incentives of IPR? Finally, does international protection of intellectual property boost domestic innovation in all exporting industries? This paper brings up a study on how changes in foreign IPR shape the productivity of domestic firms when products are different in technological complexity.

Current literature exhibits evidence in both directions. On one side, there is evidence that stronger IPR increases international transactions from multinationals (Javorcik 2004), technology transfer to its affiliates (Branstetter et al. 2006), and both domestic and foreign innovation (Branstetter and Saggi 2009). Moreover, this effect would be stronger in countries with strong imitative ability (Awokuse and Gu 2010). On the other side, theoretical literature claims there would be no effect of strengthening IPR on R&D (Ponzetto 2009), and evidence of no statistical impact on innovation (Qiu 2011).

The novelty of this paper is introducing controls for industries, and more specifically, the use of a complexity index (Naghavi, Spies and Toubal 2015; Fernandez Donoso 2014). By introducing an industry complexity measure, it is possible to shed light on how technological complexity shapes the effect of foreign IPR enforcement on domestic innovation. If a given production process is more complex, innovating firms have less incentives of using formal intellectual property rights, since complexity imposes a cost of imitation, such as increasing the cost of reverse engineering (Fernandez Donoso 2014). An exporting firm would then feel less intimidated by foreign imitators, even in the absence of intellectual property rights.

As a first attempt to analyze the effect of IPR on domestic innovation, I look at the distribution of productivities resulting from a dynamic process of innovation and firm growth. This will allow understanding the micro foundations of the distribution of firm productivities, and how innovation, in the form of productivity enhancing processes, is affected by exports, complexity, and foreign IPR. Dynamic models, however, get complex very fast, and often require reliance on numerical techniques and examples.

A vast literature of international trade with firm heterogeneity assumes a particular exogenous distribution of productivity (and firm size) among firms. This distribution of productivities comes from a dynamic process with specific assumptions regarding firms. A dynamic model with endogenous firm size distribution has the advantage that the underlying assumptions of firm heterogeneity are known. Firms grow over time because investments are made to innovate, and die at some point because of endogenous or exogenous reasons. Most models predict a steady state equilibrium of firm size, and thus an endogenous steady state distribution of firms can be derived. The shape of this distribution depends on the underlying assumptions of firm growth (e.g. capital accumulation, depreciation, innovation, product imitation, patenting), and the parameters of firm exit.

This idea of firm dynamics and steady state distributions was first systematically analyzed by Gibrat (1931). Its findings show a firm size distribution skewed, and following certain regularities

across time and countries. In his model, firm growth was proportional to its current size. The intuition lies in a virtual set of “opportunities” arising, and the probability of exploiting them would be proportional to the size of the firm.¹

In theory, both patenting and investments in innovation are dynamic decisions that affect firm productivity. To model these decisions, I follow Melitz (2003), in the sense that firms pay an overhead fixed cost for exporting. Firms then have to decide whether their product will be patented in the destination country. Since firms invest in innovation to be more productive, over time every firm becomes an exporter, and then patents their product variety, unless forced to exit prematurely. This setup is useful, as it allows modeling the two main decisions, innovation and patenting, using Bellman’s dynamic optimization equation. Another implicit assumption of the model consists of firms not declining over time.² The assumption implies that patenting firms will renew their patents until expiration or death.³ The resulting steady state endogenous distributions can be simulated using numerical tools to analyze the effect of changes in parameters. In the second part of this paper, I contrast the numerical findings of the model using a measure of industry labor productivity collected by the OECD.

The remainder of this paper is organized as follows. Section 2 describes the model and simulates the numerical equilibrium. Section 3 contrasts the findings of the model with empirical data. Section 4 concludes.

2. Theoretical Background

2.1. The model

This model is based on Melitz (2003). It explores the resulting steady state distribution of exporting firms (in terms of productivity) from a dynamic process with endogenous innovation. If exporting firms decide to innovate, they can invest part of their profits to increase their productivity. An innovation is a cost reducing (productivity increasing) technology investment that firms make over time.

2.1.1. Demand

At each instant, firms export intermediate inputs that are costlessly assembled and consumed in an importing country according to CES preferences. Let $\psi(\omega) \in [\psi_{\min}, \psi_{\max}]$ be the complexity of

¹ This hypothesis was supported with empirical data on large public firms (Gibrat 1931, Simon 1987). However, micro-evidence found differences with Gibrat’s hypothesis (Evans 1987, Dunne, Roberts, and Samuelson 1988, 1989).

² The simpler version of models where Gibrat’s law holds for growth as well as for decline converge to a logarithmic steady state distribution (Johnson et al., 1992, p. 285), and a truncated negative binomial in the generalization case, where small firms grow faster (Johnson et al., 1992, p. 225).

³ The annual renewal of patents has two benefits: the returns during the coming years and the option to renew later on. If the patent is not renewed then the assignee loses the rights forever. Pakes (1986) analyzes this dropout of patent holders for France, Germany, and the UK. Since the cost of renewal is very low, non-renewals may be due more to product obsolescence (patent returns to be worth zero) rather than a firm stopping problems. In Melitz type of models, where firms are single product producers, this difference is irrelevant.

each variety. After normalizing to one the minimum complexity, the discounted utility function can be expressed as

$$U_j(q_i(\omega, t)) = \int_0^\infty e^{\rho t} Q_j(t) dt$$

$$Q_j(t) = \left[\int_0^1 (\psi(\omega)^\gamma q_{ij}(\omega, t))^\sigma d\omega \right]^{\frac{\sigma}{\sigma-1}}$$

where ω is a variety of the intermediate output, $q_{ij}(\omega)$ is the quantity of intermediate goods ω produced in country i and assembled in country j , $\sigma > 1$ is the elasticity of substitution between goods, and γ is a parameter capturing preference for more technologically sophisticated products. Since there are no state variables, the consumer problem can be treated as a static problem, where consumers choose quantity at each instant with a continuum of firms that produce the goods.

Hence, at each instant, consumers solve

$$\max [Q_j(t)]$$

subject to

$$\int_0^1 p(\omega) q_{ij}(\omega) d\omega = X_j$$

The last line is the budget constraint, and X_j is the total expenditure in country j . The solution for the consumer problem is the quality adjusted Dixit-Stiglitz demand function

$$x_j(\omega) = p_j(\omega) q_j(\omega; p, P, X_j) = X_j \left(\frac{p_j(\omega)}{P_j} \right)^{1-\sigma}$$

where P is the Dixit-Stiglitz quality adjusted price index

$$P_i = \left[\int_0^1 \left(\frac{p(\omega)}{\psi(\omega)^\gamma} \right)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}$$

2.1.2. Imitation and patenting

At any moment, and for each product, there is a pool of potential entrants that can enter the market by paying an entry fixed cost f_E . Firms die with exogenous probability Δ_{EN} . Firms may exit for two reasons: their product becomes obsolete, or their product is imitated by a competitor in the host country. The probability of firm exit is the summation of these two probabilities (obsolescence and imitation).

As expected, the technological complexity of the product shapes the probability of firm exit. On one side, highly technological (sophisticated) products, that are expected to be more complex on average, become obsolete faster (have a shorter product cycle). Let Δ_D be the probability of product obsolescence, then $\partial\Delta_D / \partial\psi > 0$. On the other side, very complex products are more difficult to imitate (e.g. reverse engineer), and hence have a higher likelihood to survive under competition. For simplicity, assume that once the variety is copied in the host country, the firm producing that variety cannot compete and thus exits the market. Let Δ_{IN} be the probability of imitation, then $\partial\Delta_{IN} / \partial\psi < 0$.

Firms then exit the market at any moment with probability Δ_{EN} , where

$$\Delta_{EN} = \begin{cases} \Delta_{IN} + \Delta_D, & \Delta_{IN} + \Delta_D \leq 1 \\ 1, & \Delta_{IN} + \Delta_D > 1 \end{cases}$$

The final effect of ψ on Δ_{EN} will depend on the functional assumptions on Δ_{IN} and Δ_D .

Patents are a mechanism to reduce the probability of imitation. For simplicity, assume that the length of a patent protection is forever, and that the vigor of enforcement $\Omega \in [0,1]$ depends on the intellectual property rights of the country where the patent is filed. Firms must pay a patenting cost of f_p . Once the patent is granted, the probability of imitation is $1 - \Omega$.

Since the discount factor is ρ , the perpetuity equivalent of imitation after patenting is $\Delta_{IP} = \Delta_{IN} \times \rho(1 - \Omega)$. Hence the probability of exit of a patenting firm is:

$$\Delta_{EN} = \begin{cases} \Delta_{IP} + \Delta_D, & \Delta_{IN} + \Delta_D \leq 1 \\ 1, & \Delta_{IN} + \Delta_D > 1 \end{cases}$$

2.1.3. Innovation

Firms are owned by domestic consumers. Given a productivity level z , and labor services n , the firm producing variety ω has access to the following technology:

$$y(\omega; z, n) = z^{\frac{1}{\sigma-1}} n$$

There is a preference parameter in the technology, this normalization simplifies the algebra (Atkenson and Burstein 2010). The counterpart is that a change in σ would be difficult to interpret, as it would change both technology and preferences.

Firms can make expenses to increase their productivity z . The cost of increasing the productivity by amount \dot{z} depends on the current productivity level z , and is given by

$$c_i\left(z, \dot{z}\right) = \frac{f_R}{z} \left[\frac{1}{2} \left(\frac{\dot{z}}{z} \right)^2 \right]$$

Where f_i is the cost of innovating in country i . As firms gain productivity over time, the cost of innovation decreases.

There is a pool of potential exporters that can enter to market j at any time by paying sunk cost f_{xj} . After paying the cost, entrants start producing with productivity $z = 1$. There are iceberg trade costs $d_{ij} \geq 1$ with triangle inequality.

2.1.4. The problem of exporting firms

Exporters face two decisions, one static and two dynamics. The static decision involves how much to produce, and the price to charge for each unit of production. The first dynamic decision is how much to invest on innovation. The second dynamic decision is whether they should patent the product or not.

Static Decision. The problem of the firm is deciding how much to produce and the price given its current productivity. If the firm does not patent the product, then the problem is

$$\max_{p,q,n} pq - w_i n$$

subject to

$$q = \frac{z^{\frac{1}{\sigma-1}} n}{d_{ij}}$$

The solution of the problem is the Dixit-Stiglitz markup over marginal cost rule

$$p(\omega) = \frac{\sigma}{\sigma-1} \frac{d_{ij}}{z^{\frac{1}{\sigma-1}}}$$

Then the profits in market j before paying the innovation costs for a non-patenting firm are

$$\pi_{Nj}(z, P_j, X_j) = \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} \sigma^{-1} X_j P_j^{\sigma-1} z (d_{ij})^{1-\sigma}$$

And the profits in market j before paying the innovation costs for a patenting firm are

$$\pi_{Pj}(z, P_j, X_j) = \pi_{Nj} - f_{Pj}$$

Dynamic decisions. Firms must solve to problems: how much to innovate, and if using the patenting system.

To solve the innovation problem, the Hamilton-Jacobi-Bellman equation for the patenting firm is

$$(\rho + \Delta_{EPj})V_{Pj}(z) = \max_z \pi_{Pj} - w_j \frac{f_{Pj}}{2z} \left(\frac{\dot{z}}{z} \right)^2 + V_{Pj}'(z) \dot{z}$$

The productivity threshold for the patenting decision is z_{Pj} . Firms with productivity strictly above z_{Pj} will always patent their product in country j .

For the non-patenting firm, the problem is

$$(\rho + \Delta_{EN})V_{Nj}(z) = \max_z \pi_{Nj} - w_j \frac{f_{Nj}}{2z} \left(\frac{\dot{z}}{z} \right)^2 + V_{Nj}'(z) \dot{z}$$

subject to

$$V_{Nj}'(z_{Pj}) = V_{Pj}'(z_{Pj})$$

$$V_{Nj}(z_{Pj}) = V_{Pj}(z_{Pj}) - w_j f_{Pj}$$

$$V_{Nj}(z=1) = w_j f_{Nj}$$

The first restriction is the smooth pasting condition. It states that the growth rate of firm size cannot show leaps in the vicinity of z_{Pj} . Moreover, the slope of the value function has to be the same before and after patenting. The second condition is the value matching condition, which is also the border condition of the non-patenting firm's problem. The final condition is the free entry condition.

Defining a steady state in which productivity of patenting firms grow at a constant rate solves the patenting problem. After verifying that $V_P(z)$ is homogenous of degree one, the growth rate of the patenting firm is

$$g_{Pj} = (\rho + \Delta_{EPj}) \left(1 - \sqrt{1 - \frac{2\pi_{Pj}}{(\rho + \Delta_{EP})^2 f_{Pj}}} \right)$$

And the closed form solution for the value function of the patenting firm is

$$V_{Pj}(z) = w_j f_{Pj} g_{Pj} z$$

After re-arranging terms, and substituting in the Bellman equation, the differential equation that solves the non-patenting problem is

$$V_{Nj}'(z) = \sqrt{2f_{Nj} \left((\rho + \Delta_{EN}) \frac{V_{Nj}(z)}{z} - \pi_{Nj} \right)}$$

With the initial condition $g_{Nj}(z_{Pj}) = g_{Pj}$, since g_{Pj} does not depend on z . This differential equation cannot be solved in closed form, but can be computed using numerical solutions.

Then the value of the threshold is

$$z_{Pj} = \frac{2f_{li}(g_{Pj} - 1)(\rho + \Delta_{EN})w_j}{2\pi_{Nj} + f_{li}(g_{Pj})^2 w_j}$$

Hence, the distribution of firm size is given by the function $z^{-\Delta_{EN}/g_N(z)}$ or $z^{-\Delta_{EP}/g_P}$, depending on z .

2.2. Numerical simulations

The forces described in the theoretical model have multiple effects on the productivity and firm size of each industry. As complexity increases, the probability of imitation decreases, but the probability of product obsolescence becomes higher. The effect on patenting is then difficult to predict, as it depends on the magnitudes of each effect. This section shows the results of different simulations. The parameters chosen for these simulations are consistent with the empirical results presented in the next section.

For numerical simulations, first I need to define parameters and functional forms. A simple form for firm death is $\Delta_D = \delta^{1/\psi}$, and I assume $\delta = 0.3$. I also assume that complexity increases the cost of imitation exponentially. The probability of imitation is $\Delta_{IN} = e^{-\psi}$.

To calibrate the simulations, I set $\sigma = 5$ as in Bertrand et al. (2003) and Eaton and Kortum (2002). The cost of patenting triples the unit cost of innovation. The discount factor is 4%. I generate a productivity grid for $z \in [1, 4]$, and evaluate at which productivity level z_P firms start patenting. If $z_P > 4$, then no firm would use the patenting system, and the distribution of firm productivity is $z^{-\Delta_{EN}/g_N(z)}$. If $z_P \in [1, 4]$, the distribution of firm productivity is $z^{-\Delta_{EN}/g_N(z)}$ for $z \leq z_P$, and $z^{-\Delta_{EP}/g_P}$ for $z > z_P$.

The interest lies in five numerical outputs of the simulation: the productivity threshold, the probabilities of firm death, and the productivity growth rates with and without patent (which shape the distribution functions). With all the outcomes, I can compute the percentage of patenting firms, and the mean productivity of exporting firms, since the distribution function shows the mass of firms at each productivity level.⁴

Since the model is dynamic, a change in the intellectual property rights enforcement can have an impact in the entire distribution of firm size, even if firms never patent. The numerical results under low intellectual property enforcement are shown in Table 1, and under high intellectual property enforcement on Table 2.

⁴ To solve numerically the differential equation, I use *ode45* for MATLAB.⁴

Table 1: Numerical simulations (Low IPR)

Complexity (ψ)	Productivity threshold (z_p)	Rate of Patenting firms	Mean Productivity
1	4.02	0	1.03
1.5	2.04	22%	1.57
2	1.43	33%	2.08
2.5	1.19	46%	2.11
3	1.44	32%	2.08

Table 2: Numerical simulations (High IPR)

Complexity (ψ)	Productivity threshold (z_p)	Rate of Patenting firms	Mean Productivity
1	4.46	0	1.03
1.5	2.12	34%	2.01
2	1.46	41%	2.26
2.5	1.20	46%	2.30
3	1.21	44%	2.30

The simulations illustrate two main effects. The first one, is that the intellectual property enforcement in the host country increases the productivity of every exporting industry, regardless of the level of technological complexity.

The second effect, is that the effect of complexity shows a non-monotonicity. Complexity increases the productivity to a certain level, and then productivity remains high, or even decreases marginally, since "older firms", which are the most productive in the model, die faster. I test these effects using aggregate data in the next section.

3. Empirical Analysis

3.1. Data

Complexity is measured using the product complexity index by Naghavi, Spies, and Toubal (2015). The index is similar to Costinot et al. (2011), as it is constructed using labor surveys published at the O*NET database. It also follows a symmetry assumption, in the sense that it assumes that all countries have the same production technology for each industry. The index covers 32 industries at the two digit SIC classification.

The measure for IPR is a trading-partner-weighted IPR index constructed from Park (2008). To avoid potential endogeneity problems (IPR changing with exports associated with productivity growths), I generate the index using fixed weights. The international protection of intellectual property rights that country i faces for industry ω is:

$$IPR_{i\omega t} = \sum_j \frac{q(\omega)_{ij} IPR_{jt}}{\sum_j q(\omega)_{ij}}$$

where $q(\omega)_{ij}$ is the exports of good ω from country i to country j in 2000, and IPR_{jt} is the Park (2008) IPR enforcement index.

Labor productivity measure comes from the STAN database, collected by the OECD.⁵ The index measures labor productivity based on value added and employment data, and the construction is the ratio of value added over total employment.

As proxies for market size and wages, I use GDP and GDP per capita respectively, both from the World Bank. Total exports of each industry come from trade database by UNCTAD. The summary of the main variables is presented on Table 3.

Table 3: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Exports	4079	8.75E+09	2.16E+10	1205	2.64E+11
Productivity	4079	114.0449	35.33589	4.769423	775.5048
Complexity	4039	0.2304938	0.0632795	0.1146149	0.3246673
IPR	4079	3.99818	0.5025539	0.4206488	4.859369
GDP	4079	1.14E+12	2.31E+12	5.68E+09	1.42E+13
GDP p/c	4079	30077.61	16701.68	3057.791	112028.5

3.2. Estimation strategy

In order to test the implications of the theoretical model and the simulations, I run a set of regressions to assess the impact of complexity and IPR on productivity. The estimating equation of interest is

$$z_{i\omega t} = \alpha + \beta \begin{pmatrix} IPR_{i\omega t} \\ Complex_{\omega} \\ Complex_{\omega}^2 \\ IPR_{i\omega t} \times Complex_{\omega} \end{pmatrix} + \delta \begin{pmatrix} Exports_{i\omega t} \\ GDP_{it} \\ GDPp/c_{it} \end{pmatrix} + \eta_t + \eta_i + \varepsilon_{i\omega t}$$

⁵ Countries in the sample are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United States, and United Kingdom.

If the complexity story holds, the coefficients for $Complex_{\omega}$ and $Complex_{\omega}^2$ should be positive and negative respectively. I expect the coefficient for $IPR_{i\omega}$ to be positive, and I added an interacted variable $IPR_{i\omega} \times Complex_{\omega}$ to control for possible interacted effects.

The set of regressions include country fixed effects, random effects, and interacted time and country fixed effects to account for all country specific omitted variables.

3.3. Results

The results of the regressions using country fixed and random effects are shown in Table 4. The first two columns show the coefficients of the variables of interest without controls, for country fixed and random effects respectively. The following columns include controls for GDP and GDP per capita.

Table 4: Country effects regressions

	FE1	RE1	FE2	RE2
Exports	1.68e-10***	1.62e-10***	1.19e-10***	1.23e-10***
	0.00	0.00	0.00	0.00
Complexity	204.716**	208.205**	196.068**	202.253**
	-73.47	-73.42	-71.52	-72.03
Complexity^2	-430.203*	-448.364*	-437.892*	-467.033*
	-207.89	-207.75	-202.35	-203.83
IPR	7.659**	6.922**	6.766**	5.566*
	-2.39	-2.37	-2.32	-2.33
IPR*Complexity	-14.747	-12.083	-6.192	-2.617
	-33.7	-33.69	-32.81	-33.06
GDP			0.00	0.00
			0.00	0.00
GDP p/c			0.001***	0.001***
			0.00	0.00
Constant	62.680***	64.434***	39.187***	49.930***
	-12.08	-12.24	-11.89	-12.07
R-sqr	0.0191	0.0471	0.0711	0.0747
N	4039	4039	4039	4039

* p<0.05, ** p<0.01, *** p<0.001

Exports is positive and statistically significant at level 0.001 for all specifications. Higher exports are correlated with more productive industries, which is consistent with Melitz (2003) type of models of firm heterogeneity.

Complexity has the linear coefficient positive and significant, and the squared coefficient negative and significant at levels 0.01 and 0.05 respectively. This is consistent with the inverted U-shape results of the numerical simulations.

The IPR index is also positive and statistically significant at level 0.01 for all specifications except the last random effects (significance level 0.05), supporting the positive relation between foreign IPR and domestic productivity. I find no interacted effect of IPR and complexity.

As a robustness check, I run a simulation using an interacted year and country fixed effect. The limitation of this specification is that most country level variables are perfectly collinear. This specification has the merit to control for all omitted variables of each country. Results are shown in Table 5.

Table 5: Interacted fixed effects regressions

	FE
Exports	1.23e-10***
	0.00
Complexity	204.218**
	-68.91
Complexity^2	-483.855*
	-195.32
IPR	4.059
	-2.26
IPR*Complexity	0.319
	-31.84
Constant	77.212***
	-11.4
R-sqr	0.012
N	4039

* p<0.05, ** p<0.01, *** p<0.001

When using interacted fixed effects, exports and complexity have similar magnitudes than in the previous set of regressions, and significant at 0.001 for exports, 0.01 for the linear coefficient of complexity, and 0.05 for the squared complexity coefficient. IPR is no longer significant, and evidence of interacted effect between IPR and complexity is not supported.

This is a very demanding specification, since fixed effects are taking into account both country and time specific unobserved characteristics. Yet, the complexity inverted U-shape story is still statistically significant under this specification.

4. Conclusion

By endogenizing the innovation decision of exporting firms in a dynamic model of monopolistic competition, firm size and productivity will depend on previous innovating efforts. Exporting firms face potential foreign imitators, and there is an exogenous probability of imitation that depends on the foreign protection of IPR. Products have different technological complexity, which shapes the effect of foreign IPR on domestic innovation.

The simulations of the model show that complexity affects both the probability of firm's death, and the cost of imitating the product. In a numerical equilibrium, IPR affects productivity positively, while complexity has a non-monotonic effect on productivity.

Testing these results using productivity measures from the OECD support the theory of an inverted U-shape relation between complexity and productivity. Moreover, under most specification, a positive relationship between foreign IPR and domestic productivity is supported.

References

Awokuse T. O., and W. G. Gu (2010) Does foreign intellectual property rights protection affect U.S. exports and FDI?. Working Papers, vol. 10-10, University of Delaware, Department of Economics.

Bernard, A., J. Eaton, J.B. Jensen, S. Kortum (2003) Plants and Productivity in International Trade. American Economic Review, American Economic Association, vol. 93(4), pages 1268-1290, September.

Branstetter, L. G., R. Fisman, and C.F. Foley (2006) Do stronger intellectual property rights increase international technology transfer? Empirical evidence from U.S. firm-level panel data. Quarterly Journal of Economics, 121(1), 321-349, February.

Branstetter L., and K. Saggi (2011) Intellectual Property Rights, Foreign Direct Investment and Industrial Development. Economic Journal, Royal Economic Society, vol. 121(555), pages 1161-1191, 09.

Costinot, A., L. Oldenski and J. Rauch (2011) Adaptation and the Boundary of Multinational Firms. The Review of Economics and Statistics, MIT Press, vol. 93(1), pages 298-308, February.

Dunne, T., M. J. Roberts, and L. Samuelson (1988) Patterns of firm entry and exit in U.S. manufacturing industries. Rand Journal of Economics, vol. 19 (4), 495- 515.

Dunne, T., M. J. Roberts, and L. Samuelson (1989). The growth and failure of U.S. manufacturing plants. Quarterly Journal of Economics, vol. 104(4), 671-698.

Eaton, J. and S. Kortum (2002) Technology, Geography, and Trade. Econometrica, 70 (5), pages 1741-1779, September.

Evans, D. S., (1987a.) The relationship between firm growth, size, and age: estimates for 100 manufacturing industries. Journal of Industrial Economics, vol. 35 (4), 567- 581.

Fernandez Donoso, J., (2014) Do complex inventions need less international patent protection? Economics Letters, vol. 125(2), pages 278-281.

Gibrat, R., (1931) Les Inegalites Economiques. Sirey, Paris.

Javorcik B.S. (2004) The Composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies. European Economic Review, vol. 48 pages 39-62.

Johnson, N., S. Kotz, and A. W. Kemp (1992) Univariate Discrete Distributions. New York, second edition.

Melitz, M. J. (2003) The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. Econometrica, vol. 71 (6), pages 1695-1725, November.

Naghavi A., Spies J., and Toubal F. (2015) Intellectual Property Rights, Product Complexity, and the Organization of Multinational Firms. *Canadian Journal of Economics*, vol. 48 (3).

Pakes, A. (1986) Patents as options: some estimates of the value of holding European patent stocks. *Econometrica*, Vol. 54 (4), 755-784.

Park, W. (2008) International Patent Protection. *Research Policy*, Vol. 37, Issue 4, pp. 761-766.

Ponzetto, G. (2009) Intellectual Property Rights and Firm Organization. CREI Working Papers.

Qiu, L. and H. Yu (2010) Does the protection of foreign intellectual property rights stimulate innovation in the U.S.? *Review of International Economics*, 18(5), pages 882-895.

Simon, H. A., and C. P. Bonini (1958) The size distribution of business firms. *American Economic Review*, vol. 48, pages 607-617.